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# Variants of the *X*-phase in the Mn–Co–Ge system

**Vitalii Shtender,* Simon R. Larsen and Martin Sahlberg**

Department of Chemistry, Ångström Laboratory, Uppsala University, Box 538, 75121 Uppsala, Sweden. *Correspondence e-mail: vitalii.shtender@kemi.uu.se

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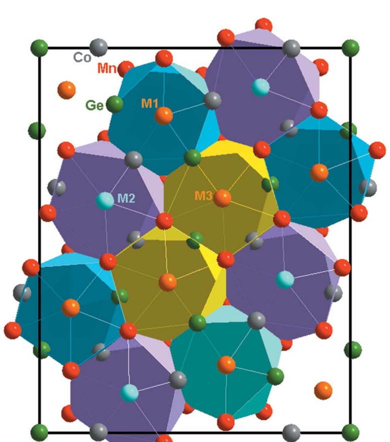
We report two new variants of the *X*-phase (orthorhombic, space group *Pnnm*) derived from the Mn–Co–Ge system. Two compositionally related crystals were investigated by means of single-crystal X-ray diffraction (XRD) and energy dispersive spectroscopy (EDS). The $Mn_{14.9}Co_{15.5}Ge_{6.6}$ and $Mn_{14}Co_{16.2}Ge_{6.8}$ intermetallic compounds are part of the homogeneity region of the *X*-phase and adopt the $Mn_{14}(Mn_{0.11}Co_{0.64}Si_{0.25})_{23}$ structure type. The composition obtained from refinement of the XRD data is in agreement with the EDS results. In the present study, chemical disorder was only detected on the 8*h* positions. The ordering is compared with other members of the *X*-phase family and shows that the degree of disordering depends on the chemical composition. No completely ordered variants of the *X*-phase have yet been reported.






## 1. Introduction

Topologically close packed (TCP) phases or Frank–Kasper phases as they are also known encompass a large number of intermetallic compounds (Dshemuchadse & Steurer, 2015; Ovchinnikov *et al.*, 2020). As a result, TCP phases often appear in various widely used alloys such as steels. In single-crystal superalloys they are reported to reduce microstructural stability, promote creep porosities and induce cracking and crack propagation (Tan *et al.*, 2020). In high-entropy alloys, they often appear in the form of the $\sigma$-phase and have been reported to improve strength while providing good ductility (Jo *et al.*, 2018). Due to this, control of the formation of these phases is desired as they have a large impact on the mechanical properties of materials.

Conventional close packing of atoms of the same size create tetrahedral and octahedral interstitial holes. When atoms of slightly different sizes pack together, TCPs can arise as they achieve a better packing by forming small non-uniform tetrahedral interstices. The non-uniform nature of the tetrahedral interstices allow for coordination numbers of 12, 14, 15 and 16 (Frank & Kasper, 1958; Wang & Mar, 2001; Ovchinnikov *et al.*, 2020). The Valence Electron Concentration (VEC) also plays a role in determining the structure and stability of the TCP phase, so much so that maps based on the VEC and divergence from the average atomic size can be used to predict the various phases seen (Seiser *et al.*, 2011; Hammerschmidt *et al.*, 2013). Theoretical calculations also indicate that magnetism has a minor effect on the structural stability of certain phases (Hammerschmidt *et al.*, 2013).

The *X*-phase is a rare structure type that has only been reported for two systems. The Mn–Co–Si system, from which the base structure is derived, was discovered in the 1970s by two independent groups (Yarmolyuk *et al.*, 1970; Manor *et al.*, 1972). This structure has been reported as $Mn_{15.84}Co_{15.87}Si_{5.29}$ and $Mn_{44.4}Co_{40.0}Si_{15.1}$, respectively. In general, these phases

**Table 1**
Crystallographic data and structure refinement parameters for the studied Mn–Co–Ge single crystals.

Experiments were carried out at 296 K with Mo *Kα* radiation using a Bruker APEXII CCD diffractometer (see *Characterization*, §2.2). The absorption correction was mpirical (using intensity measurements) (*SADABS*; Bruker, 2015).

| | $Mn_{14.9}Co_{15.5}Ge_{6.6}$ | $Mn_{14}Co_{16.2}Ge_{6.8}$ |
|---|---|---|
| Compound | $Mn_{14.89\,(5)}Co_{15.48\,(4)}Ge_{6.62\,(2)}$ | $Mn_{14}Co_{16.16\,(3)}Ge_{6.84\,(3)}$ |
| Summary formula | $Mn_{29.79\,(10)}Co_{30.97\,(8)}Ge_{13.25\,(4)}$ | $Mn_{28}Co_{32.32\,(6)}Ge_{13.68\,(6)}$ |
| Empirical formula | $Mn_{14}Co_{12}Ge_5(Mn_{0.04}Co_{0.15}Ge_{0.07})_{23}$ | $Mn_{14}Co_{14}Ge_5(Co_{0.096}Ge_{0.08})_{23}$ |
| Sample code | 10 | 7 |
| Calculated composition | $Mn_{40.2}Co_{41.9}Ge_{17.9}$ | $Mn_{37.8}Co_{43.9}Ge_{18.3}$ |
| EDS composition | $Mn_{40.4\,(5)}Co_{42.0\,(7)}Ge_{17.6\,(3)}$ | $Mn_{37.7\,(9)}Co_{45.1\,(9)}Ge_{17.2\,(5)}$ |
| CSD | 2057512 | 2057511 |
| Structure type relation | $Mn_{14}(Mn_{0.11}Co_{0.64}Si_{0.25})_{23}$ | $Mn_{14}(Mn_{0.11}Co_{0.64}Si_{0.25})_{23}$ |
| Formula weight, $M_r$ (g mol$^{-1}$) | 4422.90 | 4436.02 |
| Space group (No.) | *Pnnm* (58) | *Pnnm* (58) |
| Pearson symbol, *Z* | *oP*74, 1 | *oP*74, 1 |
| Unit-cell dimensions: | | |
| *a* (Å) | 12.6427 (10) | 12.6208 (12) |
| *b* (Å) | 15.6725 (12) | 15.6878 (15) |
| *c* (Å) | 4.8374 (4) | 4.8338 (5) |
| *V* (Å$^3$) | 958.50 (13) | 957.06 (16) |
| Calculated density, $\rho$ (g cm$^{-3}$) | 7.66 | 7.70 |
| Absorption coefficient, $\mu$ (mm$^{-1}$) | 32.54 | 32.93 |
| Theta range for data collection (°) | 2.070–42.410 | 2.071–46.877 |
| *F*(000) | 2005 | 2010 |
| Range in *h k l* | $-23 \le h \le 23$ | $-24 \le h \le 25$ |
| | $-29 \le k \le 29$ | $-25 \le k \le 32$ |
| | $-9 \le l \le 9$ | $-9 \le l \le 9$ |
| Total No. of reflections | 22326 | 38733 |
| $R_{int}/R_\sigma$ | 0.0299/0.0217 | 0.0411/0.0255 |
| No. of independent reflections | 3686 | 4648 |
| No. of reflections with $I > 2\sigma(I)$ | 3277 | 4313 |
| Data/parameters | 3686/106 | 4648/106 |
| Goodness-of-fit on $F^2$ | 1.103 | 1.219 |
| Final *R* indices [$I > 2\sigma(I)$] | $R_1 = 0.0219$ | $R_1 = 0.0323$ |
| | $wR_2 = 0.0502$ | $wR_2 = 0.0779$ |
| *R* indices (all data) | $R_1 = 0.0265$ | $R_1 = 0.0359$ |
| | $wR_2 = 0.0515$ | $wR_2 = 0.0795$ |
| Largest diff. peak and hole (e Å$^{-3}$) | 1.241 and −0.919 | 2.257 and −1.675 |

Computer programs: *APEX3* (Bruker, 2015), *SAINT* (Bruker, 2015), *SHELXT2014* (Sheldrick, 2015*a*), *SHELXL2018* (Sheldrick, 2015*b*), *DIAMOND* (Brandenburg and Putz, 2006) and *FULLPROF* (Rodriguez-Carvajal, 2001).

are assigned to the $Mn_{14}(Mn_{0.11}Co_{0.64}Si_{0.25})_{23}$ structure type (Villars & Cenzual, 2016), where seven independent positions relate to Mn and the other nine positions are mixed Co/Mn or Si/Co/Mn. Investigation of the phase diagram of the ternary Mn–Co–Si system at 800 °C revealed the formation of $Mn_{16.5}Co_{14.8}Si_{5.7}$ (Kuz'ma & Gladyshevskii, 1964), while at 1000 °C, the authors reported $Mn_{16.5}Co_{14.8}Si_{5.7}$, as well as $Mn_3Co_3Si$ (*Y*-phase) (Bardos *et al.*, 1966). A rough approximation for the stoichiometry of the *X*-phase can be given close to 3–3–1, as also used for the *Y*-phase (Gupta, 2006). There has been some discussion as to whether the structure is instead the *Y*-phase (Manor *et al.*, 1972; Gupta, 2006); the similarity of the diffraction patterns indicates that they might be the same phase with a large homogeneity region. The second system reported in 2001 is composed of Nb–Ni–Sb (Wang & Mar, 2001) and was reported as the $Nb_{28}Ni_{33.5}Sb_{12.5}$ [$Nb_{14}Ni_{16.75}Sb_{6.25}$ or $Nb_{14}(Ni_{0.728}Sb_{0.272})_{23}$] ternary compound, which crystalized in the *X*-phase structure type.

In this article, the syntheses and crystal structures of two new Mn–Co–Ge compounds, representatives of the *X*-phase, will be discussed.

## 2. Experimental

### 2.1. Synthesis

This study was initiated based on separate results obtained during the investigation of $Mn_2Co_3Ge$, a compound which was selected as a permanent magnet candidate (Vishina *et al.*, 2021). Initial trials revealed the magnetic Heusler phase $MnCo_2Ge$ (Buschow *et al.*, 1983) as being the main competing phase in that region of the phase diagram. The synthesis of the $Mn_2Co_3Ge$ compound was achieved by arc melting and negligible loses of Mn (1–3 wt%) were detected in most cases. In the event of larger losses, more Mn was added to compensate for the losses and to avoid the formation of $MnCo_2Ge$. It was found that an additional 3 wt% of Mn decreased the amount of $MnCo_2Ge$ impurities. Based on this, $Mn_2Co_3Ge$ alloys with 5, 7 and 10 wt% of excess Mn were prepared. However, while it did reduce the amount of $MnCo_2Ge$, in most cases, it did not result in higher purity of the sought-after phase. The samples of 7 and 10 wt% excess Mn did instead reveal the existence of a new phase, the crystal structure of which is presented herein.

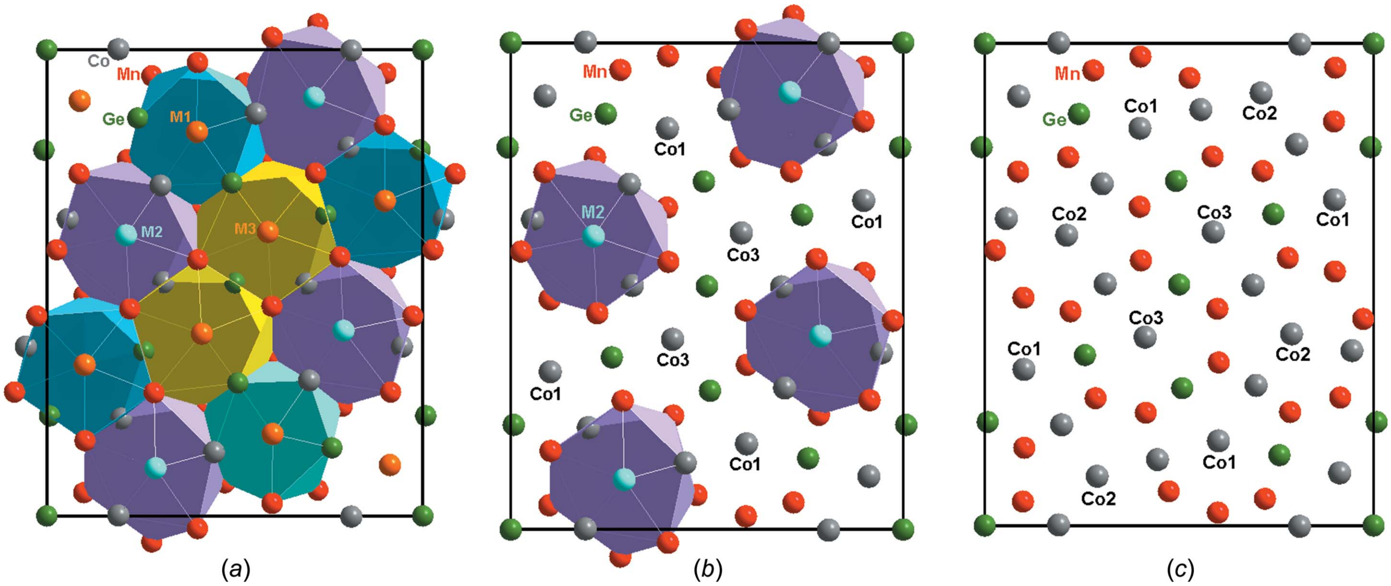



**Figure 1**
Schematic presentation of the disordering in the 8*h* positions with respect to the chemical compositions for (*a*) disordered $Mn_{14.9}Co_{15.5}Ge_{6.6}$, (*b*) partially disordered $Mn_{14}Co_{16.2}Ge_{6.8}$ and (*c*) hypothetically ordered '$Mn_{14}Co_{18}Ge_5$'. All projections of the orthorhombic unit cells are presented on the *ba* plane. Atoms names are as used in Table 2.

Samples of $Mn_2Co_3Ge$+7%Mn and $Mn_2Co_3Ge$+10%Mn were synthesized by arc melting Co (99.9+%, Alfa Aesar), Mn (99.7%, Höganäs) and Ge (99.999%, Kurt J. Lesker) under an argon atmosphere. A titanium getter was used to reduce oxygen contamination and the samples were flipped and remelted three times to promote homogeneity. Samples were placed in $Al_2O_3$ crucibles and then sealed in evacuated quartz tubes for annealing. Heat treatment was carried out for 7 d at 800 °C, after which samples were quenched with water.

### 2.2. Characterization

Crystals were picked up from the Mn–Co–Ge alloys by fragmentation and analyzed. A Bruker D8 single-crystal X-ray diffractometer with Mo *Kα* radiation (λ = 0.71073 Å) upgraded with an Incoatec Microfocus Source (IμS, beam size ∼100 μm at the sample position) and an APEXII CCD area detector (6 × 6 cm) was used to collect single-crystal X-ray diffraction (SCXRD) intensities at room temperature. The final cycle of refinement was carried out anisotropically for all species converging with low residuals and a flat difference Fourier map. The atomic positions were standardized with the use of the program *STRUCTURE TIDY* implemented in *PLATON* (Spek, 2020).

Additional methods, such as scanning electron microscopy (SEM) on a Zeiss Merlin SEM instrument equipped with a secondary electron (SE) detector and an energy-dispersive X-ray spectrometer (EDS), were employed to confirm the composition of the title compounds. The samples used for electron microscopy analysis were prepared by standard metallographic techniques through grinding with SiC paper. For the final polishing, a mixture of $SiO_2$ and $H_2O$ was used. Furthermore, the sample purity was checked by means of powder X-ray diffraction (PXRD) on a Bruker D8 X-ray diffractometer with a Lynx-eye position-sensitive detector and Cu *Kα* radiation on a zero-background single-crystal Si sample holder. Phase analysis of the X-ray data using the Rietveld method was carried out with *FULLPROF* software (Rodriguez-Carvajal, 2001).

The crystal structures of the new *X*-phase representatives were solved by single-crystal X-ray diffraction data analysis using the procedures described above. PXRD phase analysis showed that $Mn_2Co_3Ge$+7%Mn was a multiphase alloy, while $Mn_2Co_3Ge$+10%Mn consisted of a single phase. The elemental composition obtained from refinement of the crystal structure data was found to be $Mn_{40.2}Co_{41.9}Ge_{17.9}$ and $Mn_{37.8}Co_{43.9}Ge_{18.3}$ for the two crystals, respectively, agreeing with EDS results [$Mn_{40.4\,(5)}Co_{42.0\,(7)}Ge_{17.6\,(3)}$ and $Mn_{37.7\,(9)}$-$Co_{45.1\,(9)}Ge_{17.2\,(5)}$]. Tables 1 and 2 present crystallographic data and experimental details for $Mn_{14.89\,(5)}Co_{15.48\,(4)}Ge_{6.62\,(2)}$ and $Mn_{14}Co_{16.16\,(3)}Ge_{6.84\,(3)}$. Anisotropic displacement parameters, interatomic distances and angles are provided as supporting information. For simplicity, the limits of composition in the text will be referred to as $Mn_{14.9}Co_{15.5}Ge_{6.6}$ and $Mn_{14}Co_{16.2}Ge_{6.8}$.

## 3. Results and discussion

Detailed crystal structure chemistry for the previously studied representatives of the $Mn_{14}(Mn_{0.11}Co_{0.64}Si_{0.25})_{23}$ structure type are presented elsewhere (Yarmolyuk *et al.*, 1970; Manor *et al.*, 1972; Wang & Mar, 2001). In this work, two crystals of similar composition were studied with the aim of comparing the ordering/disordering of the atoms in the structure. Two ternary intermetallic compounds with orthorhombic structures (space group *Pnnm*) and very negligible changes in the unit-cell parameters indicated a small homogeneity region of the *X*-phase which was further supported by EDS analysis. The Ge content is mostly stable, while the majority of changes

**Table 2**
Atomic coordinates and equivalent isotropic displacement parameters for the $Mn_{14.9}Co_{15.5}Ge_{6.6}$ and $Mn_{14}Co_{16.2}Ge_{6.8}$ compounds.

$U_{eq}$ is defined as one-third of the trace of the orthogonalized $U_{ij}$ tensor. For $Mn_{14.89\,(5)}Co_{15.48\,(4)}Ge_{6.62\,(2)}$, *M*1 and *M*3 are 0.876 (12)Co + 0.124 (12)Mn and 0.90Co + 0.10Mn, respectively, and *M*2 = 0.594 (5)Co + 0.406 (5)Ge. For $Mn_{14}Co_{16.16\,(3)}Ge_{6.84\,(3)}$, *M*2 = 0.540 (7)Co + 0.460 (7)Ge.

| $Mn_{14.89\,(5)}Co_{15.48\,(4)}Ge_{6.62\,(2)}$ | | | | | | $Mn_{14}Co_{16.16\,(3)}Ge_{6.84\,(3)}$ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Atom | Site | *x* | *y* | *z* | $U_{eq}$ (Å$^2$) | Atom | Site | *x* | *y* | *z* | $U_{eq}$ (Å$^2$) |
| Mn1 | 4*g* | 0.02666 (3) | 0.57115 (2) | 0 | 0.00762 (5) | Mn1 | 4*g* | 0.02630 (3) | 0.57128 (2) | 0 | 0.00617 (6) |
| Mn2 | 4*g* | 0.08586 (3) | 0.73416 (2) | 0 | 0.00681 (5) | Mn2 | 4*g* | 0.08564 (3) | 0.73405 (2) | 0 | 0.00553 (5) |
| Mn3 | 4*g* | 0.10176 (3) | 0.16147 (2) | 0 | 0.00729 (5) | Mn3 | 4*g* | 0.10193 (3) | 0.16150 (3) | 0 | 0.00594 (6) |
| Mn4 | 4*g* | 0.22070 (3) | 0.44440 (2) | 0 | 0.00763 (5) | Mn4 | 4*g* | 0.22075 (3) | 0.44428 (2) | 0 | 0.00622 (6) |
| Mn5 | 4*g* | 0.28518 (3) | 0.26433 (2) | 0 | 0.00710 (5) | Mn5 | 4*g* | 0.28525 (3) | 0.26426 (2) | 0 | 0.00566 (6) |
| Mn6 | 4*g* | 0.40147 (3) | 0.54997 (2) | 0 | 0.00673 (5) | Mn6 | 4*g* | 0.40142 (3) | 0.54991 (3) | 0 | 0.00543 (6) |
| Mn7 | 4*g* | 0.59950 (3) | 0.02711 (2) | 0 | 0.00717 (5) | Mn7 | 4*g* | 0.59952 (3) | 0.02717 (2) | 0 | 0.00573 (6) |
| *M*1 | 8*h* | 0.10076 (2) | 0.32411 (2) | 0.23460 (4) | 0.00519 (4) | Co1 | 8*h* | 0.10096 (2) | 0.32409 (2) | 0.23463 (5) | 0.00405 (4) |
| *M*2 | 8*h* | 0.28921 (2) | 0.10244 (2) | 0.25373 (4) | 0.00601 (5) | *M*2 | 8*h* | 0.28931 (2) | 0.10233 (2) | 0.25377 (4) | 0.00490 (5) |
| *M*3 | 8*h* | 0.41242 (2) | 0.39078 (2) | 0.24024 (4) | 0.00525 (4) | Co3 | 8*h* | 0.41258 (2) | 0.39066 (2) | 0.24029 (4) | 0.00417 (4) |
| Co4 | 4*g* | 0.19010 (2) | 0.00139 (2) | 0 | 0.00605 (5) | Co4 | 4*g* | 0.19001 (3) | 0.00128 (2) | 0 | 0.00458 (5) |
| Co5 | 4*g* | 0.44439 (3) | 0.13693 (2) | 0 | 0.00660 (5) | Co5 | 4*g* | 0.44448 (3) | 0.13683 (2) | 0 | 0.00501 (5) |
| Co6 | 4*g* | 0.69785 (3) | 0.29091 (2) | 0 | 0.00626 (5) | Co6 | 4*g* | 0.69799 (3) | 0.29094 (2) | 0 | 0.00482 (5) |
| Ge1 | 4*g* | 0.50766 (2) | 0.28512 (2) | 0 | 0.00626 (4) | Ge1 | 4*g* | 0.50782 (2) | 0.28499 (2) | 0 | 0.00489 (4) |
| Ge2 | 4*g* | 0.75789 (2) | 0.14623 (2) | 0 | 0.00624 (4) | Ge2 | 4*g* | 0.75801 (2) | 0.14630 (2) | 0 | 0.00472 (5) |
| Ge3 | 2*a* | 0 | 0 | 0 | 0.00616 (5) | Ge3 | 2*a* | 0 | 0 | 0 | 0.00474 (6) |

occur along the Mn/Co line. For both compositions, it was established that Mn occupies seven independent 4*g* positions. Three Co and two Ge atoms also occupy independent 4*g* positions, with the final Ge atom occupying the position at 2*a*. This holds true for the $Mn_{14.9}Co_{15.5}Ge_{6.6}$ and $Mn_{14}Co_{16.2}Ge_{6.8}$ compositions.

Differences are present only at the 8*h* positions which are of higher multiplicity. The studied compounds have a large degree of Co/Ge intermixing on the 8*h* position of *M*2 (see Table 2). This is likely due to the nearest neighbours of *M*2 (Co/Ge) consisting exclusively of Mn and Co and not Ge [in Fig. 1, the outlined icosahedra (CN = 12) for *M*2 are $Mn_7Co_3M2_2$]. No clear Ge—Ge bonds that could relate to the sum of atomic radii ($r_{Ge}$ = 1.22 Å; Pearson, 1972) could be discerned in this structure. It can only be realized in the case of *M*2, for which two other *M*2 are as close as 2.3826 (4) and 2.4548 (4) Å. One of these distances could be regarded as the Ge—Ge, Co—Ge or Co—Co interatomic distance since atomic radii of Co and Ge are similar ($r_{Co}$ = 1.25 and $r_{Ge}$ = 1.22 Å; Pearson, 1972). It should be noted that for other compounds of the Mn–Co–Ge and Co–Ge systems, it is common to have shorter Ge—Ge, Co—Ge or Co—Co interatomic distances than the sum of the atomic radii (Villars & Cenzual, 2016).

The last two 8*h* positions (*M*1 and *M*3) are a statistical mixture of Mn and Co for $Mn_{14.9}Co_{15.5}Ge_{6.6}$, while for $Mn_{14}Co_{16.2}Ge_{6.8}$, they are occupied solely by Co. As the latter is Mn-lean this makes sense. The Mn/Co occupational ratio at the *M*1 site was refined and the refinement remained stable, while the ratio at *M*3 had to be constrained due to instability of the refinement. This procedure was deemed applicable as the Fourier map and *R* factors improved and the calculated composition corresponded well to results attained from EDS measurements. The unstable Mn/Co occupational ratio at *M*3 cannot be explained by the smaller volume of the surrounding icosahedron and thus the larger electron density. The volume of the *M*3-related icosahedron is 45.6 Å$^3$, while for *M*1 it is only 43.8 Å$^3$. An alternative explanation can be sought by examining the ligands for each central *Mx* atom. As was mentioned, the *M*2 site only has Mn and Co atoms surrounding it, while *M*1 has two atoms of Ge present and *M*3 has three Ge atoms ($M1@Mn_6Co_2M1_2Ge_2$ and $M3@Mn_6Co_1M3_2Ge_3$). Polyhedra for *M*3 are always in pairs (while others alternate), sharing one of the Ge atoms between them. Considering that Ge is the most electronegative atom in the present case [$\chi_{Ge}$= 2.01, $\chi_{Co}$= 1.88 and $\chi_{Mn}$= 1.55, according to the Pauling scale (Pauling, 1932)] and that the *M*3—Ge distances [2.3543 (3), 2.3942 (3) and 2.3948 (2) Å] are the shortest in the structure [for comparison, the *M*2—*M*2 distance is 2.3826 (4) Å], this might be a reason why the position of *M*3 becomes unstable with the introduction of Mn ($r_{Mn}$ = 1.27 Å; Pearson, 1972). The Co—Ge distances around *M*3 are in the range 2.3911 (4)–2.4564 (4) Å, which is similar to what is seen for *M*2, but the shortest Mn—Ge distance of 2.7233 (5) Å in the same area exhibits a sizeable difference [Mn—*M*2 = 2.6607 (4) Å]. Also, Ge lacks at least one electron in the *p*-orbital to be half-filled ($4p^2$), while Co has its excess at *d* ($3d^74s^2$, *d*-orbital more than half-filled) and Mn is stable in the *d*-orbital ($3d^54s^2$, *d*-orbital half-filled). By introducing Mn with a larger atomic radius than Co we decrease the distance of the central atom to Ge and remove the unpaired electrons of Co from the area near Ge. For this reason, the statistical mixture of Mn/Co in *M*3, unlike *M*1, cannot be stable during refinement. To summarize, though many different trials of the refinements were carried out, the presented results were found to be the best statistically that also agreed with EDS results. Nevertheless, the presented arguments are our way of explaining the outlined problem at the *M*3 site. It is difficult to conclude whether it is refinement instability or chemical/structural instability from the available data. Our results do not allow completely separate Mn and Co since this is not discernible with XRD (difference of only two electrons) and to differentiate between them neutrons are needed.

The studied compounds ($Mn_{14.9}Co_{15.5}Ge_{6.6}$ and $Mn_{14}Co_{16.2}$-$Ge_{6.8}$) are compositionally related to each other and the other members [$Mn_{15.84}Co_{15.87}Si_{5.29}$ (Yarmolyuk *et al.*, 1970), $Mn_{16.46}Co_{14.80}Si_{5.75}$ (Manor *et al.*, 1972) and $Nb_{14}Ni_{16.78}Sb_{6.22}$ (Wang & Mar, 2001)] of the *X*-phase with the $Mn_{14}(Mn_{0.11}$-$Co_{0.64}Si_{0.25})_{23}$ structure type. In all cases, the Mn atoms occupied seven independent positions (in the case of $Nb_{14}Ni_{16.78}Sb_{6.22}$, the Nb atoms occupy the same positions instead). For the first Si-based compound, the other positions were occupied by mixed Mn/Co/Si atoms and the *z* parameters at the 8*h* positions were fixed (Yarmolyuk *et al.*, 1970). The second Si-based compound had a slightly higher degree of ordering, where four positions were shared between Mn/Co/Si and five other positions were only shared between Mn/Co (*z* at the 8*h* positions were refined) (Manor *et al.*, 1972). That intermixing is seen for all elements on so many positions is likely related to the lack of the high-quality data, as the studies were carried out in the 1970s. Contrary to those studies, the most recent publication on $Nb_{14}Ni_{16.78}Sb_{6.22}$ (Wang & Mar, 2001) presents a very detailed refinement procedure supported by extended Hückel band structure calculations. In terms of numbers of elements and structural features, $Nb_{14}$-$Ni_{16.78}Sb_{6.22}$ relates closely to the presented $Mn_{14}Co_{16.2}Ge_{6.8}$ compound. The intermixing of Ni/Sb on one 8*h* position is similar to the intermixing of Co/Ge presented here. Minor differences are seen on the 4*g* positions where Ni/Sb was found to intermix as well, while only Ge was seen to be present here. This could relate to the difference in the homogeneity regions or the nature of the elements. The same might be applicable for the Si-based compounds, but a detailed analysis of these old compounds would be needed to confirm this. The currently known *X*-phases are all of the same structure type, with the minor differences of the ordering/disordering at some crystallographic positions being a key differentiator.

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# supporting information

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## Variants of the *X*-phase in the Mn–Co–Ge system

**Vitalii Shtender, Simon R. Larsen and Martin Sahlberg**

### Computing details

For both structures, data collection: *APEX3* (Bruker, 2015); cell refinement: *SAINT* (Bruker, 2015); data reduction: *SAINT* (Bruker, 2015); program(s) used to solve structure: SHELXT2014 (Sheldrick, 2015a); program(s) used to refine structure: *SHELXL2018* (Sheldrick, 2015b); molecular graphics: *DIAMOND* (Brandenburg and Putz, 2006); software used to prepare material for publication: FULLPROF (Rodriguez-Carvajal, 2001).

### Manganese cobalt germanide (Mn14Co16.2Ge6.8)

*Crystal data*

$Mn_{28}Co_{32.32}Ge_{13.68}$
$M_r$ = 4436.02
Orthorhombic, *Pnnm*
$a$ = 12.6208 (12) Å
$b$ = 15.6878 (15) Å
$c$ = 4.8338 (5) Å
$V$ = 957.06 (16) Å$^3$
$Z$ = 1
$F$(000) = 2010
$D_x$ = 7.697 Mg m$^{-3}$
Mo $K\alpha$ radiation, $\lambda$ = 0.71073 Å
Cell parameters from 38733 reflections
$\theta$ = 2.1–46.9°
$\mu$ = 32.93 mm$^{-1}$
$T$ = 296 K
Irregular fragment, metallic
0.03 × 0.02 × 0.01 mm

*Data collection*

Bruker APEXII CCD diffractometer
$\varphi$ and $\omega$ scans
Absorption correction: empirical (using intensity measurements) (SADABS; Bruker, 2015)
38733 measured reflections
4648 independent reflections
4313 reflections with $I > 2\sigma(I)$
$R_{int}$ = 0.041
$\theta_{max}$ = 46.9°, $\theta_{min}$ = 2.1°
$h$ = −24→25
$k$ = −25→32
$l$ = −9→9

*Refinement*

Refinement on $F^2$
Least-squares matrix: full
$R[F^2 > 2\sigma(F^2)]$ = 0.032
$wR(F^2)$ = 0.080
$S$ = 1.22
4648 reflections
106 parameters
0 restraints
$w = 1/[\sigma^2(F_o^2) + (0.0301P)^2 + 3.3753P]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max}$ = 0.001
$\Delta\rho_{max}$ = 2.26 e Å$^{-3}$
$\Delta\rho_{min}$ = −1.67 e Å$^{-3}$
Extinction correction: SHELXL2018 (Sheldrick, 2015b), $Fc^*=kFc[1+0.001xFc^2\lambda^3/\sin(2\theta)]^{-1/4}$
Extinction coefficient: 0.00025 (8)

*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.

**Refinement**. Crystals were picked up from the Mn–Co–Ge alloys by fragmentation and analyzed. A Bruker D8 single-crystal X-ray diffractometer with Mo *Kα* radiation ($\lambda$ = 0.71073 Å) upgraded with an Incoatec Microfocus Source (I$\mu$S, beam size ~ 100$\mu$m at the sample position) and an APEXII CCD area detector (6 × 6 cm) was used to collect single-crystal X-ray diffraction (SCXRD) intensities at room temperature. SCXRD data reduction and numerical absorption corrections were performed using the *APEX3* software from Bruker (2014). A preliminary ordered model ($Mn_{14}Co_{18}Ge_5$) of the crystal structure was first obtained with the program *SHELXT2014* (Sheldrick, 2015a) and refined using the program *SHELXL2014* (Sheldrick, 2015b) within the *APEX3* software package. The final cycle of refinement was carried out anisotropically for all species converging with low residuals and a flat difference Fourier map. The atomic positions were standardized with the use of the program *STRUCTURE TIDY* implemented in *PLATON* (Spek, 2020). Further data, in the form of a CIF file, have been sent to the Cambridge Crystallographic Data Centre (CCDC) (Groom *et al.*, 2016). CIF files are available as supplementary material for the publication. Molecular graphics made in *DIAMOND* (Brandenburg & Putz, 2005).

*Fractional atomic coordinates and isotropic or equivalent isotropic displacement parameters (Å$^2$)*

| | *x* | *y* | *z* | $U_{iso}$*/$U_{eq}$ | Occ. (<1) |
|---|---|---|---|---|---|
| Mn1 | 0.02630 (3) | 0.57128 (2) | 0.000000 | 0.00617 (6) | |
| Mn2 | 0.08564 (3) | 0.73405 (2) | 0.000000 | 0.00553 (5) | |
| Mn3 | 0.10193 (3) | 0.16150 (3) | 0.000000 | 0.00594 (6) | |
| Mn4 | 0.22075 (3) | 0.44428 (2) | 0.000000 | 0.00622 (6) | |
| Mn5 | 0.28525 (3) | 0.26426 (2) | 0.000000 | 0.00566 (6) | |
| Mn6 | 0.40142 (3) | 0.54991 (3) | 0.000000 | 0.00543 (6) | |
| Mn7 | 0.59952 (3) | 0.02717 (2) | 0.000000 | 0.00573 (6) | |
| Co1 | 0.10096 (2) | 0.32409 (2) | 0.23463 (5) | 0.00405 (4) | |
| Co2 | 0.28931 (2) | 0.10233 (2) | 0.25377 (4) | 0.00490 (5) | 0.540 (7) |
| Ge22 | 0.28931 (2) | 0.10233 (2) | 0.25377 (4) | 0.00490 (5) | 0.460 (7) |
| Co3 | 0.41258 (2) | 0.39066 (2) | 0.24029 (4) | 0.00417 (4) | |
| Co4 | 0.19001 (3) | 0.00128 (2) | 0.000000 | 0.00458 (5) | |
| Co5 | 0.44448 (3) | 0.13683 (2) | 0.000000 | 0.00501 (5) | |
| Co6 | 0.69799 (3) | 0.29094 (2) | 0.000000 | 0.00482 (5) | |
| Ge1 | 0.50782 (2) | 0.28499 (2) | 0.000000 | 0.00489 (4) | |
| Ge2 | 0.75801 (2) | 0.14630 (2) | 0.000000 | 0.00472 (5) | |
| Ge3 | 0.000000 | 0.000000 | 0.000000 | 0.00474 (6) | |

*Atomic displacement parameters (Å$^2$)*

| | $U^{11}$ | $U^{22}$ | $U^{33}$ | $U^{12}$ | $U^{13}$ | $U^{23}$ |
|---|---|---|---|---|---|---|
| Mn1 | 0.00800 (13) | 0.00413 (12) | 0.00638 (12) | −0.00091 (10) | 0.000 | 0.000 |
| Mn2 | 0.00647 (12) | 0.00426 (12) | 0.00587 (12) | −0.00057 (9) | 0.000 | 0.000 |
| Mn3 | 0.00725 (13) | 0.00470 (12) | 0.00587 (12) | 0.00014 (9) | 0.000 | 0.000 |
| Mn4 | 0.00942 (13) | 0.00443 (12) | 0.00482 (12) | −0.00100 (10) | 0.000 | 0.000 |
| Mn5 | 0.00678 (12) | 0.00489 (12) | 0.00532 (12) | −0.00009 (10) | 0.000 | 0.000 |
| Mn6 | 0.00678 (12) | 0.00466 (12) | 0.00486 (12) | 0.00001 (9) | 0.000 | 0.000 |
| Mn7 | 0.00578 (12) | 0.00354 (12) | 0.00787 (13) | −0.00016 (9) | 0.000 | 0.000 |
| Co1 | 0.00550 (8) | 0.00446 (8) | 0.00218 (7) | −0.00012 (6) | 0.00007 (6) | 0.00049 (5) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Co2 | 0.00668 (8) | 0.00436 (8) | 0.00367 (8) | −0.00072 (5) | 0.00102 (5) | −0.00110 (5) |
| Ge22 | 0.00668 (8) | 0.00436 (8) | 0.00367 (8) | −0.00072 (5) | 0.00102 (5) | −0.00110 (5) |
| Co3 | 0.00642 (8) | 0.00375 (8) | 0.00233 (7) | 0.00010 (6) | 0.00082 (6) | −0.00088 (5) |
| Co4 | 0.00513 (11) | 0.00262 (10) | 0.00599 (11) | −0.00082 (8) | 0.000 | 0.000 |
| Co5 | 0.00484 (11) | 0.00480 (11) | 0.00539 (11) | −0.00129 (8) | 0.000 | 0.000 |
| Co6 | 0.00573 (11) | 0.00276 (10) | 0.00596 (11) | −0.00068 (8) | 0.000 | 0.000 |
| Ge1 | 0.00619 (9) | 0.00331 (9) | 0.00516 (9) | 0.00175 (7) | 0.000 | 0.000 |
| Ge2 | 0.00476 (9) | 0.00358 (9) | 0.00582 (9) | 0.00096 (7) | 0.000 | 0.000 |
| Ge3 | 0.00497 (12) | 0.00412 (12) | 0.00515 (12) | 0.00154 (9) | 0.000 | 0.000 |

*Geometric parameters (Å, º)*

| | | | |
|---|---|---|---|
| Mn1—Mn1$^{i}$ | 2.3329 (8) | Mn5—Co6$^{vii}$ | 2.7936 (3) |
| Mn1—Co1$^{ii}$ | 2.5613 (5) | Mn5—Co3$^{ix}$ | 2.8042 (5) |
| Mn1—Co1$^{i}$ | 2.5613 (5) | Mn5—Co3 | 2.8042 (5) |
| Mn1—Co5$^{iii}$ | 2.6523 (3) | Mn5—Ge2$^{vii}$ | 2.8157 (3) |
| Mn1—Co5$^{iv}$ | 2.6523 (3) | Mn5—Ge2$^{vi}$ | 2.8157 (3) |
| Mn1—Co2$^{v}$ | 2.6589 (5) | Mn5—Co2 | 2.8214 (5) |
| Mn1—Co2$^{iv}$ | 2.6589 (5) | Mn5—Co2$^{ix}$ | 2.8215 (5) |
| Mn1—Mn2 | 2.6611 (6) | Mn6—Co3$^{ix}$ | 2.7587 (5) |
| Mn1—Mn7$^{iv}$ | 2.9736 (4) | Mn6—Co3 | 2.7587 (5) |
| Mn1—Mn7$^{iii}$ | 2.9736 (4) | Mn6—Co3$^{xi}$ | 2.7800 (5) |
| Mn1—Mn7$^{vi}$ | 3.0135 (4) | Mn6—Co3$^{viii}$ | 2.7800 (5) |
| Mn1—Mn7$^{vii}$ | 3.0135 (4) | Mn6—Co4$^{iv}$ | 2.7848 (3) |
| Mn2—Ge2$^{viii}$ | 2.7233 (5) | Mn6—Co4$^{iii}$ | 2.7848 (3) |
| Mn2—Co6$^{viii}$ | 2.7587 (6) | Mn6—Co6$^{viii}$ | 2.7942 (6) |
| Mn2—Co3$^{v}$ | 2.7591 (5) | Mn6—Co2$^{iv}$ | 2.8084 (5) |
| Mn2—Co3$^{iv}$ | 2.7591 (5) | Mn6—Co2$^{v}$ | 2.8084 (5) |
| Mn2—Co1$^{i}$ | 2.7684 (5) | Mn6—Ge3$^{xii}$ | 2.8288 (3) |
| Mn2—Co1$^{ii}$ | 2.7684 (5) | Mn6—Ge3$^{xiii}$ | 2.8288 (3) |
| Mn2—Ge1$^{iv}$ | 2.8055 (3) | Mn7—Co5 | 2.6054 (5) |
| Mn2—Ge1$^{iii}$ | 2.8055 (3) | Mn7—Co5$^{xiv}$ | 2.6320 (6) |
| Mn2—Co2$^{iv}$ | 2.8597 (5) | Mn7—Mn7$^{xiv}$ | 2.6529 (8) |
| Mn2—Co2$^{v}$ | 2.8597 (5) | Mn7—Co1$^{xii}$ | 2.6628 (5) |
| Mn2—Mn3$^{i}$ | 2.8791 (6) | Mn7—Co1$^{xv}$ | 2.6628 (5) |
| Mn3—Co4 | 2.7484 (6) | Mn7—Co4$^{xiv}$ | 2.6935 (6) |
| Mn3—Co1$^{ix}$ | 2.7916 (5) | Mn7—Ge2 | 2.7374 (5) |
| Mn3—Co1 | 2.7916 (5) | Mn7—Co2$^{xiv}$ | 2.7570 (4) |
| Mn3—Co6$^{vii}$ | 2.8050 (3) | Mn7—Co2$^{xvi}$ | 2.7570 (4) |
| Mn3—Co6$^{vi}$ | 2.8050 (3) | Co1—Co1$^{ix}$ | 2.2683 (5) |
| Mn3—Mn5 | 2.8200 (6) | Co1—Ge2$^{vii}$ | 2.4063 (4) |
| Mn3—Co3$^{x}$ | 2.8207 (5) | Co1—Co5$^{vii}$ | 2.4334 (4) |
| Mn3—Co3$^{vii}$ | 2.8207 (5) | Co1—Ge1$^{vii}$ | 2.4404 (4) |
| Mn3—Ge1$^{vi}$ | 2.8209 (3) | Co1—Co6$^{vii}$ | 2.5301 (4) |
| Mn3—Ge1$^{vii}$ | 2.8209 (3) | Co1—Co1$^{xvii}$ | 2.5655 (5) |
| Mn3—Co2$^{ix}$ | 2.8211 (5) | Co2—Co6$^{vii}$ | 2.3555 (4) |
| Mn3—Co2 | 2.8211 (5) | Co2—Co4 | 2.3640 (4) |
| Mn4—Co1 | 2.6697 (5) | Co2—Co5 | 2.3733 (4) |

| | | | |
|---|---|---|---|
| Mn4—Co1$^{ix}$ | 2.6697 (5) | Co2—Co2$^{xvii}$ | 2.3805 (5) |
| Mn4—Co2$^{v}$ | 2.7533 (5) | Co2—Co2$^{ix}$ | 2.4533 (5) |
| Mn4—Co2$^{iv}$ | 2.7533 (5) | Co3—Co3$^{ix}$ | 2.3230 (5) |
| Mn4—Co4$^{iii}$ | 2.8124 (3) | Co3—Ge1 | 2.3541 (4) |
| Mn4—Co4$^{iv}$ | 2.8124 (3) | Co3—Ge2$^{vii}$ | 2.3913 (4) |
| Mn4—Co3$^{ix}$ | 2.8139 (5) | Co3—Ge3$^{xii}$ | 2.3949 (3) |
| Mn4—Co3 | 2.8140 (5) | Co3—Co4$^{iii}$ | 2.5028 (4) |
| Mn4—Mn6 | 2.8188 (6) | Co3—Co3$^{xvii}$ | 2.5108 (5) |
| Mn4—Ge2$^{vi}$ | 2.8429 (3) | Co4—Ge3 | 2.3982 (4) |
| Mn4—Ge2$^{vii}$ | 2.8429 (3) | Co4—Ge2$^{xiv}$ | 2.4063 (5) |
| Mn4—Mn7$^{vi}$ | 2.8953 (4) | Co5—Ge1 | 2.4579 (5) |
| Mn5—Co1 | 2.7527 (5) | Co6—Ge2 | 2.3922 (5) |
| Mn5—Co1$^{ix}$ | 2.7528 (5) | Co6—Ge1 | 2.4020 (5) |
| Mn5—Co6$^{vi}$ | 2.7936 (3) | | |

| | | | |
|---|---|---|---|
| Mn1$^{i}$—Mn1—Co1$^{ii}$ | 115.84 (2) | Co1$^{xvii}$—Co1—Mn3 | 113.971 (6) |
| Mn1$^{i}$—Mn1—Co1$^{i}$ | 115.84 (2) | Mn7$^{vii}$—Co1—Mn3 | 175.170 (11) |
| Co1$^{ii}$—Mn1—Co1$^{i}$ | 52.568 (14) | Mn4—Co1—Mn3 | 118.049 (13) |
| Mn1$^{i}$—Mn1—Co5$^{iii}$ | 114.282 (11) | Mn5—Co1—Mn3 | 61.140 (12) |
| Co1$^{ii}$—Mn1—Co5$^{iii}$ | 55.612 (11) | Mn2$^{i}$—Co1—Mn3 | 62.370 (12) |
| Co1$^{i}$—Mn1—Co5$^{iii}$ | 104.019 (17) | Co6$^{vii}$—Co2—Co4 | 118.654 (16) |
| Mn1$^{i}$—Mn1—Co5$^{iv}$ | 114.282 (11) | Co6$^{vii}$—Co2—Co5 | 120.187 (15) |
| Co1$^{ii}$—Mn1—Co5$^{iv}$ | 104.019 (17) | Co4—Co2—Co5 | 108.793 (13) |
| Co1$^{i}$—Mn1—Co5$^{iv}$ | 55.612 (11) | Co6$^{vii}$—Co2—Co2$^{xvii}$ | 59.648 (7) |
| Co5$^{iii}$—Mn1—Co5$^{iv}$ | 131.36 (2) | Co4—Co2—Co2$^{xvii}$ | 121.257 (7) |
| Mn1$^{i}$—Mn1—Co2$^{v}$ | 115.13 (2) | Co5—Co2—Co2$^{xvii}$ | 121.122 (7) |
| Co1$^{ii}$—Mn1—Co2$^{v}$ | 103.485 (13) | Co6$^{vii}$—Co2—Co2$^{ix}$ | 120.352 (7) |
| Co1$^{i}$—Mn1—Co2$^{v}$ | 129.023 (18) | Co4—Co2—Co2$^{ix}$ | 58.742 (7) |
| Co5$^{iii}$—Mn1—Co2$^{v}$ | 53.085 (10) | Co5—Co2—Co2$^{ix}$ | 58.880 (7) |
| Co5$^{iv}$—Mn1—Co2$^{v}$ | 102.427 (16) | Co2$^{xvii}$—Co2—Co2$^{ix}$ | 180.0 |
| Mn1$^{i}$—Mn1—Co2$^{iv}$ | 115.13 (2) | Co6$^{vii}$—Co2—Mn1$^{xix}$ | 109.407 (13) |
| Co1$^{ii}$—Mn1—Co2$^{iv}$ | 129.023 (18) | Co4—Co2—Mn1$^{xix}$ | 124.986 (15) |
| Co1$^{i}$—Mn1—Co2$^{iv}$ | 103.485 (13) | Co5—Co2—Mn1$^{xix}$ | 63.317 (11) |
| Co5$^{iii}$—Mn1—Co2$^{iv}$ | 102.427 (16) | Co2$^{xvii}$—Co2—Mn1$^{xix}$ | 63.407 (6) |
| Co5$^{iv}$—Mn1—Co2$^{iv}$ | 53.085 (10) | Co2$^{ix}$—Co2—Mn1$^{xix}$ | 116.594 (7) |
| Co2$^{v}$—Mn1—Co2$^{iv}$ | 53.185 (13) | Co6$^{vii}$—Co2—Mn4$^{xix}$ | 113.523 (13) |
| Mn1$^{i}$—Mn1—Mn2 | 179.81 (3) | Co4—Co2—Mn4$^{xix}$ | 66.167 (11) |
| Co1$^{ii}$—Mn1—Mn2 | 63.992 (14) | Co5—Co2—Mn4$^{xix}$ | 117.828 (15) |
| Co1$^{i}$—Mn1—Mn2 | 63.992 (14) | Co2$^{xvii}$—Co2—Mn4$^{xix}$ | 64.386 (6) |
| Co5$^{iii}$—Mn1—Mn2 | 65.723 (11) | Co2$^{ix}$—Co2—Mn4$^{xix}$ | 115.613 (6) |
| Co5$^{iv}$—Mn1—Mn2 | 65.723 (11) | Mn1$^{xix}$—Co2—Mn4$^{xix}$ | 71.448 (13) |
| Co2$^{v}$—Mn1—Mn2 | 65.031 (13) | Co6$^{vii}$—Co2—Mn7$^{xiv}$ | 176.066 (11) |
| Co2$^{iv}$—Mn1—Mn2 | 65.031 (13) | Co4—Co2—Mn7$^{xiv}$ | 62.915 (13) |
| Mn1$^{i}$—Mn1—Mn7$^{iv}$ | 67.972 (13) | Co5—Co2—Mn7$^{xiv}$ | 61.194 (13) |
| Co1$^{ii}$—Mn1—Mn7$^{iv}$ | 100.030 (16) | Co2$^{xvii}$—Co2—Mn7$^{xiv}$ | 116.419 (6) |
| Co1$^{i}$—Mn1—Mn7$^{iv}$ | 56.928 (12) | Co2$^{ix}$—Co2—Mn7$^{xiv}$ | 63.582 (6) |
| Co5$^{iii}$—Mn1—Mn7$^{iv}$ | 154.839 (19) | Mn1$^{xix}$—Co2—Mn7$^{xiv}$ | 67.589 (11) |
| Co5$^{iv}$—Mn1—Mn7$^{iv}$ | 54.816 (11) | Mn4$^{xix}$—Co2—Mn7$^{xiv}$ | 63.395 (11) |

| | |
|---|---|
| $Co2^{v}$—Mn1—$Mn7^{iv}$ | 150.915 (13) |
| $Co2^{iv}$—Mn1—$Mn7^{iv}$ | 98.408 (11) |
| Mn2—Mn1—$Mn7^{iv}$ | 111.936 (13) |
| $Mn1^{i}$—Mn1—$Mn7^{iii}$ | 67.972 (13) |
| $Co1^{ii}$—Mn1—$Mn7^{iii}$ | 56.928 (11) |
| $Co1^{i}$—Mn1—$Mn7^{iii}$ | 100.030 (16) |
| $Co5^{iii}$—Mn1—$Mn7^{iii}$ | 54.816 (11) |
| $Co5^{iv}$—Mn1—$Mn7^{iii}$ | 154.839 (19) |
| $Co2^{v}$—Mn1—$Mn7^{iii}$ | 98.408 (10) |
| $Co2^{iv}$—Mn1—$Mn7^{iii}$ | 150.915 (13) |
| Mn2—Mn1—$Mn7^{iii}$ | 111.936 (13) |
| $Mn7^{iv}$—Mn1—$Mn7^{iii}$ | 108.741 (19) |
| $Mn1^{i}$—Mn1—$Mn7^{vi}$ | 66.167 (13) |
| $Co1^{ii}$—Mn1—$Mn7^{vi}$ | 151.155 (14) |
| $Co1^{i}$—Mn1—$Mn7^{vi}$ | 99.533 (11) |
| $Co5^{iii}$—Mn1—$Mn7^{vi}$ | 152.489 (19) |
| $Co5^{iv}$—Mn1—$Mn7^{vi}$ | 54.916 (12) |
| $Co2^{v}$—Mn1—$Mn7^{vi}$ | 100.633 (16) |
| $Co2^{iv}$—Mn1—$Mn7^{vi}$ | 57.756 (11) |
| Mn2—Mn1—$Mn7^{vi}$ | 113.924 (13) |
| $Mn7^{iv}$—Mn1—$Mn7^{vi}$ | 52.600 (14) |
| $Mn7^{iii}$—Mn1—$Mn7^{vi}$ | 134.139 (15) |
| $Mn1^{i}$—Mn1—$Mn7^{vii}$ | 66.167 (13) |
| $Co1^{ii}$—Mn1—$Mn7^{vii}$ | 99.533 (11) |
| $Co1^{i}$—Mn1—$Mn7^{vii}$ | 151.155 (14) |
| $Co5^{iii}$—Mn1—$Mn7^{vii}$ | 54.916 (12) |
| $Co5^{iv}$—Mn1—$Mn7^{vii}$ | 152.489 (19) |
| $Co2^{v}$—Mn1—$Mn7^{vii}$ | 57.756 (10) |
| $Co2^{iv}$—Mn1—$Mn7^{vii}$ | 100.633 (16) |
| Mn2—Mn1—$Mn7^{vii}$ | 113.924 (13) |
| $Mn7^{iv}$—Mn1—$Mn7^{vii}$ | 134.139 (15) |
| $Mn7^{iii}$—Mn1—$Mn7^{vii}$ | 52.600 (14) |
| $Mn7^{vi}$—Mn1—$Mn7^{vii}$ | 106.649 (18) |
| Mn1—Mn2—$Ge2^{viii}$ | 149.91 (2) |
| Mn1—Mn2—$Co6^{viii}$ | 98.174 (17) |
| $Ge2^{viii}$—Mn2—$Co6^{viii}$ | 51.739 (13) |
| Mn1—Mn2—$Co3^{v}$ | 148.954 (11) |
| $Ge2^{viii}$—Mn2—$Co3^{v}$ | 51.714 (10) |
| $Co6^{viii}$—Mn2—$Co3^{v}$ | 96.807 (14) |
| Mn1—Mn2—$Co3^{iv}$ | 148.954 (11) |
| $Ge2^{viii}$—Mn2—$Co3^{iv}$ | 51.714 (10) |
| $Co6^{viii}$—Mn2—$Co3^{iv}$ | 96.807 (14) |
| $Co3^{v}$—Mn2—$Co3^{iv}$ | 54.130 (13) |
| Mn1—Mn2—$Co1^{i}$ | 56.251 (12) |
| $Ge2^{viii}$—Mn2—$Co1^{i}$ | 147.504 (13) |
| $Co6^{viii}$—Mn2—$Co1^{i}$ | 142.672 (14) |
| $Co3^{v}$—Mn2—$Co1^{i}$ | 119.124 (16) |
| $Co3^{iv}$—Mn2—$Co1^{i}$ | 96.540 (12) |
| $Co6^{vii}$—Co2—$Mn6^{xix}$ | 64.825 (13) |
| Co4—Co2—$Mn6^{xix}$ | 64.480 (11) |
| Co5—Co2—$Mn6^{xix}$ | 173.246 (12) |
| $Co2^{xvii}$—Co2—$Mn6^{xix}$ | 64.924 (6) |
| $Co2^{ix}$—Co2—$Mn6^{xix}$ | 115.074 (6) |
| $Mn1^{xix}$—Co2—$Mn6^{xix}$ | 120.451 (12) |
| $Mn4^{xix}$—Co2—$Mn6^{xix}$ | 60.894 (13) |
| $Mn7^{xiv}$—Co2—$Mn6^{xix}$ | 114.139 (14) |
| $Co6^{vii}$—Co2—Mn3 | 64.894 (11) |
| Co4—Co2—Mn3 | 63.297 (13) |
| Co5—Co2—Mn3 | 113.076 (13) |
| $Co2^{xvii}$—Co2—Mn3 | 115.773 (6) |
| $Co2^{ix}$—Co2—Mn3 | 64.226 (6) |
| $Mn1^{xix}$—Co2—Mn3 | 171.344 (15) |
| $Mn4^{xix}$—Co2—Mn3 | 116.462 (14) |
| $Mn7^{xiv}$—Co2—Mn3 | 118.397 (12) |
| $Mn6^{xix}$—Co2—Mn3 | 64.032 (12) |
| $Co6^{vii}$—Co2—Mn5 | 64.585 (11) |
| Co4—Co2—Mn5 | 111.630 (13) |
| Co5—Co2—Mn5 | 65.478 (12) |
| $Co2^{xvii}$—Co2—Mn5 | 115.771 (6) |
| $Co2^{ix}$—Co2—Mn5 | 64.230 (6) |
| $Mn1^{xix}$—Co2—Mn5 | 112.053 (14) |
| $Mn4^{xix}$—Co2—Mn5 | 176.316 (15) |
| $Mn7^{xiv}$—Co2—Mn5 | 118.640 (12) |
| $Mn6^{xix}$—Co2—Mn5 | 115.617 (14) |
| Mn3—Co2—Mn5 | 59.970 (12) |
| $Co6^{vii}$—Co2—$Mn2^{xix}$ | 63.005 (14) |
| Co4—Co2—$Mn2^{xix}$ | 173.286 (11) |
| Co5—Co2—$Mn2^{xix}$ | 66.106 (11) |
| $Co2^{xvii}$—Co2—$Mn2^{xix}$ | 65.404 (6) |
| $Co2^{ix}$—Co2—$Mn2^{xix}$ | 114.597 (6) |
| $Mn1^{xix}$—Co2—$Mn2^{xix}$ | 57.522 (13) |
| $Mn4^{xix}$—Co2—$Mn2^{xix}$ | 119.753 (12) |
| $Mn7^{xiv}$—Co2—$Mn2^{xix}$ | 115.902 (15) |
| $Mn6^{xix}$—Co2—$Mn2^{xix}$ | 120.547 (11) |
| Mn3—Co2—$Mn2^{xix}$ | 113.947 (14) |
| Mn5—Co2—$Mn2^{xix}$ | 62.636 (11) |
| $Co3^{ix}$—Co3—Ge1 | 60.437 (7) |
| $Co3^{ix}$—Co3—$Ge2^{vii}$ | 121.667 (7) |
| Ge1—Co3—$Ge2^{vii}$ | 120.316 (14) |
| $Co3^{ix}$—Co3—$Ge3^{xii}$ | 121.615 (6) |
| Ge1—Co3—$Ge3^{xii}$ | 121.858 (14) |
| $Ge2^{vii}$—Co3—$Ge3^{xii}$ | 105.921 (11) |
| $Co3^{ix}$—Co3—$Co4^{iii}$ | 120.106 (7) |
| Ge1—Co3—$Co4^{iii}$ | 179.127 (14) |
| $Ge2^{vii}$—Co3—$Co4^{iii}$ | 58.850 (12) |
| $Ge3^{xii}$—Co3—$Co4^{iii}$ | 58.587 (10) |

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| Mn1—Mn2—Co1$^{ii}$ | 56.251 (12) | Co3$^{ix}$—Co3—Co3$^{xvii}$ | 180.0 |
| Ge2$^{viii}$—Mn2—Co1$^{ii}$ | 147.504 (13) | Ge1—Co3—Co3$^{xvii}$ | 119.564 (7) |
| Co6$^{viii}$—Mn2—Co1$^{ii}$ | 142.672 (14) | Ge2$^{vii}$—Co3—Co3$^{xvii}$ | 58.331 (7) |
| Co3$^{v}$—Mn2—Co1$^{ii}$ | 96.540 (12) | Ge3$^{xii}$—Co3—Co3$^{xvii}$ | 58.385 (6) |
| Co3$^{iv}$—Mn2—Co1$^{ii}$ | 119.124 (16) | Co4$^{iii}$—Co3—Co3$^{xvii}$ | 59.893 (7) |
| Co1$^{i}$—Mn2—Co1$^{ii}$ | 48.370 (13) | Co3$^{ix}$—Co3—Mn6 | 65.100 (7) |
| Mn1—Mn2—Ge1$^{iv}$ | 98.916 (12) | Ge1—Co3—Mn6 | 117.135 (12) |
| Ge2$^{viii}$—Mn2—Ge1$^{iv}$ | 96.218 (11) | Ge2$^{vii}$—Co3—Mn6 | 113.515 (14) |
| Co6$^{viii}$—Mn2—Ge1$^{iv}$ | 117.169 (10) | Ge3$^{xii}$—Co3—Mn6 | 66.147 (10) |
| Co3$^{v}$—Mn2—Ge1$^{iv}$ | 98.151 (14) | Co4$^{iii}$—Co3—Mn6 | 63.697 (11) |
| Co3$^{iv}$—Mn2—Ge1$^{iv}$ | 50.046 (9) | Co3$^{xvii}$—Co3—Mn6 | 114.899 (7) |
| Co1$^{i}$—Mn2—Ge1$^{iv}$ | 51.924 (9) | Co3$^{ix}$—Co3—Mn2$^{xix}$ | 117.066 (7) |
| Co1$^{ii}$—Mn2—Ge1$^{iv}$ | 95.115 (15) | Ge1—Co3—Mn2$^{xix}$ | 66.001 (11) |
| Mn1—Mn2—Ge1$^{iii}$ | 98.916 (12) | Ge2$^{vii}$—Co3—Mn2$^{xix}$ | 63.373 (12) |
| Ge2$^{viii}$—Mn2—Ge1$^{iii}$ | 96.218 (11) | Ge3$^{xii}$—Co3—Mn2$^{xix}$ | 113.298 (12) |
| Co6$^{viii}$—Mn2—Ge1$^{iii}$ | 117.169 (10) | Co4$^{iii}$—Co3—Mn2$^{xix}$ | 113.163 (13) |
| Co3$^{v}$—Mn2—Ge1$^{iii}$ | 50.046 (9) | Co3$^{xvii}$—Co3—Mn2$^{xix}$ | 62.935 (7) |
| Co3$^{iv}$—Mn2—Ge1$^{iii}$ | 98.151 (14) | Mn6—Co3—Mn2$^{xix}$ | 176.744 (13) |
| Co1$^{i}$—Mn2—Ge1$^{iii}$ | 95.115 (15) | Co3$^{ix}$—Co3—Mn6$^{viii}$ | 65.305 (6) |
| Co1$^{ii}$—Mn2—Ge1$^{iii}$ | 51.924 (9) | Ge1—Co3—Mn6$^{viii}$ | 66.354 (13) |
| Ge1$^{iv}$—Mn2—Ge1$^{iii}$ | 118.966 (19) | Ge2$^{vii}$—Co3—Mn6$^{viii}$ | 171.704 (12) |
| Mn1—Mn2—Co2$^{iv}$ | 57.446 (13) | Ge3$^{xii}$—Co3—Mn6$^{viii}$ | 65.785 (10) |
| Ge2$^{viii}$—Mn2—Co2$^{iv}$ | 95.632 (15) | Co4$^{iii}$—Co3—Mn6$^{viii}$ | 114.451 (15) |
| Co6$^{viii}$—Mn2—Co2$^{iv}$ | 49.533 (10) | Co3$^{xvii}$—Co3—Mn6$^{viii}$ | 114.696 (7) |
| Co3$^{v}$—Mn2—Co2$^{iv}$ | 145.929 (17) | Mn6—Co3—Mn6$^{viii}$ | 64.120 (15) |
| Co3$^{iv}$—Mn2—Co2$^{iv}$ | 116.717 (12) | Mn2$^{xix}$—Co3—Mn6$^{viii}$ | 118.807 (14) |
| Co1$^{i}$—Mn2—Co2$^{iv}$ | 93.490 (13) | Co3$^{ix}$—Co3—Mn5 | 65.531 (6) |
| Co1$^{ii}$—Mn2—Co2$^{iv}$ | 113.697 (16) | Ge1—Co3—Mn5 | 65.811 (13) |
| Ge1$^{iv}$—Mn2—Co2$^{iv}$ | 94.547 (10) | Ge2$^{vii}$—Co3—Mn5 | 65.067 (10) |
| Ge1$^{iii}$—Mn2—Co2$^{iv}$ | 142.787 (13) | Ge3$^{xii}$—Co3—Mn5 | 170.964 (12) |
| Mn1—Mn2—Co2$^{v}$ | 57.446 (13) | Co4$^{iii}$—Co3—Mn5 | 113.676 (16) |
| Ge2$^{viii}$—Mn2—Co2$^{v}$ | 95.632 (16) | Co3$^{xvii}$—Co3—Mn5 | 114.469 (6) |
| Co6$^{viii}$—Mn2—Co2$^{v}$ | 49.533 (10) | Mn6—Co3—Mn5 | 115.895 (13) |
| Co3$^{v}$—Mn2—Co2$^{v}$ | 116.717 (12) | Mn2$^{xix}$—Co3—Mn5 | 64.117 (11) |
| Co3$^{iv}$—Mn2—Co2$^{v}$ | 145.929 (17) | Mn6$^{viii}$—Co3—Mn5 | 123.228 (12) |
| Co1$^{i}$—Mn2—Co2$^{v}$ | 113.697 (16) | Co3$^{ix}$—Co3—Mn4 | 65.621 (6) |
| Co1$^{ii}$—Mn2—Co2$^{v}$ | 93.490 (13) | Ge1—Co3—Mn4 | 116.495 (12) |
| Ge1$^{iv}$—Mn2—Co2$^{v}$ | 142.787 (13) | Ge2$^{vii}$—Co3—Mn4 | 65.622 (11) |
| Ge1$^{iii}$—Mn2—Co2$^{v}$ | 94.547 (10) | Ge3$^{xii}$—Co3—Mn4 | 113.493 (12) |
| Co2$^{iv}$—Mn2—Co2$^{v}$ | 49.192 (12) | Co4$^{iii}$—Co3—Mn4 | 63.555 (11) |
| Mn1—Mn2—Mn3$^{i}$ | 108.343 (19) | Co3$^{xvii}$—Co3—Mn4 | 114.378 (6) |
| Ge2$^{viii}$—Mn2—Mn3$^{i}$ | 101.744 (18) | Mn6—Co3—Mn4 | 60.763 (12) |
| Co6$^{viii}$—Mn2—Mn3$^{i}$ | 153.483 (19) | Mn2$^{xix}$—Co3—Mn4 | 117.449 (14) |
| Co3$^{v}$—Mn2—Mn3$^{i}$ | 59.994 (12) | Mn6$^{viii}$—Co3—Mn4 | 116.988 (13) |
| Co3$^{iv}$—Mn2—Mn3$^{i}$ | 59.994 (12) | Mn5—Co3—Mn4 | 63.085 (14) |
| Co1$^{i}$—Mn2—Mn3$^{i}$ | 59.207 (13) | Co3$^{ix}$—Co3—Mn3$^{xii}$ | 116.428 (6) |
| Co1$^{ii}$—Mn2—Mn3$^{i}$ | 59.207 (13) | Ge1—Co3—Mn3$^{xii}$ | 65.340 (11) |
| Ge1$^{iv}$—Mn2—Mn3$^{i}$ | 59.485 (9) | Ge2$^{vii}$—Co3—Mn3$^{xii}$ | 112.779 (12) |

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| Ge1$^{iii}$—Mn2—Mn3$^{i}$ | 59.485 (9) | Ge3$^{xii}$—Co3—Mn3$^{xii}$ | 65.429 (11) |
| Co2$^{iv}$—Mn2—Mn3$^{i}$ | 149.889 (11) | Co4$^{iii}$—Co3—Mn3$^{xii}$ | 114.595 (12) |
| Co2$^{v}$—Mn2—Mn3$^{i}$ | 149.889 (11) | Co3$^{xvii}$—Co3—Mn3$^{xii}$ | 63.573 (6) |
| Co4—Mn3—Co1$^{ix}$ | 146.871 (13) | Mn6—Co3—Mn3$^{xii}$ | 119.562 (14) |
| Co4—Mn3—Co1 | 146.871 (13) | Mn2$^{xix}$—Co3—Mn3$^{xii}$ | 62.115 (12) |
| Co1$^{ix}$—Mn3—Co1 | 47.944 (13) | Mn6$^{viii}$—Co3—Mn3$^{xii}$ | 64.396 (12) |
| Co4—Mn3—Co6$^{vii}$ | 93.926 (12) | Mn5—Co3—Mn3$^{xii}$ | 117.693 (14) |
| Co1$^{ix}$—Mn3—Co6$^{vii}$ | 96.253 (15) | Mn4—Co3—Mn3$^{xii}$ | 177.938 (10) |
| Co1—Mn3—Co6$^{vii}$ | 53.755 (10) | Co2$^{ix}$—Co4—Co2 | 62.515 (14) |
| Co4—Mn3—Co6$^{vi}$ | 93.926 (12) | Co2$^{ix}$—Co4—Ge3 | 122.390 (13) |
| Co1$^{ix}$—Mn3—Co6$^{vi}$ | 53.755 (10) | Co2—Co4—Ge3 | 122.390 (13) |
| Co1—Mn3—Co6$^{vi}$ | 96.252 (15) | Co2$^{ix}$—Co4—Ge2$^{xiv}$ | 120.047 (15) |
| Co6$^{vii}$—Mn3—Co6$^{vi}$ | 119.00 (2) | Co2—Co4—Ge2$^{xiv}$ | 120.047 (15) |
| Co4—Mn3—Mn5 | 101.011 (17) | Ge3—Co4—Ge2$^{xiv}$ | 105.342 (14) |
| Co1$^{ix}$—Mn3—Mn5 | 58.751 (12) | Co2$^{ix}$—Co4—Co3$^{xviii}$ | 118.617 (9) |
| Co1—Mn3—Mn5 | 58.750 (12) | Co2—Co4—Co3$^{xviii}$ | 178.209 (15) |
| Co6$^{vii}$—Mn3—Mn5 | 59.556 (10) | Ge3—Co4—Co3$^{xviii}$ | 58.458 (10) |
| Co6$^{vi}$—Mn3—Mn5 | 59.556 (10) | Ge2$^{xiv}$—Co4—Co3$^{xviii}$ | 58.262 (11) |
| Co4—Mn3—Co3$^{x}$ | 94.438 (14) | Co2$^{ix}$—Co4—Co3$^{xx}$ | 178.209 (15) |
| Co1$^{ix}$—Mn3—Co3$^{x}$ | 94.616 (12) | Co2—Co4—Co3$^{xx}$ | 118.618 (10) |
| Co1—Mn3—Co3$^{x}$ | 116.241 (15) | Ge3—Co4—Co3$^{xx}$ | 58.458 (10) |
| Co6$^{vii}$—Mn3—Co3$^{x}$ | 145.774 (13) | Ge2$^{xiv}$—Co4—Co3$^{xx}$ | 58.262 (11) |
| Co6$^{vi}$—Mn3—Co3$^{x}$ | 93.431 (11) | Co3$^{xviii}$—Co4—Co3$^{xx}$ | 60.213 (14) |
| Mn5—Mn3—Co3$^{x}$ | 149.423 (11) | Co2$^{ix}$—Co4—Mn7$^{xiv}$ | 65.692 (13) |
| Co4—Mn3—Co3$^{vii}$ | 94.438 (14) | Co2—Co4—Mn7$^{xiv}$ | 65.691 (12) |
| Co1$^{ix}$—Mn3—Co3$^{vii}$ | 116.240 (15) | Ge3—Co4—Mn7$^{xiv}$ | 169.984 (17) |
| Co1—Mn3—Co3$^{vii}$ | 94.617 (12) | Ge2$^{xiv}$—Co4—Mn7$^{xiv}$ | 64.642 (13) |
| Co6$^{vii}$—Mn3—Co3$^{vii}$ | 93.431 (11) | Co3$^{xviii}$—Co4—Mn7$^{xiv}$ | 113.286 (15) |
| Co6$^{vi}$—Mn3—Co3$^{vii}$ | 145.774 (13) | Co3$^{xx}$—Co4—Mn7$^{xiv}$ | 113.286 (15) |
| Mn5—Mn3—Co3$^{vii}$ | 149.423 (11) | Co2$^{ix}$—Co4—Mn3 | 66.490 (13) |
| Co3$^{x}$—Mn3—Co3$^{vii}$ | 52.855 (13) | Co2—Co4—Mn3 | 66.490 (13) |
| Co4—Mn3—Ge1$^{vi}$ | 116.264 (10) | Ge3—Co4—Mn3 | 66.620 (12) |
| Co1$^{ix}$—Mn3—Ge1$^{vi}$ | 51.544 (9) | Ge2$^{xiv}$—Co4—Mn3 | 171.962 (18) |
| Co1—Mn3—Ge1$^{vi}$ | 94.261 (14) | Co3$^{xviii}$—Co4—Mn3 | 115.140 (15) |
| Co6$^{vii}$—Mn3—Ge1$^{vi}$ | 147.255 (18) | Co3$^{xx}$—Co4—Mn3 | 115.140 (15) |
| Co6$^{vi}$—Mn3—Ge1$^{vi}$ | 50.549 (11) | Mn7$^{xiv}$—Co4—Mn3 | 123.397 (17) |
| Mn5—Mn3—Ge1$^{vi}$ | 100.099 (12) | Co2$^{ix}$—Co4—Mn6$^{xviii}$ | 65.517 (11) |
| Co3$^{x}$—Mn3—Ge1$^{vi}$ | 49.326 (9) | Co2—Co4—Mn6$^{xviii}$ | 119.095 (16) |
| Co3$^{vii}$—Mn3—Ge1$^{vi}$ | 96.367 (14) | Ge3—Co4—Mn6$^{xviii}$ | 65.665 (10) |
| Co4—Mn3—Ge1$^{vii}$ | 116.264 (10) | Ge2$^{xiv}$—Co4—Mn6$^{xviii}$ | 112.122 (11) |
| Co1$^{ix}$—Mn3—Ge1$^{vii}$ | 94.261 (14) | Co3$^{xviii}$—Co4—Mn6$^{xviii}$ | 62.629 (12) |
| Co1—Mn3—Ge1$^{vii}$ | 51.545 (9) | Co3$^{xx}$—Co4—Mn6$^{xviii}$ | 114.263 (16) |
| Co6$^{vii}$—Mn3—Ge1$^{vii}$ | 50.549 (11) | Mn7$^{xiv}$—Co4—Mn6$^{xviii}$ | 117.004 (10) |
| Co6$^{vi}$—Mn3—Ge1$^{vii}$ | 147.255 (18) | Mn3—Co4—Mn6$^{xviii}$ | 65.280 (10) |
| Mn5—Mn3—Ge1$^{vii}$ | 100.099 (12) | Co2$^{ix}$—Co4—Mn6$^{xix}$ | 119.095 (16) |
| Co3$^{x}$—Mn3—Ge1$^{vii}$ | 96.367 (15) | Co2—Co4—Mn6$^{xix}$ | 65.518 (11) |
| Co3$^{vii}$—Mn3—Ge1$^{vii}$ | 49.326 (9) | Ge3—Co4—Mn6$^{xix}$ | 65.665 (10) |
| Ge1$^{vi}$—Mn3—Ge1$^{vii}$ | 117.917 (18) | Ge2$^{xiv}$—Co4—Mn6$^{xix}$ | 112.122 (11) |

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| Co4—Mn3—Co2$^{ix}$ | 50.212 (10) | Co3$^{xviii}$—Co4—Mn6$^{xix}$ | 114.263 (15) |
| Co1$^{ix}$—Mn3—Co2$^{ix}$ | 97.335 (12) | Co3$^{xx}$—Co4—Mn6$^{xix}$ | 62.629 (12) |
| Co1—Mn3—Co2$^{ix}$ | 118.750 (15) | Mn7$^{xiv}$—Co4—Mn6$^{xix}$ | 117.004 (10) |
| Co6$^{vii}$—Mn3—Co2$^{ix}$ | 95.732 (15) | Mn3—Co4—Mn6$^{xix}$ | 65.280 (10) |
| Co6$^{vi}$—Mn3—Co2$^{ix}$ | 49.500 (9) | Mn6$^{xviii}$—Co4—Mn6$^{xix}$ | 120.427 (19) |
| Mn5—Mn3—Co2$^{ix}$ | 60.022 (12) | Co2$^{ix}$—Co4—Mn4$^{xix}$ | 116.542 (16) |
| Co3$^{x}$—Mn3—Co2$^{ix}$ | 114.912 (12) | Co2—Co4—Mn4$^{xix}$ | 63.576 (12) |
| Co3$^{vii}$—Mn3—Co2$^{ix}$ | 143.927 (17) | Ge3—Co4—Mn4$^{xix}$ | 113.441 (11) |
| Ge1$^{vi}$—Mn3—Co2$^{ix}$ | 94.494 (9) | Ge2$^{xiv}$—Co4—Mn4$^{xix}$ | 65.478 (10) |
| Ge1$^{vii}$—Mn3—Co2$^{ix}$ | 145.433 (13) | Co3$^{xviii}$—Co4—Mn4$^{xix}$ | 114.698 (16) |
| Co4—Mn3—Co2 | 50.213 (10) | Co3$^{xx}$—Co4—Mn4$^{xix}$ | 63.620 (12) |
| Co1$^{ix}$—Mn3—Co2 | 118.750 (15) | Mn7$^{xiv}$—Co4—Mn4$^{xix}$ | 63.409 (11) |
| Co1—Mn3—Co2 | 97.334 (12) | Mn3—Co4—Mn4$^{xix}$ | 116.919 (10) |
| Co6$^{vii}$—Mn3—Co2 | 49.500 (9) | Mn6$^{xviii}$—Co4—Mn4$^{xix}$ | 177.315 (17) |
| Co6$^{vi}$—Mn3—Co2 | 95.732 (15) | Mn6$^{xix}$—Co4—Mn4$^{xix}$ | 60.475 (12) |
| Mn5—Mn3—Co2 | 60.021 (12) | Co2—Co5—Co2$^{ix}$ | 62.242 (15) |
| Co3$^{x}$—Mn3—Co2 | 143.928 (17) | Co2—Co5—Co1$^{xii}$ | 117.043 (10) |
| Co3$^{vii}$—Mn3—Co2 | 114.913 (12) | Co2$^{ix}$—Co5—Co1$^{xii}$ | 178.316 (18) |
| Ge1$^{vi}$—Mn3—Co2 | 145.433 (13) | Co2—Co5—Co1$^{xv}$ | 178.316 (18) |
| Ge1$^{vii}$—Mn3—Co2 | 94.495 (9) | Co2$^{ix}$—Co5—Co1$^{xv}$ | 117.043 (10) |
| Co2$^{ix}$—Mn3—Co2 | 51.548 (13) | Co1$^{xii}$—Co5—Co1$^{xv}$ | 63.625 (15) |
| Co1—Mn4—Co1$^{ix}$ | 50.280 (14) | Co2—Co5—Ge1 | 118.946 (14) |
| Co1—Mn4—Co2$^{v}$ | 115.231 (13) | Co2$^{ix}$—Co5—Ge1 | 118.946 (14) |
| Co1$^{ix}$—Mn4—Co2$^{v}$ | 142.520 (19) | Co1$^{xii}$—Co5—Ge1 | 59.854 (11) |
| Co1—Mn4—Co2$^{iv}$ | 142.521 (19) | Co1$^{xv}$—Co5—Ge1 | 59.854 (11) |
| Co1$^{ix}$—Mn4—Co2$^{iv}$ | 115.231 (13) | Co2—Co5—Mn7 | 117.980 (16) |
| Co2$^{v}$—Mn4—Co2$^{iv}$ | 51.226 (13) | Co2$^{ix}$—Co5—Mn7 | 117.980 (15) |
| Co1—Mn4—Co4$^{iii}$ | 94.947 (10) | Co1$^{xii}$—Co5—Mn7 | 63.695 (13) |
| Co1$^{ix}$—Mn4—Co4$^{iii}$ | 144.729 (13) | Co1$^{xv}$—Co5—Mn7 | 63.695 (13) |
| Co2$^{v}$—Mn4—Co4$^{iii}$ | 50.256 (9) | Ge1—Co5—Mn7 | 112.341 (18) |
| Co2$^{iv}$—Mn4—Co4$^{iii}$ | 95.949 (15) | Co2—Co5—Mn7$^{xiv}$ | 66.610 (12) |
| Co1—Mn4—Co4$^{iv}$ | 144.729 (13) | Co2$^{ix}$—Co5—Mn7$^{xiv}$ | 66.610 (12) |
| Co1$^{ix}$—Mn4—Co4$^{iv}$ | 94.948 (10) | Co1$^{xii}$—Co5—Mn7$^{xiv}$ | 114.678 (15) |
| Co2$^{v}$—Mn4—Co4$^{iv}$ | 95.949 (15) | Co1$^{xv}$—Co5—Mn7$^{xiv}$ | 114.678 (15) |
| Co2$^{iv}$—Mn4—Co4$^{iv}$ | 50.256 (9) | Ge1—Co5—Mn7$^{xiv}$ | 173.201 (19) |
| Co4$^{iii}$—Mn4—Co4$^{iv}$ | 118.49 (2) | Mn7—Co5—Mn7$^{xiv}$ | 60.861 (17) |
| Co1—Mn4—Co3$^{ix}$ | 116.840 (16) | Co2—Co5—Mn1$^{xviii}$ | 119.820 (16) |
| Co1$^{ix}$—Mn4—Co3$^{ix}$ | 95.785 (13) | Co2$^{ix}$—Co5—Mn1$^{xviii}$ | 63.598 (12) |
| Co2$^{v}$—Mn4—Co3$^{ix}$ | 119.162 (16) | Co1$^{xii}$—Co5—Mn1$^{xviii}$ | 117.724 (17) |
| Co2$^{iv}$—Mn4—Co3$^{ix}$ | 97.493 (12) | Co1$^{xv}$—Co5—Mn1$^{xviii}$ | 60.298 (12) |
| Co4$^{iii}$—Mn4—Co3$^{ix}$ | 96.038 (15) | Ge1—Co5—Mn1$^{xviii}$ | 108.748 (12) |
| Co4$^{iv}$—Mn4—Co3$^{ix}$ | 52.824 (10) | Mn7—Co5—Mn1$^{xviii}$ | 68.876 (11) |
| Co1—Mn4—Co3 | 95.785 (13) | Mn7$^{xiv}$—Co5—Mn1$^{xviii}$ | 69.535 (11) |
| Co1$^{ix}$—Mn4—Co3 | 116.840 (16) | Co2—Co5—Mn1$^{xix}$ | 63.598 (12) |
| Co2$^{v}$—Mn4—Co3 | 97.494 (12) | Co2$^{ix}$—Co5—Mn1$^{xix}$ | 119.820 (16) |
| Co2$^{iv}$—Mn4—Co3 | 119.162 (16) | Co1$^{xii}$—Co5—Mn1$^{xix}$ | 60.298 (12) |
| Co4$^{iii}$—Mn4—Co3 | 52.825 (10) | Co1$^{xv}$—Co5—Mn1$^{xix}$ | 117.724 (17) |
| Co4$^{iv}$—Mn4—Co3 | 96.038 (15) | Ge1—Co5—Mn1$^{xix}$ | 108.748 (12) |

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| $Co3^{ix}$—Mn4—Co3 | 48.757 (13) | Mn7—Co5—$Mn1^{xix}$ | 68.876 (11) |
| Co1—Mn4—Mn6 | 150.847 (11) | $Mn7^{xiv}$—Co5—$Mn1^{xix}$ | 69.535 (12) |
| $Co1^{ix}$—Mn4—Mn6 | 150.847 (11) | $Mn1^{xviii}$—Co5—$Mn1^{xix}$ | 131.36 (2) |
| $Co2^{v}$—Mn4—Mn6 | 60.518 (12) | Co2—Co5—Mn5 | 64.902 (13) |
| $Co2^{iv}$—Mn4—Mn6 | 60.518 (12) | $Co2^{ix}$—Co5—Mn5 | 64.902 (13) |
| $Co4^{iii}$—Mn4—Mn6 | 59.278 (10) | $Co1^{xii}$—Co5—Mn5 | 113.431 (15) |
| $Co4^{iv}$—Mn4—Mn6 | 59.278 (10) | $Co1^{xv}$—Co5—Mn5 | 113.431 (15) |
| $Co3^{ix}$—Mn4—Mn6 | 58.649 (13) | Ge1—Co5—Mn5 | 64.128 (15) |
| Co3—Mn4—Mn6 | 58.649 (13) | Mn7—Co5—Mn5 | 176.469 (18) |
| Co1—Mn4—$Ge2^{vi}$ | 95.845 (14) | $Mn7^{xiv}$—Co5—Mn5 | 122.671 (18) |
| $Co1^{ix}$—Mn4—$Ge2^{vi}$ | 51.646 (9) | $Mn1^{xviii}$—Co5—Mn5 | 111.838 (11) |
| $Co2^{v}$—Mn4—$Ge2^{vi}$ | 145.618 (12) | $Mn1^{xix}$—Co5—Mn5 | 111.838 (11) |
| $Co2^{iv}$—Mn4—$Ge2^{vi}$ | 95.178 (10) | Co2—Co5—$Mn2^{xix}$ | 65.075 (11) |
| $Co4^{iii}$—Mn4—$Ge2^{vi}$ | 145.415 (19) | $Co2^{ix}$—Co5—$Mn2^{xix}$ | 116.430 (16) |
| $Co4^{iv}$—Mn4—$Ge2^{vi}$ | 50.361 (10) | $Co1^{xii}$—Co5—$Mn2^{xix}$ | 62.083 (11) |
| $Co3^{ix}$—Mn4—$Ge2^{vi}$ | 50.010 (9) | $Co1^{xv}$—Co5—$Mn2^{xix}$ | 114.558 (15) |
| Co3—Mn4—$Ge2^{vi}$ | 93.393 (14) | Ge1—Co5—$Mn2^{xix}$ | 62.781 (10) |
| Mn6—Mn4—$Ge2^{vi}$ | 99.209 (12) | Mn7—Co5—$Mn2^{xix}$ | 116.636 (11) |
| Co1—Mn4—$Ge2^{vii}$ | 51.646 (9) | $Mn7^{xiv}$—Co5—$Mn2^{xix}$ | 119.295 (10) |
| $Co1^{ix}$—Mn4—$Ge2^{vii}$ | 95.845 (14) | $Mn1^{xviii}$—Co5—$Mn2^{xix}$ | 170.869 (17) |
| $Co2^{v}$—Mn4—$Ge2^{vii}$ | 95.178 (10) | $Mn1^{xix}$—Co5—$Mn2^{xix}$ | 57.285 (12) |
| $Co2^{iv}$—Mn4—$Ge2^{vii}$ | 145.618 (12) | Mn5—Co5—$Mn2^{xix}$ | 62.188 (10) |
| $Co4^{iii}$—Mn4—$Ge2^{vii}$ | 50.361 (10) | $Co2^{xii}$—Co6—$Co2^{xv}$ | 60.705 (15) |
| $Co4^{iv}$—Mn4—$Ge2^{vii}$ | 145.415 (19) | $Co2^{xii}$—Co6—Ge2 | 121.286 (15) |
| $Co3^{ix}$—Mn4—$Ge2^{vii}$ | 93.393 (14) | $Co2^{xv}$—Co6—Ge2 | 121.286 (15) |
| Co3—Mn4—$Ge2^{vii}$ | 50.010 (9) | $Co2^{xii}$—Co6—Ge1 | 121.102 (15) |
| Mn6—Mn4—$Ge2^{vii}$ | 99.209 (12) | $Co2^{xv}$—Co6—Ge1 | 121.102 (15) |
| $Ge2^{vi}$—Mn4—$Ge2^{vii}$ | 116.460 (18) | Ge2—Co6—Ge1 | 106.231 (16) |
| Co1—Mn4—$Mn7^{vi}$ | 99.475 (16) | $Co2^{xii}$—Co6—$Co1^{xv}$ | 179.656 (18) |
| $Co1^{ix}$—Mn4—$Mn7^{vi}$ | 56.999 (12) | $Co2^{xv}$—Co6—$Co1^{xv}$ | 119.185 (10) |
| $Co2^{v}$—Mn4—$Mn7^{vi}$ | 101.374 (15) | Ge2—Co6—$Co1^{xv}$ | 58.449 (11) |
| $Co2^{iv}$—Mn4—$Mn7^{vi}$ | 58.365 (11) | Ge1—Co6—$Co1^{xv}$ | 59.242 (11) |
| $Co4^{iii}$—Mn4—$Mn7^{vi}$ | 151.623 (19) | $Co2^{xii}$—Co6—$Co1^{xii}$ | 119.185 (10) |
| $Co4^{iv}$—Mn4—$Mn7^{vi}$ | 56.293 (11) | $Co2^{xv}$—Co6—$Co1^{xii}$ | 179.656 (18) |
| $Co3^{ix}$—Mn4—$Mn7^{vi}$ | 98.993 (11) | Ge2—Co6—$Co1^{xii}$ | 58.449 (11) |
| Co3—Mn4—$Mn7^{vi}$ | 147.720 (13) | Ge1—Co6—$Co1^{xii}$ | 59.242 (11) |
| Mn6—Mn4—$Mn7^{vi}$ | 109.666 (13) | $Co1^{xv}$—Co6—$Co1^{xii}$ | 60.924 (15) |
| $Ge2^{vi}$—Mn4—$Mn7^{vi}$ | 56.978 (10) | $Co2^{xii}$—Co6—$Mn2^{viii}$ | 67.463 (13) |
| $Ge2^{vii}$—Mn4—$Mn7^{vi}$ | 150.976 (18) | $Co2^{xv}$—Co6—$Mn2^{viii}$ | 67.463 (13) |
| Co1—Mn5—$Co1^{ix}$ | 48.663 (13) | Ge2—Co6—$Mn2^{viii}$ | 63.368 (13) |
| Co1—Mn5—$Co6^{vi}$ | 97.414 (15) | Ge1—Co6—$Mn2^{viii}$ | 169.598 (18) |
| $Co1^{ix}$—Mn5—$Co6^{vi}$ | 54.276 (10) | $Co1^{xv}$—Co6—$Mn2^{viii}$ | 112.193 (14) |
| Co1—Mn5—$Co6^{vii}$ | 54.276 (10) | $Co1^{xii}$—Co6—$Mn2^{viii}$ | 112.193 (14) |
| $Co1^{ix}$—Mn5—$Co6^{vii}$ | 97.413 (15) | $Co2^{xii}$—Co6—$Mn5^{xii}$ | 65.815 (12) |
| $Co6^{vi}$—Mn5—$Co6^{vii}$ | 119.80 (2) | $Co2^{xv}$—Co6—$Mn5^{xii}$ | 117.688 (16) |
| Co1—Mn5—$Co3^{ix}$ | 114.443 (16) | Ge2—Co6—$Mn5^{xii}$ | 65.234 (10) |
| $Co1^{ix}$—Mn5—$Co3^{ix}$ | 94.156 (13) | Ge1—Co6—$Mn5^{xii}$ | 112.450 (11) |
| $Co6^{vi}$—Mn5—$Co3^{ix}$ | 94.978 (10) | $Co1^{xv}$—Co6—$Mn5^{xii}$ | 114.098 (16) |

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| Co6$^{vii}$—Mn5—Co3$^{ix}$ | 143.463 (13) |
| Co1—Mn5—Co3 | 94.156 (13) |
| Co1$^{ix}$—Mn5—Co3 | 114.444 (16) |
| Co6$^{vi}$—Mn5—Co3 | 143.463 (13) |
| Co6$^{vii}$—Mn5—Co3 | 94.979 (10) |
| Co3$^{ix}$—Mn5—Co3 | 48.938 (13) |
| Co1—Mn5—Ge2$^{vii}$ | 51.190 (9) |
| Co1$^{ix}$—Mn5—Ge2$^{vii}$ | 94.622 (14) |
| Co6$^{vi}$—Mn5—Ge2$^{vii}$ | 148.097 (18) |
| Co6$^{vii}$—Mn5—Ge2$^{vii}$ | 50.484 (10) |
| Co3$^{ix}$—Mn5—Ge2$^{vii}$ | 94.195 (14) |
| Co3—Mn5—Ge2$^{vii}$ | 50.364 (9) |
| Co1—Mn5—Ge2$^{vi}$ | 94.622 (14) |
| Co1$^{ix}$—Mn5—Ge2$^{vi}$ | 51.190 (9) |
| Co6$^{vi}$—Mn5—Ge2$^{vi}$ | 50.484 (10) |
| Co6$^{vii}$—Mn5—Ge2$^{vi}$ | 148.097 (18) |
| Co3$^{ix}$—Mn5—Ge2$^{vi}$ | 50.363 (9) |
| Co3—Mn5—Ge2$^{vi}$ | 94.195 (14) |
| Ge2$^{vii}$—Mn5—Ge2$^{vi}$ | 118.267 (18) |
| Co1—Mn5—Mn3 | 60.110 (13) |
| Co1$^{ix}$—Mn5—Mn3 | 60.109 (13) |
| Co6$^{vi}$—Mn5—Mn3 | 59.955 (10) |
| Co6$^{vii}$—Mn5—Mn3 | 59.955 (10) |
| Co3$^{ix}$—Mn5—Mn3 | 150.980 (11) |
| Co3—Mn5—Mn3 | 150.980 (11) |
| Ge2$^{vii}$—Mn5—Mn3 | 100.643 (12) |
| Ge2$^{vi}$—Mn5—Mn3 | 100.643 (12) |
| Co1—Mn5—Co2 | 98.232 (12) |
| Co1$^{ix}$—Mn5—Co2 | 120.095 (16) |
| Co6$^{vi}$—Mn5—Co2 | 95.980 (14) |
| Co6$^{vii}$—Mn5—Co2 | 49.602 (9) |
| Co3$^{ix}$—Mn5—Co2 | 143.742 (17) |
| Co3—Mn5—Co2 | 116.500 (12) |
| Ge2$^{vii}$—Mn5—Co2 | 94.455 (9) |
| Ge2$^{vi}$—Mn5—Co2 | 145.492 (12) |
| Mn3—Mn5—Co2 | 60.009 (12) |
| Co1—Mn5—Co2$^{ix}$ | 120.095 (16) |
| Co1$^{ix}$—Mn5—Co2$^{ix}$ | 98.231 (12) |
| Co6$^{vi}$—Mn5—Co2$^{ix}$ | 49.602 (9) |
| Co6$^{vii}$—Mn5—Co2$^{ix}$ | 95.980 (15) |
| Co3$^{ix}$—Mn5—Co2$^{ix}$ | 116.500 (12) |
| Co3—Mn5—Co2$^{ix}$ | 143.742 (17) |
| Ge2$^{vii}$—Mn5—Co2$^{ix}$ | 145.492 (12) |
| Ge2$^{vi}$—Mn5—Co2$^{ix}$ | 94.455 (10) |
| Mn3—Mn5—Co2$^{ix}$ | 60.008 (12) |
| Co2—Mn5—Co2$^{ix}$ | 51.540 (12) |
| Co3$^{ix}$—Mn6—Co3 | 49.800 (13) |
| Co3$^{ix}$—Mn6—Co3$^{xi}$ | 115.880 (15) |
| Co1$^{xii}$—Co6—Mn5$^{xii}$ | 62.037 (11) |
| Mn2$^{viii}$—Co6—Mn5$^{xii}$ | 64.259 (10) |
| Co2$^{xii}$—Co6—Mn5$^{xiii}$ | 117.688 (16) |
| Co2$^{xv}$—Co6—Mn5$^{xiii}$ | 65.815 (11) |
| Ge2—Co6—Mn5$^{xiii}$ | 65.234 (10) |
| Ge1—Co6—Mn5$^{xiii}$ | 112.450 (11) |
| Co1$^{xv}$—Co6—Mn5$^{xiii}$ | 62.037 (12) |
| Co1$^{xii}$—Co6—Mn5$^{xiii}$ | 114.098 (16) |
| Mn2$^{viii}$—Co6—Mn5$^{xiii}$ | 64.259 (10) |
| Mn5$^{xii}$—Co6—Mn5$^{xiii}$ | 119.80 (2) |
| Co2$^{xii}$—Co6—Mn6$^{viii}$ | 65.454 (13) |
| Co2$^{xv}$—Co6—Mn6$^{viii}$ | 65.454 (13) |
| Ge2—Co6—Mn6$^{viii}$ | 171.779 (18) |
| Ge1—Co6—Mn6$^{viii}$ | 65.548 (14) |
| Co1$^{xv}$—Co6—Mn6$^{viii}$ | 114.831 (15) |
| Co1$^{xii}$—Co6—Mn6$^{viii}$ | 114.831 (15) |
| Mn2$^{viii}$—Co6—Mn6$^{viii}$ | 124.853 (17) |
| Mn5$^{xii}$—Co6—Mn6$^{viii}$ | 117.003 (10) |
| Mn5$^{xiii}$—Co6—Mn6$^{viii}$ | 117.003 (10) |
| Co2$^{xii}$—Co6—Mn3$^{xiii}$ | 117.246 (16) |
| Co2$^{xv}$—Co6—Mn3$^{xiii}$ | 65.606 (12) |
| Ge2—Co6—Mn3$^{xiii}$ | 112.902 (11) |
| Ge1—Co6—Mn3$^{xiii}$ | 65.069 (10) |
| Co1$^{xv}$—Co6—Mn3$^{xiii}$ | 62.850 (11) |
| Co1$^{xii}$—Co6—Mn3$^{xiii}$ | 114.667 (16) |
| Mn2$^{viii}$—Co6—Mn3$^{xiii}$ | 117.750 (11) |
| Mn5$^{xii}$—Co6—Mn3$^{xiii}$ | 176.662 (18) |
| Mn5$^{xiii}$—Co6—Mn3$^{xiii}$ | 60.488 (11) |
| Mn6$^{viii}$—Co6—Mn3$^{xiii}$ | 64.422 (11) |
| Co2$^{xii}$—Co6—Mn3$^{xii}$ | 65.606 (12) |
| Co2$^{xv}$—Co6—Mn3$^{xii}$ | 117.246 (16) |
| Ge2—Co6—Mn3$^{xii}$ | 112.902 (11) |
| Ge1—Co6—Mn3$^{xii}$ | 65.069 (11) |
| Co1$^{xv}$—Co6—Mn3$^{xii}$ | 114.667 (16) |
| Co1$^{xii}$—Co6—Mn3$^{xii}$ | 62.850 (12) |
| Mn2$^{viii}$—Co6—Mn3$^{xii}$ | 117.750 (10) |
| Mn5$^{xii}$—Co6—Mn3$^{xii}$ | 60.488 (11) |
| Mn5$^{xiii}$—Co6—Mn3$^{xii}$ | 176.662 (18) |
| Mn6$^{viii}$—Co6—Mn3$^{xii}$ | 64.422 (11) |
| Mn3$^{xiii}$—Co6—Mn3$^{xii}$ | 119.01 (2) |
| Co3—Ge1—Co3$^{ix}$ | 59.126 (14) |
| Co3—Ge1—Co6 | 118.866 (14) |
| Co3$^{ix}$—Ge1—Co6 | 118.866 (14) |
| Co3—Ge1—Co1$^{xv}$ | 177.514 (12) |
| Co3$^{ix}$—Ge1—Co1$^{xv}$ | 118.710 (10) |
| Co6—Ge1—Co1$^{xv}$ | 62.997 (11) |
| Co3—Ge1—Co1$^{xii}$ | 118.710 (10) |
| Co3$^{ix}$—Ge1—Co1$^{xii}$ | 177.514 (12) |

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| Co3—Mn6—Co3$^{xi}$ | 94.856 (13) | Co6—Ge1—Co1$^{xii}$ | 62.997 (11) |
| Co3$^{ix}$—Mn6—Co3$^{viii}$ | 94.857 (13) | Co1$^{xv}$—Ge1—Co1$^{xii}$ | 63.422 (14) |
| Co3—Mn6—Co3$^{viii}$ | 115.879 (15) | Co3—Ge1—Co5 | 119.993 (14) |
| Co3$^{xi}$—Mn6—Co3$^{viii}$ | 49.392 (13) | Co3$^{ix}$—Ge1—Co5 | 119.992 (14) |
| Co3$^{ix}$—Mn6—Co4$^{iv}$ | 53.674 (10) | Co6—Ge1—Co5 | 111.209 (16) |
| Co3—Mn6—Co4$^{iv}$ | 97.957 (15) | Co1$^{xv}$—Ge1—Co5 | 59.574 (11) |
| Co3$^{xi}$—Mn6—Co4$^{iv}$ | 143.550 (13) | Co1$^{xii}$—Ge1—Co5 | 59.574 (11) |
| Co3$^{viii}$—Mn6—Co4$^{iv}$ | 94.541 (10) | Co3—Ge1—Mn2$^{xviii}$ | 114.265 (15) |
| Co3$^{ix}$—Mn6—Co4$^{iii}$ | 97.957 (15) | Co3$^{ix}$—Ge1—Mn2$^{xviii}$ | 63.952 (11) |
| Co3—Mn6—Co4$^{iii}$ | 53.674 (10) | Co6—Ge1—Mn2$^{xviii}$ | 115.542 (10) |
| Co3$^{xi}$—Mn6—Co4$^{iii}$ | 94.541 (11) | Co1$^{xv}$—Ge1—Mn2$^{xviii}$ | 63.255 (11) |
| Co3$^{viii}$—Mn6—Co4$^{iii}$ | 143.550 (13) | Co1$^{xii}$—Ge1—Mn2$^{xviii}$ | 117.105 (14) |
| Co4$^{iv}$—Mn6—Co4$^{iii}$ | 120.43 (2) | Co5—Ge1—Mn2$^{xviii}$ | 66.043 (10) |
| Co3$^{ix}$—Mn6—Co6$^{viii}$ | 146.315 (13) | Co3—Ge1—Mn2$^{xix}$ | 63.952 (11) |
| Co3—Mn6—Co6$^{viii}$ | 146.316 (13) | Co3$^{ix}$—Ge1—Mn2$^{xix}$ | 114.265 (14) |
| Co3$^{xi}$—Mn6—Co6$^{viii}$ | 94.561 (15) | Co6—Ge1—Mn2$^{xix}$ | 115.542 (10) |
| Co3$^{viii}$—Mn6—Co6$^{viii}$ | 94.561 (15) | Co1$^{xv}$—Ge1—Mn2$^{xix}$ | 117.105 (14) |
| Co4$^{iv}$—Mn6—Co6$^{viii}$ | 93.369 (12) | Co1$^{xii}$—Ge1—Mn2$^{xix}$ | 63.255 (11) |
| Co4$^{iii}$—Mn6—Co6$^{viii}$ | 93.369 (12) | Co5—Ge1—Mn2$^{xix}$ | 66.043 (10) |
| Co3$^{ix}$—Mn6—Co2$^{iv}$ | 97.499 (12) | Mn2$^{xviii}$—Ge1—Mn2$^{xix}$ | 118.966 (19) |
| Co3—Mn6—Co2$^{iv}$ | 119.169 (16) | Co3—Ge1—Mn3$^{xii}$ | 65.334 (12) |
| Co3$^{xi}$—Mn6—Co2$^{iv}$ | 143.380 (17) | Co3$^{ix}$—Ge1—Mn3$^{xii}$ | 115.349 (14) |
| Co3$^{viii}$—Mn6—Co2$^{iv}$ | 116.646 (12) | Co6—Ge1—Mn3$^{xii}$ | 64.382 (10) |
| Co4$^{iv}$—Mn6—Co2$^{iv}$ | 50.003 (9) | Co1$^{xv}$—Ge1—Mn3$^{xii}$ | 117.143 (14) |
| Co4$^{iii}$—Mn6—Co2$^{iv}$ | 95.330 (15) | Co1$^{xii}$—Ge1—Mn3$^{xii}$ | 63.608 (12) |
| Co6$^{viii}$—Mn6—Co2$^{iv}$ | 49.721 (10) | Co5—Ge1—Mn3$^{xii}$ | 114.733 (10) |
| Co3$^{ix}$—Mn6—Co2$^{v}$ | 119.168 (15) | Mn2$^{xviii}$—Ge1—Mn3$^{xii}$ | 179.217 (15) |
| Co3—Mn6—Co2$^{v}$ | 97.499 (12) | Mn2$^{xix}$—Ge1—Mn3$^{xii}$ | 61.555 (11) |
| Co3$^{xi}$—Mn6—Co2$^{v}$ | 116.646 (12) | Co3—Ge1—Mn3$^{xiii}$ | 115.349 (14) |
| Co3$^{viii}$—Mn6—Co2$^{v}$ | 143.380 (17) | Co3$^{ix}$—Ge1—Mn3$^{xiii}$ | 65.335 (12) |
| Co4$^{iv}$—Mn6—Co2$^{v}$ | 95.330 (15) | Co6—Ge1—Mn3$^{xiii}$ | 64.382 (10) |
| Co4$^{iii}$—Mn6—Co2$^{v}$ | 50.003 (9) | Co1$^{xv}$—Ge1—Mn3$^{xiii}$ | 63.608 (12) |
| Co6$^{viii}$—Mn6—Co2$^{v}$ | 49.721 (10) | Co1$^{xii}$—Ge1—Mn3$^{xiii}$ | 117.143 (14) |
| Co2$^{iv}$—Mn6—Co2$^{v}$ | 50.150 (12) | Co5—Ge1—Mn3$^{xiii}$ | 114.733 (10) |
| Co3$^{ix}$—Mn6—Mn4 | 60.587 (13) | Mn2$^{xviii}$—Ge1—Mn3$^{xiii}$ | 61.555 (12) |
| Co3—Mn6—Mn4 | 60.588 (13) | Mn2$^{xix}$—Ge1—Mn3$^{xiii}$ | 179.217 (15) |
| Co3$^{xi}$—Mn6—Mn4 | 151.666 (11) | Mn3$^{xii}$—Ge1—Mn3$^{xiii}$ | 117.917 (18) |
| Co3$^{viii}$—Mn6—Mn4 | 151.666 (11) | Co3—Ge1—Mn5 | 64.774 (12) |
| Co4$^{iv}$—Mn6—Mn4 | 60.246 (10) | Co3$^{ix}$—Ge1—Mn5 | 64.773 (12) |
| Co4$^{iii}$—Mn6—Mn4 | 60.246 (10) | Co6—Ge1—Mn5 | 175.628 (16) |
| Co6$^{viii}$—Mn6—Mn4 | 99.327 (18) | Co1$^{xv}$—Ge1—Mn5 | 113.445 (13) |
| Co2$^{iv}$—Mn6—Mn4 | 58.587 (13) | Co1$^{xii}$—Ge1—Mn5 | 113.445 (13) |
| Co2$^{v}$—Mn6—Mn4 | 58.587 (13) | Co5—Ge1—Mn5 | 64.419 (13) |
| Co3$^{ix}$—Mn6—Ge3$^{xii}$ | 94.968 (13) | Mn2$^{xviii}$—Ge1—Mn5 | 63.233 (10) |
| Co3—Mn6—Ge3$^{xii}$ | 50.739 (7) | Mn2$^{xix}$—Ge1—Mn5 | 63.233 (10) |
| Co3$^{xi}$—Mn6—Ge3$^{xii}$ | 50.543 (7) | Mn3$^{xii}$—Ge1—Mn5 | 116.906 (10) |
| Co3$^{viii}$—Mn6—Ge3$^{xii}$ | 94.498 (13) | Mn3$^{xiii}$—Ge1—Mn5 | 116.906 (10) |
| Co4$^{iv}$—Mn6—Ge3$^{xii}$ | 147.984 (17) | Co3—Ge1—Mn6$^{viii}$ | 64.053 (12) |

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| Co4$^{iii}$—Mn6—Ge3$^{xii}$ | 50.573 (9) | Co3$^{ix}$—Ge1—Mn6$^{viii}$ | 64.054 (12) |
| Co6$^{viii}$—Mn6—Ge3$^{xii}$ | 116.411 (9) | Co6—Ge1—Mn6$^{viii}$ | 63.912 (13) |
| Co2$^{iv}$—Mn6—Ge3$^{xii}$ | 145.095 (11) | Co1$^{xv}$—Ge1—Mn6$^{viii}$ | 116.517 (14) |
| Co2$^{v}$—Mn6—Ge3$^{xii}$ | 95.504 (8) | Co1$^{xii}$—Ge1—Mn6$^{viii}$ | 116.517 (14) |
| Mn4—Mn6—Ge3$^{xii}$ | 101.131 (11) | Co5—Ge1—Mn6$^{viii}$ | 175.121 (16) |
| Co3$^{ix}$—Mn6—Ge3$^{xiii}$ | 50.740 (7) | Mn2$^{xviii}$—Ge1—Mn6$^{viii}$ | 115.500 (10) |
| Co3—Mn6—Ge3$^{xiii}$ | 94.968 (13) | Mn2$^{xix}$—Ge1—Mn6$^{viii}$ | 115.500 (10) |
| Co3$^{xi}$—Mn6—Ge3$^{xiii}$ | 94.498 (13) | Mn3$^{xii}$—Ge1—Mn6$^{viii}$ | 63.736 (10) |
| Co3$^{viii}$—Mn6—Ge3$^{xiii}$ | 50.543 (7) | Mn3$^{xiii}$—Ge1—Mn6$^{viii}$ | 63.736 (10) |
| Co4$^{iv}$—Mn6—Ge3$^{xiii}$ | 50.573 (9) | Mn5—Ge1—Mn6$^{viii}$ | 120.460 (15) |
| Co4$^{iii}$—Mn6—Ge3$^{xiii}$ | 147.984 (17) | Co3$^{xii}$—Ge2—Co3$^{xv}$ | 63.336 (15) |
| Co6$^{viii}$—Mn6—Ge3$^{xiii}$ | 116.411 (9) | Co3$^{xii}$—Ge2—Co6 | 119.232 (13) |
| Co2$^{iv}$—Mn6—Ge3$^{xiii}$ | 95.504 (8) | Co3$^{xv}$—Ge2—Co6 | 119.232 (13) |
| Co2$^{v}$—Mn6—Ge3$^{xiii}$ | 145.095 (11) | Co3$^{xii}$—Ge2—Co4$^{xiv}$ | 62.888 (11) |
| Mn4—Mn6—Ge3$^{xiii}$ | 101.131 (11) | Co3$^{xv}$—Ge2—Co4$^{xiv}$ | 62.888 (11) |
| Ge3$^{xii}$—Mn6—Ge3$^{xiii}$ | 117.382 (15) | Co6—Ge2—Co4$^{xiv}$ | 177.361 (17) |
| Co5—Mn7—Co5$^{xiv}$ | 119.139 (17) | Co3$^{xii}$—Ge2—Co1$^{xv}$ | 177.093 (15) |
| Co5—Mn7—Mn7$^{xiv}$ | 60.067 (17) | Co3$^{xv}$—Ge2—Co1$^{xv}$ | 116.039 (11) |
| Co5$^{xiv}$—Mn7—Mn7$^{xiv}$ | 59.072 (16) | Co6—Ge2—Co1$^{xv}$ | 63.644 (11) |
| Co5—Mn7—Co1$^{xii}$ | 55.005 (11) | Co4$^{xiv}$—Ge2—Co1$^{xv}$ | 114.225 (13) |
| Co5$^{xiv}$—Mn7—Co1$^{xii}$ | 149.093 (10) | Co3$^{xii}$—Ge2—Co1$^{xii}$ | 116.039 (11) |
| Mn7$^{xiv}$—Mn7—Co1$^{xii}$ | 106.741 (19) | Co3$^{xv}$—Ge2—Co1$^{xii}$ | 177.093 (15) |
| Co5—Mn7—Co1$^{xv}$ | 55.005 (11) | Co6—Ge2—Co1$^{xii}$ | 63.644 (11) |
| Co5$^{xiv}$—Mn7—Co1$^{xv}$ | 149.093 (9) | Co4$^{xiv}$—Ge2—Co1$^{xii}$ | 114.225 (13) |
| Mn7$^{xiv}$—Mn7—Co1$^{xv}$ | 106.741 (19) | Co1$^{xv}$—Ge2—Co1$^{xii}$ | 64.426 (15) |
| Co1$^{xii}$—Mn7—Co1$^{xv}$ | 57.596 (14) | Co3$^{xii}$—Ge2—Mn2$^{viii}$ | 64.913 (12) |
| Co5—Mn7—Co4$^{xiv}$ | 148.216 (19) | Co3$^{xv}$—Ge2—Mn2$^{viii}$ | 64.913 (12) |
| Co5$^{xiv}$—Mn7—Co4$^{xiv}$ | 92.644 (16) | Co6—Ge2—Mn2$^{viii}$ | 64.893 (15) |
| Mn7$^{xiv}$—Mn7—Co4$^{xiv}$ | 151.72 (3) | Co4$^{xiv}$—Ge2—Mn2$^{viii}$ | 117.746 (17) |
| Co1$^{xii}$—Mn7—Co4$^{xiv}$ | 97.961 (14) | Co1$^{xv}$—Ge2—Mn2$^{viii}$ | 117.633 (13) |
| Co1$^{xv}$—Mn7—Co4$^{xiv}$ | 97.961 (14) | Co1$^{xii}$—Ge2—Mn2$^{viii}$ | 117.633 (13) |
| Co5—Mn7—Ge2 | 95.625 (17) | Co3$^{xii}$—Ge2—Mn7 | 115.504 (14) |
| Co5$^{xiv}$—Mn7—Ge2 | 145.236 (18) | Co3$^{xv}$—Ge2—Mn7 | 115.504 (14) |
| Mn7$^{xiv}$—Mn7—Ge2 | 155.69 (3) | Co6—Ge2—Mn7 | 114.595 (16) |
| Co1$^{xii}$—Mn7—Ge2 | 52.900 (11) | Co4$^{xiv}$—Ge2—Mn7 | 62.766 (14) |
| Co1$^{xv}$—Mn7—Ge2 | 52.900 (11) | Co1$^{xv}$—Ge2—Mn7 | 61.958 (12) |
| Co4$^{xiv}$—Mn7—Ge2 | 52.592 (12) | Co1$^{xii}$—Ge2—Mn7 | 61.958 (12) |
| Co5—Mn7—Co2$^{xiv}$ | 150.316 (10) | Mn2$^{viii}$—Ge2—Mn7 | 179.488 (16) |
| Co5$^{xiv}$—Mn7—Co2$^{xiv}$ | 52.198 (11) | Co3$^{xii}$—Ge2—Mn5$^{xii}$ | 64.568 (11) |
| Mn7$^{xiv}$—Mn7—Co2$^{xiv}$ | 104.19 (2) | Co3$^{xv}$—Ge2—Mn5$^{xii}$ | 118.154 (14) |
| Co1$^{xii}$—Mn7—Co2$^{xiv}$ | 148.941 (17) | Co6—Ge2—Mn5$^{xii}$ | 64.280 (10) |
| Co1$^{xv}$—Mn7—Co2$^{xiv}$ | 115.339 (11) | Co4$^{xiv}$—Ge2—Mn5$^{xii}$ | 116.494 (10) |
| Co4$^{xiv}$—Mn7—Co2$^{xiv}$ | 51.393 (10) | Co1$^{xv}$—Ge2—Mn5$^{xii}$ | 117.515 (14) |
| Ge2—Mn7—Co2$^{xiv}$ | 97.541 (15) | Co1$^{xii}$—Ge2—Mn5$^{xii}$ | 63.053 (11) |
| Co5—Mn7—Co2$^{xvi}$ | 150.316 (10) | Mn2$^{viii}$—Ge2—Mn5$^{xii}$ | 64.411 (10) |
| Co5$^{xiv}$—Mn7—Co2$^{xvi}$ | 52.198 (11) | Mn7—Ge2—Mn5$^{xii}$ | 115.430 (10) |
| Mn7$^{xiv}$—Mn7—Co2$^{xvi}$ | 104.19 (2) | Co3$^{xii}$—Ge2—Mn5$^{xiii}$ | 118.154 (14) |
| Co1$^{xii}$—Mn7—Co2$^{xvi}$ | 115.339 (11) | Co3$^{xv}$—Ge2—Mn5$^{xiii}$ | 64.568 (11) |

| | | | |
|---|---|---|---|
| $Co1^{xv}$—Mn7—$Co2^{xvi}$ | 148.941 (17) | Co6—Ge2—$Mn5^{xiii}$ | 64.280 (10) |
| $Co4^{xiv}$—Mn7—$Co2^{xvi}$ | 51.393 (10) | $Co4^{xiv}$—Ge2—$Mn5^{xiii}$ | 116.494 (10) |
| Ge2—Mn7—$Co2^{xvi}$ | 97.541 (15) | $Co1^{xv}$—Ge2—$Mn5^{xiii}$ | 63.053 (11) |
| $Co2^{xiv}$—Mn7—$Co2^{xvi}$ | 52.838 (13) | $Co1^{xii}$—Ge2—$Mn5^{xiii}$ | 117.515 (14) |
| Co5—Mn7—$Mn4^{xii}$ | 107.142 (13) | $Mn2^{viii}$—Ge2—$Mn5^{xiii}$ | 64.411 (10) |
| $Co5^{xiv}$—Mn7—$Mn4^{xii}$ | 105.230 (13) | Mn7—Ge2—$Mn5^{xiii}$ | 115.430 (10) |
| $Mn7^{xiv}$—Mn7—$Mn4^{xii}$ | 123.375 (10) | $Mn5^{xii}$—Ge2—$Mn5^{xiii}$ | 118.268 (18) |
| $Co1^{xii}$—Mn7—$Mn4^{xii}$ | 57.231 (11) | $Co3^{xii}$—Ge2—$Mn4^{xiii}$ | 117.392 (14) |
| $Co1^{xv}$—Mn7—$Mn4^{xii}$ | 105.248 (16) | $Co3^{xv}$—Ge2—$Mn4^{xiii}$ | 64.367 (12) |
| $Co4^{xiv}$—Mn7—$Mn4^{xii}$ | 60.297 (11) | Co6—Ge2—$Mn4^{xiii}$ | 114.946 (10) |
| Ge2—Mn7—$Mn4^{xii}$ | 60.546 (10) | $Co4^{xiv}$—Ge2—$Mn4^{xiii}$ | 64.162 (10) |
| $Co2^{xiv}$—Mn7—$Mn4^{xii}$ | 102.502 (15) | $Co1^{xv}$—Ge2—$Mn4^{xiii}$ | 60.464 (11) |
| $Co2^{xvi}$—Mn7—$Mn4^{xii}$ | 58.240 (11) | $Co1^{xii}$—Ge2—$Mn4^{xiii}$ | 114.421 (15) |
| Co5—Mn7—$Mn4^{xiii}$ | 107.142 (13) | $Mn2^{viii}$—Ge2—$Mn4^{xiii}$ | 117.669 (10) |
| $Co5^{xiv}$—Mn7—$Mn4^{xiii}$ | 105.230 (13) | Mn7—Ge2—$Mn4^{xiii}$ | 62.476 (10) |
| $Mn7^{xiv}$—Mn7—$Mn4^{xiii}$ | 123.375 (10) | $Mn5^{xii}$—Ge2—$Mn4^{xiii}$ | 177.474 (16) |
| $Co1^{xii}$—Mn7—$Mn4^{xiii}$ | 105.248 (16) | $Mn5^{xiii}$—Ge2—$Mn4^{xiii}$ | 62.582 (12) |
| $Co1^{xv}$—Mn7—$Mn4^{xiii}$ | 57.231 (11) | $Co3^{xii}$—Ge2—$Mn4^{xii}$ | 64.367 (12) |
| $Co4^{xiv}$—Mn7—$Mn4^{xiii}$ | 60.297 (11) | $Co3^{xv}$—Ge2—$Mn4^{xii}$ | 117.392 (14) |
| Ge2—Mn7—$Mn4^{xiii}$ | 60.546 (10) | Co6—Ge2—$Mn4^{xii}$ | 114.946 (10) |
| $Co2^{xiv}$—Mn7—$Mn4^{xiii}$ | 58.240 (11) | $Co4^{xiv}$—Ge2—$Mn4^{xii}$ | 64.162 (10) |
| $Co2^{xvi}$—Mn7—$Mn4^{xiii}$ | 102.502 (15) | $Co1^{xv}$—Ge2—$Mn4^{xii}$ | 114.421 (15) |
| $Mn4^{xii}$—Mn7—$Mn4^{xiii}$ | 113.18 (2) | $Co1^{xii}$—Ge2—$Mn4^{xii}$ | 60.464 (11) |
| Co5—Mn7—$Mn1^{xviii}$ | 56.307 (10) | $Mn2^{viii}$—Ge2—$Mn4^{xii}$ | 117.669 (10) |
| $Co5^{xiv}$—Mn7—$Mn1^{xviii}$ | 96.591 (13) | Mn7—Ge2—$Mn4^{xii}$ | 62.476 (10) |
| $Mn7^{xiv}$—Mn7—$Mn1^{xviii}$ | 64.473 (12) | $Mn5^{xii}$—Ge2—$Mn4^{xii}$ | 62.582 (12) |
| $Co1^{xii}$—Mn7—$Mn1^{xviii}$ | 101.025 (15) | $Mn5^{xiii}$—Ge2—$Mn4^{xii}$ | 177.474 (16) |
| $Co1^{xv}$—Mn7—$Mn1^{xviii}$ | 53.712 (11) | $Mn4^{xiii}$—Ge2—$Mn4^{xii}$ | 116.459 (18) |
| $Co4^{xiv}$—Mn7—$Mn1^{xviii}$ | 124.418 (10) | $Co3^{xviii}$—Ge3—$Co3^{vii}$ | 180.000 (13) |
| Ge2—Mn7—$Mn1^{xviii}$ | 103.377 (13) | $Co3^{xviii}$—Ge3—$Co3^{x}$ | 116.771 (13) |
| $Co2^{xiv}$—Mn7—$Mn1^{xviii}$ | 94.683 (11) | $Co3^{vii}$—Ge3—$Co3^{x}$ | 63.229 (13) |
| $Co2^{xvi}$—Mn7—$Mn1^{xviii}$ | 143.602 (15) | $Co3^{xviii}$—Ge3—$Co3^{xx}$ | 63.229 (13) |
| $Mn4^{xii}$—Mn7—$Mn1^{xviii}$ | 157.625 (19) | $Co3^{vii}$—Ge3—$Co3^{xx}$ | 116.771 (13) |
| $Mn4^{xiii}$—Mn7—$Mn1^{xviii}$ | 64.388 (12) | $Co3^{x}$—Ge3—$Co3^{xx}$ | 180.000 (13) |
| $Co1^{ix}$—Co1—$Ge2^{vii}$ | 122.215 (7) | $Co3^{xviii}$—Ge3—$Co4^{xxi}$ | 117.046 (9) |
| $Co1^{ix}$—Co1—$Co5^{vii}$ | 121.811 (8) | $Co3^{vii}$—Ge3—$Co4^{xxi}$ | 62.954 (9) |
| $Ge2^{vii}$—Co1—$Co5^{vii}$ | 109.809 (13) | $Co3^{x}$—Ge3—$Co4^{xxi}$ | 62.954 (9) |
| $Co1^{ix}$—Co1—$Ge1^{vii}$ | 121.709 (7) | $Co3^{xx}$—Ge3—$Co4^{xxi}$ | 117.046 (9) |
| $Ge2^{vii}$—Co1—$Ge1^{vii}$ | 104.593 (12) | $Co3^{xviii}$—Ge3—Co4 | 62.955 (9) |
| $Co5^{vii}$—Co1—$Ge1^{vii}$ | 60.572 (12) | $Co3^{vii}$—Ge3—Co4 | 117.045 (9) |
| $Co1^{ix}$—Co1—$Co6^{vii}$ | 120.463 (7) | $Co3^{x}$—Ge3—Co4 | 117.045 (9) |
| $Ge2^{vii}$—Co1—$Co6^{vii}$ | 57.907 (12) | $Co3^{xx}$—Ge3—Co4 | 62.955 (9) |
| $Co5^{vii}$—Co1—$Co6^{vii}$ | 107.775 (13) | $Co4^{xxi}$—Ge3—Co4 | 180.0 |
| $Ge1^{vii}$—Co1—$Co6^{vii}$ | 57.762 (12) | $Co3^{xviii}$—Ge3—$Mn6^{vi}$ | 63.673 (11) |
| $Co1^{ix}$—Co1—$Mn1^{i}$ | 63.716 (7) | $Co3^{vii}$—Ge3—$Mn6^{vi}$ | 116.327 (11) |
| $Ge2^{vii}$—Co1—$Mn1^{i}$ | 128.970 (15) | $Co3^{x}$—Ge3—$Mn6^{vi}$ | 63.113 (11) |
| $Co5^{vii}$—Co1—$Mn1^{i}$ | 64.089 (11) | $Co3^{xx}$—Ge3—$Mn6^{vi}$ | 116.887 (11) |
| $Ge1^{vii}$—Co1—$Mn1^{i}$ | 112.336 (15) | $Co4^{xxi}$—Ge3—$Mn6^{vi}$ | 63.762 (8) |

| | | | |
|---|---|---|---|
| Co6$^{vii}$—Co1—Mn1$^{i}$ | 170.093 (15) | Co4—Ge3—Mn6$^{vi}$ | 116.238 (8) |
| Co1$^{ix}$—Co1—Co1$^{xvii}$ | 180.0 | Co3$^{xviii}$—Ge3—Mn6$^{xix}$ | 116.327 (11) |
| Ge2$^{vii}$—Co1—Co1$^{xvii}$ | 57.787 (7) | Co3$^{vii}$—Ge3—Mn6$^{xix}$ | 63.673 (11) |
| Co5$^{vii}$—Co1—Co1$^{xvii}$ | 58.187 (8) | Co3$^{x}$—Ge3—Mn6$^{xix}$ | 116.887 (11) |
| Ge1$^{vii}$—Co1—Co1$^{xvii}$ | 58.289 (7) | Co3$^{xx}$—Ge3—Mn6$^{xix}$ | 63.113 (11) |
| Co6$^{vii}$—Co1—Co1$^{xvii}$ | 59.537 (7) | Co4$^{xxi}$—Ge3—Mn6$^{xix}$ | 116.238 (8) |
| Mn1$^{i}$—Co1—Co1$^{xvii}$ | 116.283 (7) | Co4—Ge3—Mn6$^{xix}$ | 63.762 (8) |
| Co1$^{ix}$—Co1—Mn7$^{vii}$ | 118.800 (7) | Mn6$^{vi}$—Ge3—Mn6$^{xix}$ | 180.000 (14) |
| Ge2$^{vii}$—Co1—Mn7$^{vii}$ | 65.142 (12) | Co3$^{xviii}$—Ge3—Mn6$^{vii}$ | 116.887 (11) |
| Co5$^{vii}$—Co1—Mn7$^{vii}$ | 61.299 (13) | Co3$^{vii}$—Ge3—Mn6$^{vii}$ | 63.113 (11) |
| Ge1$^{vii}$—Co1—Mn7$^{vii}$ | 110.976 (13) | Co3$^{x}$—Ge3—Mn6$^{vii}$ | 116.327 (11) |
| Co6$^{vii}$—Co1—Mn7$^{vii}$ | 112.585 (13) | Co3$^{xx}$—Ge3—Mn6$^{vii}$ | 63.673 (11) |
| Mn1$^{i}$—Co1—Mn7$^{vii}$ | 69.360 (12) | Co4$^{xxi}$—Ge3—Mn6$^{vii}$ | 63.762 (8) |
| Co1$^{xvii}$—Co1—Mn7$^{vii}$ | 61.202 (7) | Co4—Ge3—Mn6$^{vii}$ | 116.238 (8) |
| Co1$^{ix}$—Co1—Mn4 | 64.861 (7) | Mn6$^{vi}$—Ge3—Mn6$^{vii}$ | 117.381 (15) |
| Ge2$^{vii}$—Co1—Mn4 | 67.892 (11) | Mn6$^{xix}$—Ge3—Mn6$^{vii}$ | 62.619 (15) |
| Co5$^{vii}$—Co1—Mn4 | 120.371 (16) | Co3$^{xviii}$—Ge3—Mn6$^{xviii}$ | 63.113 (11) |
| Ge1$^{vii}$—Co1—Mn4 | 172.449 (13) | Co3$^{vii}$—Ge3—Mn6$^{xviii}$ | 116.887 (11) |
| Co6$^{vii}$—Co1—Mn4 | 116.423 (16) | Co3$^{x}$—Ge3—Mn6$^{xviii}$ | 63.673 (11) |
| Mn1$^{i}$—Co1—Mn4 | 73.406 (15) | Co3$^{xx}$—Ge3—Mn6$^{xviii}$ | 116.327 (11) |
| Co1$^{xvii}$—Co1—Mn4 | 115.141 (7) | Co4$^{xxi}$—Ge3—Mn6$^{xviii}$ | 116.238 (8) |
| Mn7$^{vii}$—Co1—Mn4 | 65.771 (12) | Co4—Ge3—Mn6$^{xviii}$ | 63.762 (8) |
| Co1$^{ix}$—Co1—Mn5 | 65.669 (7) | Mn6$^{vi}$—Ge3—Mn6$^{xviii}$ | 62.619 (15) |
| Ge2$^{vii}$—Co1—Mn5 | 65.758 (11) | Mn6$^{xix}$—Ge3—Mn6$^{xviii}$ | 117.381 (15) |
| Co5$^{vii}$—Co1—Mn5 | 171.438 (13) | Mn6$^{vii}$—Ge3—Mn6$^{xviii}$ | 180.00 (2) |
| Ge1$^{vii}$—Co1—Mn5 | 112.613 (14) | Co3$^{xviii}$—Ge3—Mn3 | 115.470 (10) |
| Co6$^{vii}$—Co1—Mn5 | 63.686 (10) | Co3$^{vii}$—Ge3—Mn3 | 64.530 (10) |
| Mn1$^{i}$—Co1—Mn5 | 124.467 (12) | Co3$^{x}$—Ge3—Mn3 | 64.530 (10) |
| Co1$^{xvii}$—Co1—Mn5 | 114.332 (7) | Co3$^{xx}$—Ge3—Mn3 | 115.470 (10) |
| Mn7$^{vii}$—Co1—Mn5 | 120.198 (14) | Co4$^{xxi}$—Ge3—Mn3 | 117.398 (12) |
| Mn4—Co1—Mn5 | 65.622 (14) | Co4—Ge3—Mn3 | 62.602 (12) |
| Co1$^{ix}$—Co1—Mn2$^{i}$ | 65.814 (6) | Mn6$^{vi}$—Ge3—Mn3 | 116.482 (8) |
| Ge2$^{vii}$—Co1—Mn2$^{i}$ | 169.331 (13) | Mn6$^{xix}$—Ge3—Mn3 | 63.518 (8) |
| Co5$^{vii}$—Co1—Mn2$^{i}$ | 66.959 (12) | Mn6$^{vii}$—Ge3—Mn3 | 116.482 (8) |
| Ge1$^{vii}$—Co1—Mn2$^{i}$ | 64.820 (10) | Mn6$^{xviii}$—Ge3—Mn3 | 63.518 (8) |
| Co6$^{vii}$—Co1—Mn2$^{i}$ | 112.608 (15) | Co3$^{xviii}$—Ge3—Mn3$^{xxi}$ | 64.531 (10) |
| Mn1$^{i}$—Co1—Mn2$^{i}$ | 59.755 (14) | Co3$^{vii}$—Ge3—Mn3$^{xxi}$ | 115.469 (10) |
| Co1$^{xvii}$—Co1—Mn2$^{i}$ | 114.183 (6) | Co3$^{x}$—Ge3—Mn3$^{xxi}$ | 115.469 (10) |
| Mn7$^{vii}$—Co1—Mn2$^{i}$ | 118.706 (14) | Co3$^{xx}$—Ge3—Mn3$^{xxi}$ | 64.531 (10) |
| Mn4—Co1—Mn2$^{i}$ | 122.711 (12) | Co4$^{xxi}$—Ge3—Mn3$^{xxi}$ | 62.602 (12) |
| Mn5—Co1—Mn2$^{i}$ | 115.954 (13) | Co4—Ge3—Mn3$^{xxi}$ | 117.399 (12) |
| Co1$^{ix}$—Co1—Mn3 | 66.028 (7) | Mn6$^{vi}$—Ge3—Mn3$^{xxi}$ | 63.517 (8) |
| Ge2$^{vii}$—Co1—Mn3 | 112.912 (13) | Mn6$^{xix}$—Ge3—Mn3$^{xxi}$ | 116.483 (8) |
| Co5$^{vii}$—Co1—Mn3 | 116.614 (14) | Mn6$^{vii}$—Ge3—Mn3$^{xxi}$ | 63.518 (8) |
| Ge1$^{vii}$—Co1—Mn3 | 64.847 (10) | Mn6$^{xviii}$—Ge3—Mn3$^{xxi}$ | 116.482 (8) |

| | | | |
|---|---|---|---|
| Co6$^{vii}$—Co1—Mn3 | 63.393 (11) | Mn3—Ge3—Mn3$^{xxi}$ | 180.0 |
| Mn1$^{i}$—Co1—Mn3 | 114.106 (13) | | |

Symmetry codes: (i) −*x*, −*y*+1, −*z*; (ii) −*x*, −*y*+1, *z*; (iii) −*x*+1/2, *y*+1/2, *z*+1/2; (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*+1, −*z*; (ix) *x*, *y*, −*z*; (x) *x*−1/2, −*y*+1/2, *z*−1/2; (xi) −*x*+1, −*y*+1, *z*; (xii) *x*+1/2, −*y*+1/2, −*z*+1/2; (xiii) *x*+1/2, −*y*+1/2, −*z*−1/2; (xiv) −*x*+1, −*y*, −*z*; (xv) *x*+1/2, −*y*+1/2, *z*−1/2; (xvi) −*x*+1, −*y*, *z*; (xvii) *x*, *y*, −*z*+1; (xviii) −*x*+1/2, *y*−1/2, *z*−1/2; (xix) −*x*+1/2, *y*−1/2, *z*+1/2; (xx) −*x*+1/2, *y*−1/2, −*z*+1/2; (xxi) −*x*, −*y*, −*z*.

## Manganese cobalt germanide (Mn14.9Co15.5Ge6.6)

### *Crystal data*

$Mn_{29.79}Co_{30.97}Ge_{13.25}$
$M_r$ = 4422.90
Orthorhombic, *Pnnm*
*a* = 12.6427 (10) Å
*b* = 15.6725 (12) Å
*c* = 4.8374 (4) Å
*V* = 958.50 (13) Å$^3$
*Z* = 1
*F*(000) = 2005
$D_x$ = 7.662 Mg m$^{-3}$
Mo *Kα* radiation, $\lambda$ = 0.71073 Å
Cell parameters from 22326 reflections
$\theta$ = 2.1–42.4°
$\mu$ = 32.54 mm$^{-1}$
*T* = 296 K
Irregular fragment, metallic
0.03 × 0.02 × 0.01 mm

### *Data collection*

Bruker APEXII CCD diffractometer
$\varphi$ and $\omega$ scans
Absorption correction: empirical (using intensity measurements) (SADABS; Bruker, 2015)
22326 measured reflections
3686 independent reflections
3277 reflections with $I > 2\sigma(I)$
$R_{int}$ = 0.030
$\theta_{max}$ = 42.4°, $\theta_{min}$ = 2.1°
*h* = −23→23
*k* = −29→29
*l* = −9→9

### *Refinement*

Refinement on $F^2$
Least-squares matrix: full
$R[F^2 > 2\sigma(F^2)]$ = 0.022
$wR(F^2)$ = 0.052
*S* = 1.10
3686 reflections
106 parameters
0 restraints
$w = 1/[\sigma^2(F_o^2) + (0.0166P)^2 + 1.7225P]$ where $P = (F_o^2 + 2F_c^2)/3$
$(\Delta/\sigma)_{max}$ = 0.002
$\Delta\rho_{max}$ = 1.24 e Å$^{-3}$
$\Delta\rho_{min}$ = −0.92 e Å$^{-3}$

### *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.

**Refinement**. Crystals were picked up from the Mn–Co–Ge alloys by fragmentation and analyzed. A Bruker D8 single-crystal X-ray diffractometer with Mo *Kα* radiation ($\lambda$ = 0.71073 Å) upgraded with an Incoatec Microfocus Source (I$\mu$S, beam size ~ 100$\mu$m at the sample position) and an APEXII CCD area detector (6 × 6 cm) was used to collect single-crystal X-ray diffraction (SCXRD) intensities at room temperature. SCXRD data reduction and numerical absorption corrections were performed using the *APEX3* software from Bruker (2014). A preliminary ordered model ($Mn_{14}Co_{18}Ge_5$) of the crystal structure was first obtained with the program *SHELXT2014* (Sheldrick, 2015a) and refined using the program *SHELXL2014* (Sheldrick, 2015b) within the *APEX3* software package. The final cycle of refinement was carried out anisotropically for all species converging with low residuals and a flat difference Fourier map. The atomic positions were standardized with the use of the program *STRUCTURE TIDY* implemented in *PLATON* (Spek, 2020). Further data, in the form of a CIF file, have been sent to the Cambridge Crystallographic Data Centre (CCDC) (Groom *et al.*, 2016). CIF files are available as supplementary material for the publication. Molecular graphics made in *DIAMOND* (Brandenburg & Putz, 2005).

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

| | *x* | *y* | *z* | $U_{iso}$*/$U_{eq}$ | Occ. (<1) |
|---|---|---|---|---|---|
| Mn1 | 0.02665 (3) | 0.57115 (2) | 0.000000 | 0.00762 (5) | |
| Mn2 | 0.08586 (3) | 0.73416 (2) | 0.000000 | 0.00681 (5) | |
| Mn3 | 0.10176 (3) | 0.16147 (2) | 0.000000 | 0.00729 (5) | |
| Mn4 | 0.22070 (3) | 0.44440 (2) | 0.000000 | 0.00763 (5) | |
| Mn5 | 0.28518 (3) | 0.26433 (2) | 0.000000 | 0.00710 (5) | |
| Mn6 | 0.40147 (3) | 0.54997 (2) | 0.000000 | 0.00673 (5) | |
| Mn7 | 0.59950 (3) | 0.02711 (2) | 0.000000 | 0.00717 (5) | |
| Co1 | 0.10076 (2) | 0.32411 (2) | 0.23460 (4) | 0.00519 (4) | 0.876 (12) |
| Mn11 | 0.10076 (2) | 0.32411 (2) | 0.23460 (4) | 0.00519 (4) | 0.124 (12) |
| Co2 | 0.28921 (2) | 0.10244 (2) | 0.25373 (4) | 0.00601 (5) | 0.594 (5) |
| Ge22 | 0.28921 (2) | 0.10244 (2) | 0.25373 (4) | 0.00601 (5) | 0.406 (5) |
| Co3 | 0.41242 (2) | 0.39078 (2) | 0.24024 (4) | 0.00525 (4) | 0.9 |
| Mn33 | 0.41242 (2) | 0.39078 (2) | 0.24024 (4) | 0.00525 (4) | 0.1 |
| Co4 | 0.19010 (2) | 0.00139 (2) | 0.000000 | 0.00605 (5) | |
| Co5 | 0.44439 (2) | 0.13693 (2) | 0.000000 | 0.00660 (5) | |
| Co6 | 0.69785 (2) | 0.29091 (2) | 0.000000 | 0.00626 (5) | |
| Ge1 | 0.50766 (2) | 0.28512 (2) | 0.000000 | 0.00626 (4) | |
| Ge2 | 0.75789 (2) | 0.14623 (2) | 0.000000 | 0.00624 (4) | |
| Ge3 | 0.000000 | 0.000000 | 0.000000 | 0.00616 (5) | |

*Atomic displacement parameters (Å²)*

| | $U^{11}$ | $U^{22}$ | $U^{33}$ | $U^{12}$ | $U^{13}$ | $U^{23}$ |
|---|---|---|---|---|---|---|
| Mn1 | 0.00776 (12) | 0.00632 (11) | 0.00877 (12) | −0.00090 (10) | 0.000 | 0.000 |
| Mn2 | 0.00568 (11) | 0.00643 (11) | 0.00831 (12) | −0.00049 (9) | 0.000 | 0.000 |
| Mn3 | 0.00671 (12) | 0.00690 (12) | 0.00826 (11) | 0.00025 (9) | 0.000 | 0.000 |
| Mn4 | 0.00888 (13) | 0.00681 (11) | 0.00721 (12) | −0.00104 (10) | 0.000 | 0.000 |
| Mn5 | 0.00615 (12) | 0.00746 (11) | 0.00771 (12) | 0.00006 (9) | 0.000 | 0.000 |
| Mn6 | 0.00600 (11) | 0.00692 (12) | 0.00728 (11) | 0.00017 (9) | 0.000 | 0.000 |
| Mn7 | 0.00517 (11) | 0.00606 (12) | 0.01029 (12) | −0.00008 (9) | 0.000 | 0.000 |
| Co1 | 0.00467 (8) | 0.00666 (8) | 0.00424 (7) | −0.00006 (6) | 0.00005 (6) | 0.00053 (5) |
| Mn11 | 0.00467 (8) | 0.00666 (8) | 0.00424 (7) | −0.00006 (6) | 0.00005 (6) | 0.00053 (5) |
| Co2 | 0.00573 (8) | 0.00671 (8) | 0.00560 (7) | −0.00075 (5) | 0.00089 (5) | −0.00113 (5) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Ge22 | 0.00573 (8) | 0.00671 (8) | 0.00560 (7) | −0.00075 (5) | 0.00089 (5) | −0.00113 (5) |
| Co3 | 0.00542 (7) | 0.00591 (8) | 0.00442 (7) | 0.00017 (6) | 0.00076 (5) | −0.00078 (5) |
| Mn33 | 0.00542 (7) | 0.00591 (8) | 0.00442 (7) | 0.00017 (6) | 0.00076 (5) | −0.00078 (5) |
| Co4 | 0.00450 (10) | 0.00521 (10) | 0.00844 (11) | −0.00084 (8) | 0.000 | 0.000 |
| Co5 | 0.00448 (10) | 0.00723 (11) | 0.00807 (11) | −0.00127 (8) | 0.000 | 0.000 |
| Co6 | 0.00516 (10) | 0.00540 (10) | 0.00824 (11) | −0.00066 (8) | 0.000 | 0.000 |
| Ge1 | 0.00568 (8) | 0.00574 (8) | 0.00735 (8) | 0.00174 (6) | 0.000 | 0.000 |
| Ge2 | 0.00424 (8) | 0.00610 (8) | 0.00838 (8) | 0.00089 (6) | 0.000 | 0.000 |
| Ge3 | 0.00428 (11) | 0.00669 (12) | 0.00750 (11) | 0.00157 (9) | 0.000 | 0.000 |

*Geometric parameters (Å, º)*

| | | | |
|---|---|---|---|
| Mn1—Mn1$^{i}$ | 2.3298 (7) | Mn5—Co3$^{ix}$ | 2.8046 (4) |
| Mn1—Co1$^{ii}$ | 2.5646 (4) | Mn5—Co3 | 2.8046 (4) |
| Mn1—Co1$^{i}$ | 2.5646 (4) | Mn5—Ge2$^{vii}$ | 2.8167 (3) |
| Mn1—Co5$^{iii}$ | 2.6546 (3) | Mn5—Ge2$^{vi}$ | 2.8167 (3) |
| Mn1—Co5$^{iv}$ | 2.6546 (3) | Mn5—Co2$^{ix}$ | 2.8190 (4) |
| Mn1—Co2$^{v}$ | 2.6607 (4) | Mn5—Co2 | 2.8190 (4) |
| Mn1—Co2$^{iv}$ | 2.6607 (4) | Mn6—Co3$^{ix}$ | 2.7556 (4) |
| Mn1—Mn2 | 2.6621 (5) | Mn6—Co3 | 2.7556 (4) |
| Mn1—Mn7$^{iv}$ | 2.9783 (3) | Mn6—Co3$^{x}$ | 2.7837 (4) |
| Mn1—Mn7$^{iii}$ | 2.9783 (3) | Mn6—Co3$^{viii}$ | 2.7837 (4) |
| Mn1—Mn7$^{vi}$ | 3.0117 (3) | Mn6—Co4$^{iv}$ | 2.7875 (3) |
| Mn1—Mn7$^{vii}$ | 3.0117 (3) | Mn6—Co4$^{iii}$ | 2.7875 (3) |
| Mn2—Ge2$^{viii}$ | 2.7233 (4) | Mn6—Co6$^{viii}$ | 2.7922 (5) |
| Mn2—Co3$^{v}$ | 2.7577 (4) | Mn6—Co2$^{iv}$ | 2.8120 (4) |
| Mn2—Co3$^{iv}$ | 2.7577 (4) | Mn6—Co2$^{v}$ | 2.8120 (4) |
| Mn2—Co6$^{viii}$ | 2.7626 (5) | Mn6—Ge1$^{viii}$ | 2.8284 (5) |
| Mn2—Co1$^{i}$ | 2.7728 (4) | Mn7—Co5 | 2.6091 (5) |
| Mn2—Co1$^{ii}$ | 2.7728 (4) | Mn7—Co5$^{xi}$ | 2.6301 (5) |
| Mn2—Ge1$^{iv}$ | 2.8082 (3) | Mn7—Mn7$^{xi}$ | 2.6556 (7) |
| Mn2—Ge1$^{iii}$ | 2.8082 (3) | Mn7—Co1$^{xii}$ | 2.6618 (4) |
| Mn2—Co2$^{iv}$ | 2.8593 (4) | Mn7—Co1$^{xiii}$ | 2.6618 (4) |
| Mn2—Co2$^{v}$ | 2.8593 (4) | Mn7—Co4$^{xi}$ | 2.6973 (5) |
| Mn2—Mn3$^{i}$ | 2.8813 (5) | Mn7—Ge2 | 2.7377 (4) |
| Mn3—Co4 | 2.7461 (5) | Mn7—Co2$^{xi}$ | 2.7584 (4) |
| Mn3—Co1 | 2.7903 (4) | Mn7—Co2$^{xiv}$ | 2.7584 (4) |
| Mn3—Co1$^{ix}$ | 2.7903 (4) | Co1—Co1$^{ix}$ | 2.2697 (4) |
| Mn3—Co6$^{vii}$ | 2.8077 (3) | Co1—Ge2$^{vii}$ | 2.4105 (3) |
| Mn3—Co6$^{vi}$ | 2.8077 (3) | Co1—Co5$^{vii}$ | 2.4350 (3) |
| Mn3—Ge1$^{vi}$ | 2.8224 (3) | Co1—Ge1$^{vii}$ | 2.4422 (3) |
| Mn3—Ge1$^{vii}$ | 2.8224 (3) | Co1—Co6$^{vii}$ | 2.5307 (3) |
| Mn3—Mn5 | 2.8243 (5) | Co1—Co1$^{xv}$ | 2.5677 (4) |
| Mn3—Co2$^{ix}$ | 2.8247 (4) | Co2—Co6$^{vii}$ | 2.3552 (3) |
| Mn3—Co2 | 2.8247 (4) | Co2—Co4 | 2.3632 (3) |
| Mn4—Co1$^{ix}$ | 2.6723 (4) | Co2—Co5 | 2.3765 (3) |
| Mn4—Co1 | 2.6723 (4) | Co2—Co2$^{xv}$ | 2.3826 (4) |
| Mn4—Co2$^{v}$ | 2.7514 (4) | Co2—Co2$^{ix}$ | 2.4548 (4) |

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|---|---|---|---|
| Mn4—Co2$^{iv}$ | 2.7514 (4) | Co3—Co3$^{ix}$ | 2.3242 (4) |
| Mn4—Co4$^{iii}$ | 2.8142 (3) | Co3—Ge1 | 2.3543 (3) |
| Mn4—Co4$^{iv}$ | 2.8142 (3) | Co3—Ge2$^{vii}$ | 2.3942 (3) |
| Mn4—Co3$^{ix}$ | 2.8162 (4) | Co3—Ge3$^{xii}$ | 2.3948 (2) |
| Mn4—Co3 | 2.8163 (4) | Co3—Co4$^{iii}$ | 2.5028 (3) |
| Mn4—Mn6 | 2.8215 (5) | Co3—Co3$^{xv}$ | 2.5132 (4) |
| Mn4—Ge2$^{vi}$ | 2.8441 (3) | Co4—Ge3 | 2.4035 (4) |
| Mn5—Co1$^{ix}$ | 2.7571 (4) | Co4—Ge2$^{xi}$ | 2.4053 (4) |
| Mn5—Co1 | 2.7571 (4) | Co5—Ge1 | 2.4564 (4) |
| Mn5—Co6$^{vi}$ | 2.7962 (3) | Co6—Ge2 | 2.3911 (4) |
| Mn5—Co6$^{vii}$ | 2.7962 (3) | Co6—Ge1 | 2.4063 (4) |

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|---|---|---|---|
| Mn1$^{i}$—Mn1—Co1$^{ii}$ | 115.53 (2) | Co6$^{vii}$—Co2—Mn7$^{xi}$ | 176.035 (10) |
| Mn1$^{i}$—Mn1—Co1$^{i}$ | 115.53 (2) | Co4—Co2—Mn7$^{xi}$ | 63.003 (11) |
| Co1$^{ii}$—Mn1—Co1$^{i}$ | 52.528 (12) | Co5—Co2—Mn7$^{xi}$ | 61.087 (11) |
| Mn1$^{i}$—Mn1—Co5$^{iii}$ | 114.306 (10) | Co2$^{xv}$—Co2—Mn7$^{xi}$ | 116.422 (6) |
| Co1$^{ii}$—Mn1—Co5$^{iii}$ | 55.589 (9) | Co2$^{ix}$—Co2—Mn7$^{xi}$ | 63.579 (5) |
| Co1$^{i}$—Mn1—Co5$^{iii}$ | 103.961 (14) | Mn1$^{xviii}$—Co2—Mn7$^{xi}$ | 67.497 (10) |
| Mn1$^{i}$—Mn1—Co5$^{iv}$ | 114.306 (10) | Mn4$^{xviii}$—Co2—Mn7$^{xi}$ | 63.463 (9) |
| Co1$^{ii}$—Mn1—Co5$^{iv}$ | 103.961 (14) | Co6$^{vii}$—Co2—Mn6$^{xviii}$ | 64.713 (11) |
| Co1$^{i}$—Mn1—Co5$^{iv}$ | 55.589 (10) | Co4—Co2—Mn6$^{xviii}$ | 64.499 (9) |
| Co5$^{iii}$—Mn1—Co5$^{iv}$ | 131.329 (19) | Co5—Co2—Mn6$^{xviii}$ | 173.252 (10) |
| Mn1$^{i}$—Mn1—Co2$^{v}$ | 115.43 (2) | Co2$^{xv}$—Co2—Mn6$^{xviii}$ | 64.934 (5) |
| Co1$^{ii}$—Mn1—Co2$^{v}$ | 103.503 (11) | Co2$^{ix}$—Co2—Mn6$^{xviii}$ | 115.065 (5) |
| Co1$^{i}$—Mn1—Co2$^{v}$ | 129.031 (15) | Mn1$^{xviii}$—Co2—Mn6$^{xviii}$ | 120.433 (11) |
| Co5$^{iii}$—Mn1—Co2$^{v}$ | 53.118 (9) | Mn4$^{xviii}$—Co2—Mn6$^{xviii}$ | 60.936 (11) |
| Co5$^{iv}$—Mn1—Co2$^{v}$ | 102.459 (14) | Mn7$^{xi}$—Co2—Mn6$^{xviii}$ | 114.237 (12) |
| Mn1$^{i}$—Mn1—Co2$^{iv}$ | 115.43 (2) | Co6$^{vii}$—Co2—Mn5 | 64.697 (9) |
| Co1$^{ii}$—Mn1—Co2$^{iv}$ | 129.031 (15) | Co4—Co2—Mn5 | 111.558 (11) |
| Co1$^{i}$—Mn1—Co2$^{iv}$ | 103.503 (11) | Co5—Co2—Mn5 | 65.503 (11) |
| Co5$^{iii}$—Mn1—Co2$^{iv}$ | 102.459 (14) | Co2$^{xv}$—Co2—Mn5 | 115.811 (5) |
| Co5$^{iv}$—Mn1—Co2$^{iv}$ | 53.118 (9) | Co2$^{ix}$—Co2—Mn5 | 64.189 (5) |
| Co2$^{v}$—Mn1—Co2$^{iv}$ | 53.197 (11) | Mn1$^{xviii}$—Co2—Mn5 | 112.126 (12) |
| Mn1$^{i}$—Mn1—Mn2 | 179.52 (3) | Mn4$^{xviii}$—Co2—Mn5 | 176.351 (13) |
| Co1$^{ii}$—Mn1—Mn2 | 64.048 (12) | Mn7$^{xi}$—Co2—Mn5 | 118.556 (10) |
| Co1$^{i}$—Mn1—Mn2 | 64.048 (12) | Mn6$^{xviii}$—Co2—Mn5 | 115.607 (12) |
| Co5$^{iii}$—Mn1—Mn2 | 65.706 (10) | Co6$^{vii}$—Co2—Mn3 | 64.907 (9) |
| Co5$^{iv}$—Mn1—Mn2 | 65.706 (10) | Co4—Co2—Mn3 | 63.187 (12) |
| Co2$^{v}$—Mn1—Mn2 | 64.983 (11) | Co5—Co2—Mn3 | 113.187 (11) |
| Co2$^{iv}$—Mn1—Mn2 | 64.983 (11) | Co2$^{xv}$—Co2—Mn3 | 115.754 (5) |
| Mn1$^{i}$—Mn1—Mn7$^{iv}$ | 67.870 (11) | Co2$^{ix}$—Co2—Mn3 | 64.244 (6) |
| Co1$^{ii}$—Mn1—Mn7$^{iv}$ | 99.865 (14) | Mn1$^{xviii}$—Co2—Mn3 | 171.499 (13) |
| Co1$^{i}$—Mn1—Mn7$^{iv}$ | 56.811 (10) | Mn4$^{xviii}$—Co2—Mn3 | 116.408 (12) |
| Co5$^{iii}$—Mn1—Mn7$^{iv}$ | 154.660 (16) | Mn7$^{xi}$—Co2—Mn3 | 118.403 (10) |
| Co5$^{iv}$—Mn1—Mn7$^{iv}$ | 54.822 (10) | Mn6$^{xviii}$—Co2—Mn3 | 63.933 (10) |
| Co2$^{v}$—Mn1—Mn7$^{iv}$ | 151.030 (11) | Mn5—Co2—Mn3 | 60.058 (10) |
| Co2$^{iv}$—Mn1—Mn7$^{iv}$ | 98.491 (9) | Co6$^{vii}$—Co2—Mn2$^{xviii}$ | 63.112 (12) |
| Mn2—Mn1—Mn7$^{iv}$ | 111.899 (11) | Co4—Co2—Mn2$^{xviii}$ | 173.281 (9) |

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|---|---|---|---|
| $Mn1^{i}—Mn1—Mn7^{iii}$ | 67.870 (11) | $Co5—Co2—Mn2^{xviii}$ | 66.106 (9) |
| $Co1^{ii}—Mn1—Mn7^{iii}$ | 56.811 (10) | $Co2^{xv}—Co2—Mn2^{xviii}$ | 65.378 (5) |
| $Co1^{i}—Mn1—Mn7^{iii}$ | 99.865 (14) | $Co2^{ix}—Co2—Mn2^{xviii}$ | 114.623 (5) |
| $Co5^{iii}—Mn1—Mn7^{iii}$ | 54.822 (10) | $Mn1^{xviii}—Co2—Mn2^{xviii}$ | 57.534 (11) |
| $Co5^{iv}—Mn1—Mn7^{iii}$ | 154.660 (16) | $Mn4^{xviii}—Co2—Mn2^{xviii}$ | 119.653 (11) |
| $Co2^{v}—Mn1—Mn7^{iii}$ | 98.491 (9) | $Mn7^{xi}—Co2—Mn2^{xviii}$ | 115.791 (13) |
| $Co2^{iv}—Mn1—Mn7^{iii}$ | 151.030 (11) | $Mn6^{xviii}—Co2—Mn2^{xviii}$ | 120.545 (10) |
| $Mn2—Mn1—Mn7^{iii}$ | 111.899 (11) | $Mn5—Co2—Mn2^{xviii}$ | 62.713 (9) |
| $Mn7^{iv}—Mn1—Mn7^{iii}$ | 108.605 (16) | $Mn3—Co2—Mn2^{xviii}$ | 114.082 (12) |
| $Mn1^{i}—Mn1—Mn7^{vi}$ | 66.355 (11) | $Co3^{ix}—Co3—Ge1$ | 60.422 (6) |
| $Co1^{ii}—Mn1—Mn7^{vi}$ | 151.018 (12) | $Co3^{ix}—Co3—Ge2^{vii}$ | 121.656 (6) |
| $Co1^{i}—Mn1—Mn7^{vi}$ | 99.440 (9) | $Ge1—Co3—Ge2^{vii}$ | 120.393 (12) |
| $Co5^{iii}—Mn1—Mn7^{vi}$ | 152.641 (16) | $Co3^{ix}—Co3—Ge3^{xii}$ | 121.650 (6) |
| $Co5^{iv}—Mn1—Mn7^{vi}$ | 54.876 (10) | $Ge1—Co3—Ge3^{xii}$ | 121.689 (12) |
| $Co2^{v}—Mn1—Mn7^{vi}$ | 100.733 (13) | $Ge2^{vii}—Co3—Ge3^{xii}$ | 105.968 (10) |
| $Co2^{iv}—Mn1—Mn7^{vi}$ | 57.797 (9) | $Co3^{ix}—Co3—Co4^{iii}$ | 120.136 (6) |
| $Mn2—Mn1—Mn7^{vi}$ | 113.875 (11) | $Ge1—Co3—Co4^{iii}$ | 179.133 (12) |
| $Mn7^{iv}—Mn1—Mn7^{vi}$ | 52.632 (12) | $Ge2^{vii}—Co3—Co4^{iii}$ | 58.786 (10) |
| $Mn7^{iii}—Mn1—Mn7^{vi}$ | 134.225 (13) | $Ge3^{xii}—Co3—Co4^{iii}$ | 58.730 (9) |
| $Mn1^{i}—Mn1—Mn7^{vii}$ | 66.355 (12) | $Co3^{ix}—Co3—Co3^{xv}$ | 180.0 |
| $Co1^{ii}—Mn1—Mn7^{vii}$ | 99.440 (9) | $Ge1—Co3—Co3^{xv}$ | 119.578 (6) |
| $Co1^{i}—Mn1—Mn7^{vii}$ | 151.018 (12) | $Ge2^{vii}—Co3—Co3^{xv}$ | 58.342 (6) |
| $Co5^{iii}—Mn1—Mn7^{vii}$ | 54.876 (10) | $Ge3^{xii}—Co3—Co3^{xv}$ | 58.351 (5) |
| $Co5^{iv}—Mn1—Mn7^{vii}$ | 152.641 (16) | $Co4^{iii}—Co3—Co3^{xv}$ | 59.863 (6) |
| $Co2^{v}—Mn1—Mn7^{vii}$ | 57.797 (9) | $Co3^{ix}—Co3—Mn6$ | 65.056 (6) |
| $Co2^{iv}—Mn1—Mn7^{vii}$ | 100.733 (13) | $Ge1—Co3—Mn6$ | 117.022 (11) |
| $Mn2—Mn1—Mn7^{vii}$ | 113.875 (11) | $Ge2^{vii}—Co3—Mn6$ | 113.562 (12) |
| $Mn7^{iv}—Mn1—Mn7^{vii}$ | 134.225 (13) | $Ge3^{xii}—Co3—Mn6$ | 66.260 (8) |
| $Mn7^{iii}—Mn1—Mn7^{vii}$ | 52.632 (12) | $Co4^{iii}—Co3—Mn6$ | 63.811 (9) |
| $Mn7^{vi}—Mn1—Mn7^{vii}$ | 106.855 (16) | $Co3^{xv}—Co3—Mn6$ | 114.944 (6) |
| $Mn1—Mn2—Ge2^{viii}$ | 149.830 (17) | $Co3^{ix}—Co3—Mn2^{xviii}$ | 117.108 (6) |
| $Mn1—Mn2—Co3^{v}$ | 148.918 (10) | $Ge1—Co3—Mn2^{xviii}$ | 66.094 (9) |
| $Ge2^{viii}—Mn2—Co3^{v}$ | 51.797 (9) | $Ge2^{vii}—Co3—Mn2^{xviii}$ | 63.359 (10) |
| $Mn1—Mn2—Co3^{iv}$ | 148.918 (10) | $Ge3^{xii}—Co3—Mn2^{xviii}$ | 113.171 (10) |
| $Ge2^{viii}—Mn2—Co3^{iv}$ | 51.797 (9) | $Co4^{iii}—Co3—Mn2^{xviii}$ | 113.070 (11) |
| $Co3^{v}—Mn2—Co3^{iv}$ | 54.215 (12) | $Co3^{xv}—Co3—Mn2^{xviii}$ | 62.893 (6) |
| $Mn1—Mn2—Co6^{viii}$ | 98.155 (15) | $Mn6—Co3—Mn2^{xviii}$ | 176.772 (11) |
| $Ge2^{viii}—Mn2—Co6^{viii}$ | 51.675 (11) | $Co3^{ix}—Co3—Mn6^{viii}$ | 65.326 (6) |
| $Co3^{v}—Mn2—Co6^{viii}$ | 96.820 (12) | $Ge1—Co3—Mn6^{viii}$ | 66.190 (11) |
| $Co3^{iv}—Mn2—Co6^{viii}$ | 96.820 (12) | $Ge2^{vii}—Co3—Mn6^{viii}$ | 171.747 (11) |
| $Mn1—Mn2—Co1^{i}$ | 56.266 (10) | $Ge3^{xii}—Co3—Mn6^{viii}$ | 65.783 (8) |
| $Ge2^{viii}—Mn2—Co1^{i}$ | 147.559 (11) | $Co4^{iii}—Co3—Mn6^{viii}$ | 114.599 (13) |
| $Co3^{v}—Mn2—Co1^{i}$ | 119.104 (14) | $Co3^{xv}—Co3—Mn6^{viii}$ | 114.676 (5) |
| $Co3^{iv}—Mn2—Co1^{i}$ | 96.513 (10) | $Mn6—Co3—Mn6^{viii}$ | 64.175 (13) |
| $Co6^{viii}—Mn2—Co1^{i}$ | 142.693 (13) | $Mn2^{xviii}—Co3—Mn6^{viii}$ | 118.717 (12) |
| $Mn1—Mn2—Co1^{ii}$ | 56.266 (10) | $Co3^{ix}—Co3—Mn5$ | 65.520 (6) |
| $Ge2^{viii}—Mn2—Co1^{ii}$ | 147.559 (11) | $Ge1—Co3—Mn5$ | 65.905 (11) |
| $Co3^{v}—Mn2—Co1^{ii}$ | 96.513 (10) | $Ge2^{vii}—Co3—Mn5$ | 65.053 (9) |

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|---|---|---|---|
| Co3$^{iv}$—Mn2—Co1$^{ii}$ | 119.104 (14) | Ge3$^{xii}$—Co3—Mn5 | 171.003 (10) |
| Co6$^{viii}$—Mn2—Co1$^{ii}$ | 142.693 (12) | Co4$^{iii}$—Co3—Mn5 | 113.606 (13) |
| Co1$^{i}$—Mn2—Co1$^{ii}$ | 48.318 (11) | Co3$^{xv}$—Co3—Mn5 | 114.479 (5) |
| Mn1—Mn2—Ge1$^{iv}$ | 98.890 (10) | Mn6—Co3—Mn5 | 115.861 (11) |
| Ge2$^{viii}$—Mn2—Ge1$^{iv}$ | 96.295 (10) | Mn2$^{xviii}$—Co3—Mn5 | 64.174 (10) |
| Co3$^{v}$—Mn2—Ge1$^{iv}$ | 98.201 (12) | Mn6$^{viii}$—Co3—Mn5 | 123.198 (10) |
| Co3$^{iv}$—Mn2—Ge1$^{iv}$ | 50.038 (7) | Co3$^{ix}$—Co3—Mn4 | 65.628 (6) |
| Co6$^{viii}$—Mn2—Ge1$^{iv}$ | 117.206 (9) | Ge1—Co3—Mn4 | 116.509 (10) |
| Co1$^{i}$—Mn2—Ge1$^{iv}$ | 51.896 (8) | Ge2$^{vii}$—Co3—Mn4 | 65.581 (9) |
| Co1$^{ii}$—Mn2—Ge1$^{iv}$ | 95.045 (13) | Ge3$^{xii}$—Co3—Mn4 | 113.654 (10) |
| Mn1—Mn2—Ge1$^{iii}$ | 98.890 (10) | Co4$^{iii}$—Co3—Mn4 | 63.566 (9) |
| Ge2$^{viii}$—Mn2—Ge1$^{iii}$ | 96.295 (10) | Co3$^{xv}$—Co3—Mn4 | 114.370 (6) |
| Co3$^{v}$—Mn2—Ge1$^{iii}$ | 50.038 (8) | Mn6—Co3—Mn4 | 60.834 (11) |
| Co3$^{iv}$—Mn2—Ge1$^{iii}$ | 98.201 (12) | Mn2$^{xviii}$—Co3—Mn4 | 117.412 (12) |
| Co6$^{viii}$—Mn2—Ge1$^{iii}$ | 117.206 (8) | Mn6$^{viii}$—Co3—Mn4 | 117.108 (11) |
| Co1$^{i}$—Mn2—Ge1$^{iii}$ | 95.045 (12) | Mn5—Co3—Mn4 | 63.012 (11) |
| Co1$^{ii}$—Mn2—Ge1$^{iii}$ | 51.896 (8) | Co3$^{ix}$—Co3—Mn3$^{xii}$ | 116.414 (6) |
| Ge1$^{iv}$—Mn2—Ge1$^{iii}$ | 118.928 (16) | Ge1—Co3—Mn3$^{xii}$ | 65.309 (9) |
| Mn1—Mn2—Co2$^{iv}$ | 57.485 (11) | Ge2$^{vii}$—Co3—Mn3$^{xii}$ | 112.814 (11) |
| Ge2$^{viii}$—Mn2—Co2$^{iv}$ | 95.523 (13) | Ge3$^{xii}$—Co3—Mn3$^{xii}$ | 65.291 (9) |
| Co3$^{v}$—Mn2—Co2$^{iv}$ | 145.906 (15) | Co4$^{iii}$—Co3—Mn3$^{xii}$ | 114.601 (11) |
| Co3$^{iv}$—Mn2—Co2$^{iv}$ | 116.643 (10) | Co3$^{xv}$—Co3—Mn3$^{xii}$ | 63.588 (6) |
| Co6$^{viii}$—Mn2—Co2$^{iv}$ | 49.498 (9) | Mn6—Co3—Mn3$^{xii}$ | 119.512 (12) |
| Co1$^{i}$—Mn2—Co2$^{iv}$ | 93.539 (11) | Mn2$^{xviii}$—Co3—Mn3$^{xii}$ | 62.132 (11) |
| Co1$^{ii}$—Mn2—Co2$^{iv}$ | 113.751 (14) | Mn6$^{viii}$—Co3—Mn3$^{xii}$ | 64.289 (10) |
| Ge1$^{iv}$—Mn2—Co2$^{iv}$ | 94.534 (8) | Mn5—Co3—Mn3$^{xii}$ | 117.743 (12) |
| Ge1$^{iii}$—Mn2—Co2$^{iv}$ | 142.822 (11) | Mn4—Co3—Mn3$^{xii}$ | 177.948 (9) |
| Mn1—Mn2—Co2$^{v}$ | 57.485 (11) | Co2$^{ix}$—Co4—Co2 | 62.582 (12) |
| Ge2$^{viii}$—Mn2—Co2$^{v}$ | 95.523 (13) | Co2$^{ix}$—Co4—Ge3 | 122.431 (12) |
| Co3$^{v}$—Mn2—Co2$^{v}$ | 116.643 (10) | Co2—Co4—Ge3 | 122.432 (12) |
| Co3$^{iv}$—Mn2—Co2$^{v}$ | 145.906 (15) | Co2$^{ix}$—Co4—Ge2$^{xi}$ | 119.978 (13) |
| Co6$^{viii}$—Mn2—Co2$^{v}$ | 49.498 (9) | Co2—Co4—Ge2$^{xi}$ | 119.977 (13) |
| Co1$^{i}$—Mn2—Co2$^{v}$ | 113.751 (14) | Ge3—Co4—Ge2$^{xi}$ | 105.345 (12) |
| Co1$^{ii}$—Mn2—Co2$^{v}$ | 93.539 (11) | Co2$^{ix}$—Co4—Co3$^{xvii}$ | 118.553 (8) |
| Ge1$^{iv}$—Mn2—Co2$^{v}$ | 142.822 (11) | Co2—Co4—Co3$^{xvii}$ | 178.226 (13) |
| Ge1$^{iii}$—Mn2—Co2$^{v}$ | 94.534 (8) | Ge3—Co4—Co3$^{xvii}$ | 58.391 (8) |
| Co2$^{iv}$—Mn2—Co2$^{v}$ | 49.245 (10) | Ge2$^{xi}$—Co4—Co3$^{xvii}$ | 58.353 (10) |
| Mn1—Mn2—Mn3$^{i}$ | 108.261 (16) | Co2$^{ix}$—Co4—Co3$^{xix}$ | 178.226 (13) |
| Ge2$^{viii}$—Mn2—Mn3$^{i}$ | 101.909 (15) | Co2—Co4—Co3$^{xix}$ | 118.553 (8) |
| Co3$^{v}$—Mn2—Mn3$^{i}$ | 60.078 (10) | Ge3—Co4—Co3$^{xix}$ | 58.391 (8) |
| Co3$^{iv}$—Mn2—Mn3$^{i}$ | 60.078 (10) | Ge2$^{xi}$—Co4—Co3$^{xix}$ | 58.353 (10) |
| Co6$^{viii}$—Mn2—Mn3$^{i}$ | 153.584 (17) | Co3$^{xvii}$—Co4—Co3$^{xix}$ | 60.276 (12) |
| Co1$^{i}$—Mn2—Mn3$^{i}$ | 59.104 (11) | Co2$^{ix}$—Co4—Mn7$^{xi}$ | 65.676 (11) |
| Co1$^{ii}$—Mn2—Mn3$^{i}$ | 59.104 (11) | Co2—Co4—Mn7$^{xi}$ | 65.676 (11) |
| Ge1$^{iv}$—Mn2—Mn3$^{i}$ | 59.466 (8) | Ge3—Co4—Mn7$^{xi}$ | 169.945 (15) |
| Ge1$^{iii}$—Mn2—Mn3$^{i}$ | 59.466 (8) | Ge2$^{xi}$—Co4—Mn7$^{xi}$ | 64.599 (12) |
| Co2$^{iv}$—Mn2—Mn3$^{i}$ | 149.842 (10) | Co3$^{xvii}$—Co4—Mn7$^{xi}$ | 113.326 (13) |
| Co2$^{v}$—Mn2—Mn3$^{i}$ | 149.842 (10) | Co3$^{xix}$—Co4—Mn7$^{xi}$ | 113.326 (13) |

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| Co4—Mn3—Co1 | 146.763 (12) | Co2$^{ix}$—Co4—Mn3 | 66.636 (11) |
| Co4—Mn3—Co1$^{ix}$ | 146.763 (12) | Co2—Co4—Mn3 | 66.637 (11) |
| Co1—Mn3—Co1$^{ix}$ | 47.997 (11) | Ge3—Co4—Mn3 | 66.522 (10) |
| Co4—Mn3—Co6$^{vii}$ | 93.834 (11) | Ge2$^{xi}$—Co4—Mn3 | 171.867 (16) |
| Co1—Mn3—Co6$^{vii}$ | 53.753 (9) | Co3$^{xvii}$—Co4—Mn3 | 114.970 (13) |
| Co1$^{ix}$—Mn3—Co6$^{vii}$ | 96.284 (13) | Co3$^{xix}$—Co4—Mn3 | 114.970 (13) |
| Co4—Mn3—Co6$^{vi}$ | 93.834 (11) | Mn7$^{xi}$—Co4—Mn3 | 123.533 (15) |
| Co1—Mn3—Co6$^{vi}$ | 96.284 (13) | Co2$^{ix}$—Co4—Mn6$^{xvii}$ | 65.577 (10) |
| Co1$^{ix}$—Mn3—Co6$^{vi}$ | 53.753 (9) | Co2—Co4—Mn6$^{xvii}$ | 119.202 (14) |
| Co6$^{vii}$—Mn3—Co6$^{vi}$ | 118.959 (17) | Ge3—Co4—Mn6$^{xvii}$ | 65.617 (9) |
| Co4—Mn3—Ge1$^{vi}$ | 116.257 (9) | Ge2$^{xi}$—Co4—Mn6$^{xvii}$ | 112.101 (10) |
| Co1—Mn3—Ge1$^{vi}$ | 94.339 (12) | Co3$^{xvii}$—Co4—Mn6$^{xvii}$ | 62.511 (10) |
| Co1$^{ix}$—Mn3—Ge1$^{vi}$ | 51.582 (8) | Co3$^{xix}$—Co4—Mn6$^{xvii}$ | 114.188 (14) |
| Co6$^{vii}$—Mn3—Ge1$^{vi}$ | 147.326 (16) | Mn7$^{xi}$—Co4—Mn6$^{xvii}$ | 117.054 (9) |
| Co6$^{vi}$—Mn3—Ge1$^{vi}$ | 50.603 (9) | Mn3—Co4—Mn6$^{xvii}$ | 65.266 (9) |
| Co4—Mn3—Ge1$^{vii}$ | 116.257 (8) | Co2$^{ix}$—Co4—Mn6$^{xviii}$ | 119.201 (14) |
| Co1—Mn3—Ge1$^{vii}$ | 51.581 (8) | Co2—Co4—Mn6$^{xviii}$ | 65.577 (10) |
| Co1$^{ix}$—Mn3—Ge1$^{vii}$ | 94.339 (12) | Ge3—Co4—Mn6$^{xviii}$ | 65.617 (9) |
| Co6$^{vii}$—Mn3—Ge1$^{vii}$ | 50.603 (9) | Ge2$^{xi}$—Co4—Mn6$^{xviii}$ | 112.101 (10) |
| Co6$^{vi}$—Mn3—Ge1$^{vii}$ | 147.326 (16) | Co3$^{xvii}$—Co4—Mn6$^{xviii}$ | 114.188 (13) |
| Ge1$^{vi}$—Mn3—Ge1$^{vii}$ | 117.952 (15) | Co3$^{xix}$—Co4—Mn6$^{xviii}$ | 62.511 (10) |
| Co4—Mn3—Mn5 | 100.809 (15) | Mn7$^{xi}$—Co4—Mn6$^{xviii}$ | 117.054 (9) |
| Co1—Mn3—Mn5 | 58.817 (10) | Mn3—Co4—Mn6$^{xviii}$ | 65.266 (9) |
| Co1$^{ix}$—Mn3—Mn5 | 58.817 (10) | Mn6$^{xvii}$—Co4—Mn6$^{xviii}$ | 120.387 (17) |
| Co6$^{vii}$—Mn3—Mn5 | 59.534 (9) | Co2$^{ix}$—Co4—Mn4$^{xviii}$ | 116.529 (14) |
| Co6$^{vi}$—Mn3—Mn5 | 59.534 (8) | Co2—Co4—Mn4$^{xviii}$ | 63.503 (10) |
| Ge1$^{vi}$—Mn3—Mn5 | 100.181 (10) | Ge3—Co4—Mn4$^{xviii}$ | 113.442 (9) |
| Ge1$^{vii}$—Mn3—Mn5 | 100.181 (11) | Ge2$^{xi}$—Co4—Mn4$^{xviii}$ | 65.489 (9) |
| Co4—Mn3—Co2$^{ix}$ | 50.176 (9) | Co3$^{xvii}$—Co4—Mn4$^{xviii}$ | 114.783 (13) |
| Co1—Mn3—Co2$^{ix}$ | 118.666 (13) | Co3$^{xix}$—Co4—Mn4$^{xviii}$ | 63.649 (10) |
| Co1$^{ix}$—Mn3—Co2$^{ix}$ | 97.253 (10) | Mn7$^{xi}$—Co4—Mn4$^{xviii}$ | 63.400 (9) |
| Co6$^{vii}$—Mn3—Co2$^{ix}$ | 95.644 (13) | Mn3—Co4—Mn4$^{xviii}$ | 116.933 (9) |
| Co6$^{vi}$—Mn3—Co2$^{ix}$ | 49.435 (8) | Mn6$^{xvii}$—Co4—Mn4$^{xviii}$ | 177.285 (15) |
| Ge1$^{vi}$—Mn3—Co2$^{ix}$ | 94.497 (8) | Mn6$^{xviii}$—Co4—Mn4$^{xviii}$ | 60.485 (10) |
| Ge1$^{vii}$—Mn3—Co2$^{ix}$ | 145.401 (11) | Co2—Co5—Co2$^{ix}$ | 62.191 (13) |
| Mn5—Mn3—Co2$^{ix}$ | 59.872 (11) | Co2—Co5—Co1$^{xii}$ | 117.062 (9) |
| Co4—Mn3—Co2 | 50.176 (9) | Co2$^{ix}$—Co5—Co1$^{xii}$ | 178.331 (15) |
| Co1—Mn3—Co2 | 97.253 (10) | Co2—Co5—Co1$^{xiii}$ | 178.332 (15) |
| Co1$^{ix}$—Mn3—Co2 | 118.665 (13) | Co2$^{ix}$—Co5—Co1$^{xiii}$ | 117.063 (9) |
| Co6$^{vii}$—Mn3—Co2 | 49.435 (8) | Co1$^{xii}$—Co5—Co1$^{xiii}$ | 63.639 (13) |
| Co6$^{vi}$—Mn3—Co2 | 95.644 (13) | Co2—Co5—Ge1 | 118.937 (12) |
| Ge1$^{vi}$—Mn3—Co2 | 145.400 (11) | Co2$^{ix}$—Co5—Ge1 | 118.937 (12) |
| Ge1$^{vii}$—Mn3—Co2 | 94.497 (8) | Co1$^{xii}$—Co5—Ge1 | 59.904 (9) |
| Mn5—Mn3—Co2 | 59.872 (11) | Co1$^{xiii}$—Co5—Ge1 | 59.904 (9) |
| Co2$^{ix}$—Mn3—Co2 | 51.510 (11) | Co2—Co5—Mn7 | 118.064 (13) |
| Co1$^{ix}$—Mn4—Co1 | 50.260 (12) | Co2$^{ix}$—Co5—Mn7 | 118.064 (13) |
| Co1$^{ix}$—Mn4—Co2$^{v}$ | 142.479 (16) | Co1$^{xii}$—Co5—Mn7 | 63.591 (11) |
| Co1—Mn4—Co2$^{v}$ | 115.174 (11) | Co1$^{xiii}$—Co5—Mn7 | 63.591 (11) |

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| Co1$^{ix}$—Mn4—Co2$^{iv}$ | 115.174 (11) | Ge1—Co5—Mn7 | 112.269 (15) |
| Co1—Mn4—Co2$^{iv}$ | 142.478 (16) | Co2—Co5—Mn7$^{xi}$ | 66.640 (10) |
| Co2$^{v}$—Mn4—Co2$^{iv}$ | 51.314 (11) | Co2$^{ix}$—Co5—Mn7$^{xi}$ | 66.640 (10) |
| Co1$^{ix}$—Mn4—Co4$^{iii}$ | 144.716 (12) | Co1$^{xii}$—Co5—Mn7$^{xi}$ | 114.609 (13) |
| Co1—Mn4—Co4$^{iii}$ | 94.953 (8) | Co1$^{xiii}$—Co5—Mn7$^{xi}$ | 114.609 (13) |
| Co2$^{v}$—Mn4—Co4$^{iii}$ | 50.234 (8) | Ge1—Co5—Mn7$^{xi}$ | 173.179 (16) |
| Co2$^{iv}$—Mn4—Co4$^{iii}$ | 96.005 (13) | Mn7—Co5—Mn7$^{xi}$ | 60.909 (15) |
| Co1$^{ix}$—Mn4—Co4$^{iv}$ | 94.952 (9) | Co2—Co5—Mn1$^{xvii}$ | 119.743 (14) |
| Co1—Mn4—Co4$^{iv}$ | 144.716 (11) | Co2$^{ix}$—Co5—Mn1$^{xvii}$ | 63.575 (10) |
| Co2$^{v}$—Mn4—Co4$^{iv}$ | 96.005 (13) | Co1$^{xii}$—Co5—Mn1$^{xvii}$ | 117.763 (14) |
| Co2$^{iv}$—Mn4—Co4$^{iv}$ | 50.234 (8) | Co1$^{xiii}$—Co5—Mn1$^{xvii}$ | 60.331 (10) |
| Co4$^{iii}$—Mn4—Co4$^{iv}$ | 118.511 (17) | Ge1—Co5—Mn1$^{xvii}$ | 108.800 (10) |
| Co1$^{ix}$—Mn4—Co3$^{ix}$ | 95.892 (11) | Mn7—Co5—Mn1$^{xvii}$ | 68.911 (10) |
| Co1—Mn4—Co3$^{ix}$ | 116.945 (14) | Mn7$^{xi}$—Co5—Mn1$^{xvii}$ | 69.483 (10) |
| Co2$^{v}$—Mn4—Co3$^{ix}$ | 119.107 (14) | Co2—Co5—Mn1$^{xviii}$ | 63.574 (10) |
| Co2$^{iv}$—Mn4—Co3$^{ix}$ | 97.418 (10) | Co2$^{ix}$—Co5—Mn1$^{xviii}$ | 119.743 (14) |
| Co4$^{iii}$—Mn4—Co3$^{ix}$ | 95.997 (13) | Co1$^{xii}$—Co5—Mn1$^{xviii}$ | 60.331 (10) |
| Co4$^{iv}$—Mn4—Co3$^{ix}$ | 52.784 (9) | Co1$^{xiii}$—Co5—Mn1$^{xviii}$ | 117.763 (14) |
| Co1$^{ix}$—Mn4—Co3 | 116.945 (14) | Ge1—Co5—Mn1$^{xviii}$ | 108.800 (10) |
| Co1—Mn4—Co3 | 95.893 (11) | Mn7—Co5—Mn1$^{xviii}$ | 68.911 (10) |
| Co2$^{v}$—Mn4—Co3 | 97.418 (10) | Mn7$^{xi}$—Co5—Mn1$^{xviii}$ | 69.483 (10) |
| Co2$^{iv}$—Mn4—Co3 | 119.107 (14) | Mn1$^{xvii}$—Co5—Mn1$^{xviii}$ | 131.327 (19) |
| Co4$^{iii}$—Mn4—Co3 | 52.784 (9) | Co2—Co5—Mn5 | 64.791 (11) |
| Co4$^{iv}$—Mn4—Co3 | 95.997 (13) | Co2$^{ix}$—Co5—Mn5 | 64.791 (11) |
| Co3$^{ix}$—Mn4—Co3 | 48.742 (11) | Co1$^{xii}$—Co5—Mn5 | 113.564 (13) |
| Co1$^{ix}$—Mn4—Mn6 | 150.846 (10) | Co1$^{xiii}$—Co5—Mn5 | 113.564 (13) |
| Co1—Mn4—Mn6 | 150.847 (10) | Ge1—Co5—Mn5 | 64.232 (12) |
| Co2$^{v}$—Mn4—Mn6 | 60.592 (11) | Mn7—Co5—Mn5 | 176.502 (16) |
| Co2$^{iv}$—Mn4—Mn6 | 60.592 (10) | Mn7$^{xi}$—Co5—Mn5 | 122.589 (16) |
| Co4$^{iii}$—Mn4—Mn6 | 59.288 (8) | Mn1$^{xvii}$—Co5—Mn5 | 111.802 (10) |
| Co4$^{iv}$—Mn4—Mn6 | 59.288 (8) | Mn1$^{xviii}$—Co5—Mn5 | 111.802 (10) |
| Co3$^{ix}$—Mn4—Mn6 | 58.521 (11) | Co2—Co5—Mn2$^{xviii}$ | 65.012 (10) |
| Co3—Mn4—Mn6 | 58.521 (11) | Co2$^{ix}$—Co5—Mn2$^{xviii}$ | 116.346 (14) |
| Co1$^{ix}$—Mn4—Ge2$^{vi}$ | 51.708 (8) | Co1$^{xii}$—Co5—Mn2$^{xviii}$ | 62.162 (10) |
| Co1—Mn4—Ge2$^{vi}$ | 95.891 (12) | Co1$^{xiii}$—Co5—Mn2$^{xviii}$ | 114.666 (13) |
| Co2$^{v}$—Mn4—Ge2$^{vi}$ | 145.625 (11) | Ge1—Co5—Mn2$^{xviii}$ | 62.846 (9) |
| Co2$^{iv}$—Mn4—Ge2$^{vi}$ | 95.101 (8) | Mn7—Co5—Mn2$^{xviii}$ | 116.628 (9) |
| Co4$^{iii}$—Mn4—Ge2$^{vi}$ | 145.407 (16) | Mn7$^{xi}$—Co5—Mn2$^{xviii}$ | 119.241 (9) |
| Co4$^{iv}$—Mn4—Ge2$^{vi}$ | 50.310 (8) | Mn1$^{xvii}$—Co5—Mn2$^{xviii}$ | 170.950 (14) |
| Co3$^{ix}$—Mn4—Ge2$^{vi}$ | 50.043 (8) | Mn1$^{xviii}$—Co5—Mn2$^{xviii}$ | 57.275 (10) |
| Co3—Mn4—Ge2$^{vi}$ | 93.420 (12) | Mn5—Co5—Mn2$^{xviii}$ | 62.209 (9) |
| Mn6—Mn4—Ge2$^{vi}$ | 99.146 (10) | Co2$^{xii}$—Co6—Co2$^{xiii}$ | 60.771 (13) |
| Co1$^{ix}$—Mn5—Co1 | 48.611 (11) | Co2$^{xii}$—Co6—Ge2 | 121.153 (13) |
| Co1$^{ix}$—Mn5—Co6$^{vi}$ | 54.217 (9) | Co2$^{xiii}$—Co6—Ge2 | 121.153 (13) |
| Co1—Mn5—Co6$^{vi}$ | 97.317 (13) | Co2$^{xii}$—Co6—Ge1 | 121.118 (13) |
| Co1$^{ix}$—Mn5—Co6$^{vii}$ | 97.317 (13) | Co2$^{xiii}$—Co6—Ge1 | 121.118 (13) |
| Co1—Mn5—Co6$^{vii}$ | 54.217 (9) | Ge2—Co6—Ge1 | 106.347 (14) |
| Co6$^{vi}$—Mn5—Co6$^{vii}$ | 119.766 (17) | Co2$^{xii}$—Co6—Co1$^{xiii}$ | 179.649 (16) |

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| Co1$^{ix}$—Mn5—Co3$^{ix}$ | 94.265 (11) | Co2$^{xiii}$—Co6—Co1$^{xiii}$ | 119.129 (8) |
| Co1—Mn5—Co3$^{ix}$ | 114.550 (14) | Ge2—Co6—Co1$^{xiii}$ | 58.568 (10) |
| Co6$^{vi}$—Mn5—Co3$^{ix}$ | 94.982 (9) | Ge1—Co6—Co1$^{xiii}$ | 59.232 (9) |
| Co6$^{vii}$—Mn5—Co3$^{ix}$ | 143.484 (12) | Co2$^{xii}$—Co6—Co1$^{xii}$ | 119.129 (8) |
| Co1$^{ix}$—Mn5—Co3 | 114.550 (14) | Co2$^{xiii}$—Co6—Co1$^{xii}$ | 179.649 (16) |
| Co1—Mn5—Co3 | 94.266 (11) | Ge2—Co6—Co1$^{xii}$ | 58.568 (10) |
| Co6$^{vi}$—Mn5—Co3 | 143.484 (11) | Ge1—Co6—Co1$^{xii}$ | 59.232 (9) |
| Co6$^{vii}$—Mn5—Co3 | 94.982 (9) | Co1$^{xiii}$—Co6—Co1$^{xii}$ | 60.970 (12) |
| Co3$^{ix}$—Mn5—Co3 | 48.958 (11) | Co2$^{xii}$—Co6—Mn2$^{viii}$ | 67.390 (11) |
| Co1$^{ix}$—Mn5—Ge2$^{vii}$ | 94.633 (12) | Co2$^{xiii}$—Co6—Mn2$^{viii}$ | 67.390 (11) |
| Co1—Mn5—Ge2$^{vii}$ | 51.236 (8) | Ge2—Co6—Mn2$^{viii}$ | 63.315 (11) |
| Co6$^{vi}$—Mn5—Ge2$^{vii}$ | 148.049 (16) | Ge1—Co6—Mn2$^{viii}$ | 169.662 (16) |
| Co6$^{vii}$—Mn5—Ge2$^{vii}$ | 50.427 (9) | Co1$^{xiii}$—Co6—Mn2$^{viii}$ | 112.260 (13) |
| Co3$^{ix}$—Mn5—Ge2$^{vii}$ | 94.269 (12) | Co1$^{xii}$—Co6—Mn2$^{viii}$ | 112.260 (13) |
| Co3—Mn5—Ge2$^{vii}$ | 50.417 (8) | Co2$^{xii}$—Co6—Mn6$^{viii}$ | 65.585 (11) |
| Co1$^{ix}$—Mn5—Ge2$^{vi}$ | 51.235 (8) | Co2$^{xiii}$—Co6—Mn6$^{viii}$ | 65.585 (11) |
| Co1—Mn5—Ge2$^{vi}$ | 94.633 (12) | Ge2—Co6—Mn6$^{viii}$ | 171.782 (16) |
| Co6$^{vi}$—Mn5—Ge2$^{vi}$ | 50.427 (9) | Ge1—Co6—Mn6$^{viii}$ | 65.435 (12) |
| Co6$^{vii}$—Mn5—Ge2$^{vi}$ | 148.049 (16) | Co1$^{xiii}$—Co6—Mn6$^{viii}$ | 114.712 (13) |
| Co3$^{ix}$—Mn5—Ge2$^{vi}$ | 50.417 (8) | Co1$^{xii}$—Co6—Mn6$^{viii}$ | 114.712 (13) |
| Co3—Mn5—Ge2$^{vi}$ | 94.269 (12) | Mn2$^{viii}$—Co6—Mn6$^{viii}$ | 124.903 (15) |
| Ge2$^{vii}$—Mn5—Ge2$^{vi}$ | 118.343 (15) | Co2$^{xii}$—Co6—Mn5$^{xii}$ | 65.707 (10) |
| Co1$^{ix}$—Mn5—Co2$^{ix}$ | 98.158 (10) | Co2$^{xiii}$—Co6—Mn5$^{xii}$ | 117.623 (14) |
| Co1—Mn5—Co2$^{ix}$ | 120.021 (14) | Ge2—Co6—Mn5$^{xii}$ | 65.231 (9) |
| Co6$^{vi}$—Mn5—Co2$^{ix}$ | 49.596 (8) | Ge1—Co6—Mn5$^{xii}$ | 112.512 (10) |
| Co6$^{vii}$—Mn5—Co2$^{ix}$ | 96.031 (13) | Co1$^{xiii}$—Co6—Mn5$^{xii}$ | 114.191 (14) |
| Co3$^{ix}$—Mn5—Co2$^{ix}$ | 116.438 (10) | Co1$^{xii}$—Co6—Mn5$^{xii}$ | 62.104 (10) |
| Co3—Mn5—Co2$^{ix}$ | 143.712 (15) | Mn2$^{viii}$—Co6—Mn5$^{xii}$ | 64.224 (9) |
| Ge2$^{vii}$—Mn5—Co2$^{ix}$ | 145.485 (11) | Mn6$^{viii}$—Co6—Mn5$^{xii}$ | 117.008 (9) |
| Ge2$^{vi}$—Mn5—Co2$^{ix}$ | 94.371 (8) | Co2$^{xii}$—Co6—Mn5$^{xvi}$ | 117.623 (14) |
| Co1$^{ix}$—Mn5—Co2 | 120.022 (14) | Co2$^{xiii}$—Co6—Mn5$^{xvi}$ | 65.707 (10) |
| Co1—Mn5—Co2 | 98.158 (10) | Ge2—Co6—Mn5$^{xvi}$ | 65.231 (9) |
| Co6$^{vi}$—Mn5—Co2 | 96.031 (13) | Ge1—Co6—Mn5$^{xvi}$ | 112.512 (10) |
| Co6$^{vii}$—Mn5—Co2 | 49.596 (8) | Co1$^{xiii}$—Co6—Mn5$^{xvi}$ | 62.104 (10) |
| Co3$^{ix}$—Mn5—Co2 | 143.712 (15) | Co1$^{xii}$—Co6—Mn5$^{xvi}$ | 114.191 (14) |
| Co3—Mn5—Co2 | 116.437 (10) | Mn2$^{viii}$—Co6—Mn5$^{xvi}$ | 64.224 (9) |
| Ge2$^{vii}$—Mn5—Co2 | 94.372 (8) | Mn6$^{viii}$—Co6—Mn5$^{xvi}$ | 117.008 (9) |
| Ge2$^{vi}$—Mn5—Co2 | 145.485 (11) | Mn5$^{xii}$—Co6—Mn5$^{xvi}$ | 119.767 (17) |
| Co2$^{ix}$—Mn5—Co2 | 51.621 (11) | Co2$^{xii}$—Co6—Mn3$^{xvi}$ | 117.340 (14) |
| Co3$^{ix}$—Mn6—Co3 | 49.887 (11) | Co2$^{xiii}$—Co6—Mn3$^{xvi}$ | 65.657 (10) |
| Co3$^{ix}$—Mn6—Co3$^{x}$ | 115.825 (13) | Ge2—Co6—Mn3$^{xvi}$ | 112.920 (10) |
| Co3—Mn6—Co3$^{x}$ | 94.790 (11) | Ge1—Co6—Mn3$^{xvi}$ | 65.014 (9) |
| Co3$^{ix}$—Mn6—Co3$^{viii}$ | 94.791 (11) | Co1$^{xiii}$—Co6—Mn3$^{xvi}$ | 62.771 (10) |
| Co3—Mn6—Co3$^{viii}$ | 115.825 (13) | Co1$^{xii}$—Co6—Mn3$^{xvi}$ | 114.613 (14) |
| Co3$^{x}$—Mn6—Co3$^{viii}$ | 49.349 (11) | Mn2$^{viii}$—Co6—Mn3$^{xvi}$ | 117.784 (9) |
| Co3$^{ix}$—Mn6—Co4$^{iv}$ | 53.679 (8) | Mn6$^{viii}$—Co6—Mn3$^{xvi}$ | 64.403 (9) |
| Co3—Mn6—Co4$^{iv}$ | 98.022 (13) | Mn5$^{xii}$—Co6—Mn3$^{xvi}$ | 176.675 (16) |
| Co3$^{x}$—Mn6—Co4$^{iv}$ | 143.553 (11) | Mn5$^{xvi}$—Co6—Mn3$^{xvi}$ | 60.529 (10) |

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| Co3$^{viii}$—Mn6—Co4$^{iv}$ | 94.585 (9) | Co2$^{xii}$—Co6—Mn3$^{xii}$ | 65.657 (10) |
| Co3$^{ix}$—Mn6—Co4$^{iii}$ | 98.022 (13) | Co2$^{xiii}$—Co6—Mn3$^{xii}$ | 117.340 (14) |
| Co3—Mn6—Co4$^{iii}$ | 53.679 (8) | Ge2—Co6—Mn3$^{xii}$ | 112.920 (10) |
| Co3$^{x}$—Mn6—Co4$^{iii}$ | 94.585 (9) | Ge1—Co6—Mn3$^{xii}$ | 65.014 (9) |
| Co3$^{viii}$—Mn6—Co4$^{iii}$ | 143.553 (11) | Co1$^{xiii}$—Co6—Mn3$^{xii}$ | 114.613 (14) |
| Co4$^{iv}$—Mn6—Co4$^{iii}$ | 120.386 (17) | Co1$^{xii}$—Co6—Mn3$^{xii}$ | 62.771 (10) |
| Co3$^{ix}$—Mn6—Co6$^{viii}$ | 146.220 (11) | Mn2$^{viii}$—Co6—Mn3$^{xii}$ | 117.784 (9) |
| Co3—Mn6—Co6$^{viii}$ | 146.221 (11) | Mn6$^{viii}$—Co6—Mn3$^{xii}$ | 64.403 (9) |
| Co3$^{x}$—Mn6—Co6$^{viii}$ | 94.715 (13) | Mn5$^{xii}$—Co6—Mn3$^{xii}$ | 60.529 (10) |
| Co3$^{viii}$—Mn6—Co6$^{viii}$ | 94.715 (13) | Mn5$^{xvi}$—Co6—Mn3$^{xii}$ | 176.675 (16) |
| Co4$^{iv}$—Mn6—Co6$^{viii}$ | 93.274 (11) | Mn3$^{xvi}$—Co6—Mn3$^{xii}$ | 118.958 (17) |
| Co4$^{iii}$—Mn6—Co6$^{viii}$ | 93.274 (11) | Co3—Ge1—Co3$^{ix}$ | 59.156 (12) |
| Co3$^{ix}$—Mn6—Co2$^{iv}$ | 97.420 (10) | Co3—Ge1—Co6 | 118.982 (12) |
| Co3—Mn6—Co2$^{iv}$ | 119.110 (13) | Co3$^{ix}$—Ge1—Co6 | 118.983 (12) |
| Co3$^{x}$—Mn6—Co2$^{iv}$ | 143.508 (15) | Co3—Ge1—Co1$^{xiii}$ | 177.501 (10) |
| Co3$^{viii}$—Mn6—Co2$^{iv}$ | 116.758 (10) | Co3$^{ix}$—Ge1—Co1$^{xiii}$ | 118.691 (8) |
| Co4$^{iv}$—Mn6—Co2$^{iv}$ | 49.922 (8) | Co6—Ge1—Co1$^{xiii}$ | 62.922 (9) |
| Co4$^{iii}$—Mn6—Co2$^{iv}$ | 95.244 (13) | Co3—Ge1—Co1$^{xii}$ | 118.690 (8) |
| Co6$^{viii}$—Mn6—Co2$^{iv}$ | 49.700 (9) | Co3$^{ix}$—Ge1—Co1$^{xii}$ | 177.500 (10) |
| Co3$^{ix}$—Mn6—Co2$^{v}$ | 119.109 (13) | Co6—Ge1—Co1$^{xii}$ | 62.922 (10) |
| Co3—Mn6—Co2$^{v}$ | 97.421 (10) | Co1$^{xiii}$—Ge1—Co1$^{xii}$ | 63.430 (12) |
| Co3$^{x}$—Mn6—Co2$^{v}$ | 116.758 (10) | Co3—Ge1—Co5 | 119.905 (12) |
| Co3$^{viii}$—Mn6—Co2$^{v}$ | 143.508 (15) | Co3$^{ix}$—Ge1—Co5 | 119.904 (12) |
| Co4$^{iv}$—Mn6—Co2$^{v}$ | 95.243 (13) | Co6—Ge1—Co5 | 111.164 (13) |
| Co4$^{iii}$—Mn6—Co2$^{v}$ | 49.922 (8) | Co1$^{xiii}$—Ge1—Co5 | 59.614 (10) |
| Co6$^{viii}$—Mn6—Co2$^{v}$ | 49.700 (9) | Co1$^{xii}$—Ge1—Co5 | 59.614 (10) |
| Co2$^{iv}$—Mn6—Co2$^{v}$ | 50.131 (11) | Co3—Ge1—Mn2$^{xvii}$ | 114.197 (12) |
| Co3$^{ix}$—Mn6—Mn4 | 60.644 (11) | Co3$^{ix}$—Ge1—Mn2$^{xvii}$ | 63.868 (10) |
| Co3—Mn6—Mn4 | 60.645 (11) | Co6—Ge1—Mn2$^{xvii}$ | 115.560 (9) |
| Co3$^{x}$—Mn6—Mn4 | 151.676 (9) | Co1$^{xiii}$—Ge1—Mn2$^{xvii}$ | 63.308 (10) |
| Co3$^{viii}$—Mn6—Mn4 | 151.676 (9) | Co1$^{xii}$—Ge1—Mn2$^{xvii}$ | 117.153 (12) |
| Co4$^{iv}$—Mn6—Mn4 | 60.226 (8) | Co5—Ge1—Mn2$^{xvii}$ | 66.048 (8) |
| Co4$^{iii}$—Mn6—Mn4 | 60.226 (9) | Co3—Ge1—Mn2$^{xviii}$ | 63.868 (10) |
| Co6$^{viii}$—Mn6—Mn4 | 99.175 (15) | Co3$^{ix}$—Ge1—Mn2$^{xviii}$ | 114.196 (13) |
| Co2$^{iv}$—Mn6—Mn4 | 58.470 (11) | Co6—Ge1—Mn2$^{xviii}$ | 115.560 (9) |
| Co2$^{v}$—Mn6—Mn4 | 58.470 (11) | Co1$^{xiii}$—Ge1—Mn2$^{xviii}$ | 117.153 (12) |
| Co3$^{ix}$—Mn6—Ge1$^{viii}$ | 143.795 (12) | Co1$^{xii}$—Ge1—Mn2$^{xviii}$ | 63.308 (10) |
| Co3—Mn6—Ge1$^{viii}$ | 143.795 (12) | Co5—Ge1—Mn2$^{xviii}$ | 66.048 (9) |
| Co3$^{x}$—Mn6—Ge1$^{viii}$ | 49.600 (8) | Mn2$^{xvii}$—Ge1—Mn2$^{xviii}$ | 118.929 (16) |
| Co3$^{viii}$—Mn6—Ge1$^{viii}$ | 49.600 (8) | Co3—Ge1—Mn3$^{xii}$ | 65.413 (10) |
| Co4$^{iv}$—Mn6—Ge1$^{viii}$ | 114.724 (9) | Co3$^{ix}$—Ge1—Mn3$^{xii}$ | 115.463 (12) |
| Co4$^{iii}$—Mn6—Ge1$^{viii}$ | 114.724 (9) | Co6—Ge1—Mn3$^{xii}$ | 64.381 (8) |
| Co6$^{viii}$—Mn6—Ge1$^{viii}$ | 50.690 (11) | Co1$^{xiii}$—Ge1—Mn3$^{xii}$ | 117.081 (12) |
| Co2$^{iv}$—Mn6—Ge1$^{viii}$ | 94.643 (12) | Co1$^{xii}$—Ge1—Mn3$^{xii}$ | 63.529 (10) |
| Co2$^{v}$—Mn6—Ge1$^{viii}$ | 94.643 (12) | Co5—Ge1—Mn3$^{xii}$ | 114.688 (9) |
| Mn4—Mn6—Ge1$^{viii}$ | 149.866 (16) | Mn2$^{xvii}$—Ge1—Mn3$^{xii}$ | 179.256 (13) |
| Co5—Mn7—Co5$^{xi}$ | 119.090 (15) | Mn2$^{xviii}$—Ge1—Mn3$^{xii}$ | 61.556 (10) |
| Co5—Mn7—Mn7$^{xi}$ | 59.937 (15) | Co3—Ge1—Mn3$^{xvi}$ | 115.463 (13) |

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| Co5$^{xi}$—Mn7—Mn7$^{xi}$ | 59.153 (14) | Co3$^{ix}$—Ge1—Mn3$^{xvi}$ | 65.414 (10) |
| Co5—Mn7—Co1$^{xii}$ | 55.019 (10) | Co6—Ge1—Mn3$^{xvi}$ | 64.381 (9) |
| Co5$^{xi}$—Mn7—Co1$^{xii}$ | 149.038 (8) | Co1$^{xiii}$—Ge1—Mn3$^{xvi}$ | 63.529 (10) |
| Mn7$^{xi}$—Mn7—Co1$^{xii}$ | 106.620 (16) | Co1$^{xii}$—Ge1—Mn3$^{xvi}$ | 117.081 (12) |
| Co5—Mn7—Co1$^{xiii}$ | 55.018 (10) | Co5—Ge1—Mn3$^{xvi}$ | 114.688 (9) |
| Co5$^{xi}$—Mn7—Co1$^{xiii}$ | 149.038 (8) | Mn2$^{xvii}$—Ge1—Mn3$^{xvi}$ | 61.556 (10) |
| Mn7$^{xi}$—Mn7—Co1$^{xiii}$ | 106.620 (16) | Mn2$^{xviii}$—Ge1—Mn3$^{xvi}$ | 179.256 (13) |
| Co1$^{xii}$—Mn7—Co1$^{xiii}$ | 57.676 (12) | Mn3$^{xii}$—Ge1—Mn3$^{xvi}$ | 117.953 (16) |
| Co5—Mn7—Co4$^{xi}$ | 148.264 (17) | Co3—Ge1—Mn6$^{viii}$ | 64.211 (10) |
| Co5$^{xi}$—Mn7—Co4$^{xi}$ | 92.646 (14) | Co3$^{ix}$—Ge1—Mn6$^{viii}$ | 64.212 (10) |
| Mn7$^{xi}$—Mn7—Co4$^{xi}$ | 151.80 (2) | Co6—Ge1—Mn6$^{viii}$ | 63.874 (12) |
| Co1$^{xii}$—Mn7—Co4$^{xi}$ | 98.002 (12) | Co1$^{xiii}$—Ge1—Mn6$^{viii}$ | 116.408 (12) |
| Co1$^{xiii}$—Mn7—Co4$^{xi}$ | 98.002 (12) | Co1$^{xii}$—Ge1—Mn6$^{viii}$ | 116.408 (12) |
| Co5—Mn7—Ge2 | 95.736 (15) | Co5—Ge1—Mn6$^{viii}$ | 175.038 (14) |
| Co5$^{xi}$—Mn7—Ge2 | 145.174 (16) | Mn2$^{xvii}$—Ge1—Mn6$^{viii}$ | 115.523 (8) |
| Mn7$^{xi}$—Mn7—Ge2 | 155.67 (2) | Mn2$^{xviii}$—Ge1—Mn6$^{viii}$ | 115.523 (9) |
| Co1$^{xii}$—Mn7—Ge2 | 53.008 (9) | Mn3$^{xii}$—Ge1—Mn6$^{viii}$ | 63.754 (8) |
| Co1$^{xiii}$—Mn7—Ge2 | 53.008 (9) | Mn3$^{xvi}$—Ge1—Mn6$^{viii}$ | 63.754 (8) |
| Co4$^{xi}$—Mn7—Ge2 | 52.528 (11) | Co6—Ge2—Co3$^{xii}$ | 119.262 (11) |
| Co5—Mn7—Co2$^{xi}$ | 150.333 (9) | Co6—Ge2—Co3$^{xiii}$ | 119.262 (11) |
| Co5$^{xi}$—Mn7—Co2$^{xi}$ | 52.274 (10) | Co3$^{xii}$—Ge2—Co3$^{xiii}$ | 63.317 (13) |
| Mn7$^{xi}$—Mn7—Co2$^{xi}$ | 104.340 (17) | Co6—Ge2—Co4$^{xi}$ | 177.355 (15) |
| Co1$^{xii}$—Mn7—Co2$^{xi}$ | 148.909 (15) | Co3$^{xii}$—Ge2—Co4$^{xi}$ | 62.862 (9) |
| Co1$^{xiii}$—Mn7—Co2$^{xi}$ | 115.285 (9) | Co3$^{xiii}$—Ge2—Co4$^{xi}$ | 62.862 (9) |
| Co4$^{xi}$—Mn7—Co2$^{xi}$ | 51.319 (9) | Co6—Ge2—Co1$^{xiii}$ | 63.612 (9) |
| Ge2—Mn7—Co2$^{xi}$ | 97.402 (13) | Co3$^{xii}$—Ge2—Co1$^{xiii}$ | 177.092 (13) |
| Co5—Mn7—Co2$^{xiv}$ | 150.333 (9) | Co3$^{xiii}$—Ge2—Co1$^{xiii}$ | 116.081 (9) |
| Co5$^{xi}$—Mn7—Co2$^{xiv}$ | 52.274 (10) | Co4$^{xi}$—Ge2—Co1$^{xiii}$ | 114.252 (11) |
| Mn7$^{xi}$—Mn7—Co2$^{xiv}$ | 104.340 (17) | Co6—Ge2—Co1$^{xii}$ | 63.612 (9) |
| Co1$^{xii}$—Mn7—Co2$^{xiv}$ | 115.285 (10) | Co3$^{xii}$—Ge2—Co1$^{xii}$ | 116.081 (9) |
| Co1$^{xiii}$—Mn7—Co2$^{xiv}$ | 148.909 (15) | Co3$^{xiii}$—Ge2—Co1$^{xii}$ | 177.092 (13) |
| Co4$^{xi}$—Mn7—Co2$^{xiv}$ | 51.319 (9) | Co4$^{xi}$—Ge2—Co1$^{xii}$ | 114.252 (11) |
| Ge2—Mn7—Co2$^{xiv}$ | 97.402 (13) | Co1$^{xiii}$—Ge2—Co1$^{xii}$ | 64.363 (13) |
| Co2$^{xi}$—Mn7—Co2$^{xiv}$ | 52.842 (11) | Co6—Ge2—Mn2$^{viii}$ | 65.009 (13) |
| Co5—Mn7—Mn4$^{xii}$ | 107.205 (11) | Co3$^{xii}$—Ge2—Mn2$^{viii}$ | 64.843 (11) |
| Co5$^{xi}$—Mn7—Mn4$^{xii}$ | 105.200 (11) | Co3$^{xiii}$—Ge2—Mn2$^{viii}$ | 64.843 (10) |
| Mn7$^{xi}$—Mn7—Mn4$^{xii}$ | 123.386 (9) | Co4$^{xi}$—Ge2—Mn2$^{viii}$ | 117.636 (14) |
| Co1$^{xii}$—Mn7—Mn4$^{xii}$ | 57.268 (9) | Co1$^{xiii}$—Ge2—Mn2$^{viii}$ | 117.714 (12) |
| Co1$^{xiii}$—Mn7—Mn4$^{xii}$ | 105.334 (13) | Co1$^{xii}$—Ge2—Mn2$^{viii}$ | 117.714 (12) |
| Co4$^{xi}$—Mn7—Mn4$^{xii}$ | 60.267 (9) | Co6—Ge2—Mn7 | 114.484 (14) |
| Ge2—Mn7—Mn4$^{xii}$ | 60.538 (9) | Co3$^{xii}$—Ge2—Mn7 | 115.570 (12) |
| Co2$^{xi}$—Mn7—Mn4$^{xii}$ | 102.420 (13) | Co3$^{xiii}$—Ge2—Mn7 | 115.570 (12) |
| Co2$^{xiv}$—Mn7—Mn4$^{xii}$ | 58.150 (10) | Co4$^{xi}$—Ge2—Mn7 | 62.872 (12) |
| Co5—Mn7—Mn4$^{xvi}$ | 107.205 (11) | Co1$^{xiii}$—Ge2—Mn7 | 61.881 (10) |
| Co5$^{xi}$—Mn7—Mn4$^{xvi}$ | 105.200 (11) | Co1$^{xii}$—Ge2—Mn7 | 61.881 (10) |
| Mn7$^{xi}$—Mn7—Mn4$^{xvi}$ | 123.386 (9) | Mn2$^{viii}$—Ge2—Mn7 | 179.493 (13) |
| Co1$^{xii}$—Mn7—Mn4$^{xvi}$ | 105.334 (13) | Co6—Ge2—Mn5$^{xii}$ | 64.342 (8) |
| Co1$^{xiii}$—Mn7—Mn4$^{xvi}$ | 57.268 (9) | Co3$^{xii}$—Ge2—Mn5$^{xii}$ | 64.529 (9) |

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| $Co4^{xi}$—Mn7—$Mn4^{xvi}$ | 60.267 (9) | $Co3^{xiii}$—Ge2—$Mn5^{xii}$ | 118.121 (13) |
| Ge2—Mn7—$Mn4^{xvi}$ | 60.538 (9) | $Co4^{xi}$—Ge2—$Mn5^{xii}$ | 116.436 (8) |
| $Co2^{xi}$—Mn7—$Mn4^{xvi}$ | 58.150 (9) | $Co1^{xiii}$—Ge2—$Mn5^{xii}$ | 117.538 (12) |
| $Co2^{xiv}$—Mn7—$Mn4^{xvi}$ | 102.420 (13) | $Co1^{xii}$—Ge2—$Mn5^{xii}$ | 63.105 (10) |
| $Mn4^{xii}$—Mn7—$Mn4^{xvi}$ | 113.160 (17) | $Mn2^{viii}$—Ge2—$Mn5^{xii}$ | 64.445 (8) |
| Co5—Mn7—$Mn1^{xvii}$ | 56.266 (8) | Mn7—Ge2—$Mn5^{xii}$ | 115.399 (9) |
| $Co5^{xi}$—Mn7—$Mn1^{xvii}$ | 96.518 (11) | Co6—Ge2—$Mn5^{xvi}$ | 64.342 (8) |
| $Mn7^{xi}$—Mn7—$Mn1^{xvii}$ | 64.331 (10) | $Co3^{xii}$—Ge2—$Mn5^{xvi}$ | 118.121 (12) |
| $Co1^{xii}$—Mn7—$Mn1^{xvii}$ | 101.065 (13) | $Co3^{xiii}$—Ge2—$Mn5^{xvi}$ | 64.529 (9) |
| $Co1^{xiii}$—Mn7—$Mn1^{xvii}$ | 53.737 (9) | $Co4^{xi}$—Ge2—$Mn5^{xvi}$ | 116.436 (9) |
| $Co4^{xi}$—Mn7—$Mn1^{xvii}$ | 124.506 (8) | $Co1^{xiii}$—Ge2—$Mn5^{xvi}$ | 63.105 (10) |
| Ge2—Mn7—$Mn1^{xvii}$ | 103.513 (11) | $Co1^{xii}$—Ge2—$Mn5^{xvi}$ | 117.538 (12) |
| $Co2^{xi}$—Mn7—$Mn1^{xvii}$ | 94.725 (9) | $Mn2^{viii}$—Ge2—$Mn5^{xvi}$ | 64.445 (9) |
| $Co2^{xiv}$—Mn7—$Mn1^{xvii}$ | 143.619 (13) | Mn7—Ge2—$Mn5^{xvi}$ | 115.399 (9) |
| $Mn4^{xii}$—Mn7—$Mn1^{xvii}$ | 157.713 (16) | $Mn5^{xii}$—Ge2—$Mn5^{xvi}$ | 118.342 (15) |
| $Mn4^{xvi}$—Mn7—$Mn1^{xvii}$ | 64.509 (10) | Co6—Ge2—$Mn4^{xvi}$ | 114.905 (9) |
| $Co1^{ix}$—Co1—$Ge2^{vii}$ | 122.180 (6) | $Co3^{xii}$—Ge2—$Mn4^{xvi}$ | 117.402 (12) |
| $Co1^{ix}$—Co1—$Co5^{vii}$ | 121.821 (7) | $Co3^{xiii}$—Ge2—$Mn4^{xvi}$ | 64.375 (10) |
| $Ge2^{vii}$—Co1—$Co5^{vii}$ | 109.870 (11) | $Co4^{xi}$—Ge2—$Mn4^{xvi}$ | 64.201 (9) |
| $Co1^{ix}$—Co1—$Ge1^{vii}$ | 121.716 (6) | $Co1^{xiii}$—Ge2—$Mn4^{xvi}$ | 60.469 (9) |
| $Ge2^{vii}$—Co1—$Ge1^{vii}$ | 104.617 (10) | $Co1^{xii}$—Ge2—$Mn4^{xvi}$ | 114.394 (13) |
| $Co5^{vii}$—Co1—$Ge1^{vii}$ | 60.484 (11) | $Mn2^{viii}$—Ge2—$Mn4^{xvi}$ | 117.625 (9) |
| $Co1^{ix}$—Co1—$Co6^{vii}$ | 120.484 (6) | Mn7—Ge2—$Mn4^{xvi}$ | 62.518 (9) |
| $Ge2^{vii}$—Co1—$Co6^{vii}$ | 57.820 (10) | $Mn5^{xii}$—Ge2—$Mn4^{xvi}$ | 177.498 (13) |
| $Co5^{vii}$—Co1—$Co6^{vii}$ | 107.755 (11) | $Mn5^{xvi}$—Ge2—$Mn4^{xvi}$ | 62.516 (10) |
| $Ge1^{vii}$—Co1—$Co6^{vii}$ | 57.844 (11) | Co6—Ge2—$Mn4^{xii}$ | 114.905 (9) |
| $Co1^{ix}$—Co1—$Mn1^{i}$ | 63.736 (6) | $Co3^{xii}$—Ge2—$Mn4^{xii}$ | 64.375 (10) |
| $Ge2^{vii}$—Co1—$Mn1^{i}$ | 129.042 (13) | $Co3^{xiii}$—Ge2—$Mn4^{xii}$ | 117.402 (12) |
| $Co5^{vii}$—Co1—$Mn1^{i}$ | 64.080 (9) | $Co4^{xi}$—Ge2—$Mn4^{xii}$ | 64.201 (8) |
| $Ge1^{vii}$—Co1—$Mn1^{i}$ | 112.246 (13) | $Co1^{xiii}$—Ge2—$Mn4^{xii}$ | 114.394 (13) |
| $Co6^{vii}$—Co1—$Mn1^{i}$ | 170.084 (13) | $Co1^{xii}$—Ge2—$Mn4^{xii}$ | 60.469 (9) |
| $Co1^{ix}$—Co1—$Co1^{xv}$ | 180.0 | $Mn2^{viii}$—Ge2—$Mn4^{xii}$ | 117.625 (9) |
| $Ge2^{vii}$—Co1—$Co1^{xv}$ | 57.818 (6) | Mn7—Ge2—$Mn4^{xii}$ | 62.518 (8) |
| $Co5^{vii}$—Co1—$Co1^{xv}$ | 58.180 (7) | $Mn5^{xii}$—Ge2—$Mn4^{xii}$ | 62.516 (10) |
| $Ge1^{vii}$—Co1—$Co1^{xv}$ | 58.285 (6) | $Mn5^{xvi}$—Ge2—$Mn4^{xii}$ | 177.498 (13) |
| $Co6^{vii}$—Co1—$Co1^{xv}$ | 59.515 (6) | $Mn4^{xvi}$—Ge2—$Mn4^{xii}$ | 116.520 (15) |
| $Mn1^{i}$—Co1—$Co1^{xv}$ | 116.265 (6) | $Co3^{xvii}$—Ge3—$Co3^{vii}$ | 180.000 (11) |
| $Co1^{ix}$—Co1—$Mn7^{vii}$ | 118.837 (6) | $Co3^{xvii}$—Ge3—$Co3^{xx}$ | 116.701 (11) |
| $Ge2^{vii}$—Co1—$Mn7^{vii}$ | 65.110 (10) | $Co3^{vii}$—Ge3—$Co3^{xx}$ | 63.299 (11) |
| $Co5^{vii}$—Co1—$Mn7^{vii}$ | 61.391 (11) | $Co3^{xvii}$—Ge3—$Co3^{xix}$ | 63.299 (11) |
| $Ge1^{vii}$—Co1—$Mn7^{vii}$ | 110.953 (11) | $Co3^{vii}$—Ge3—$Co3^{xix}$ | 116.701 (11) |
| $Co6^{vii}$—Co1—$Mn7^{vii}$ | 112.468 (11) | $Co3^{xx}$—Ge3—$Co3^{xix}$ | 180.000 (11) |
| $Mn1^{i}$—Co1—$Mn7^{vii}$ | 69.452 (10) | $Co3^{xvii}$—Ge3—Co4 | 62.879 (8) |
| $Co1^{xv}$—Co1—$Mn7^{vii}$ | 61.162 (6) | $Co3^{vii}$—Ge3—Co4 | 117.121 (8) |
| $Co1^{ix}$—Co1—Mn4 | 64.869 (6) | $Co3^{xx}$—Ge3—Co4 | 117.121 (8) |
| $Ge2^{vii}$—Co1—Mn4 | 67.822 (9) | $Co3^{xix}$—Ge3—Co4 | 62.879 (8) |
| $Co5^{vii}$—Co1—Mn4 | 120.509 (13) | $Co3^{xvii}$—Ge3—$Co4^{xxi}$ | 117.120 (8) |
| $Ge1^{vii}$—Co1—Mn4 | 172.407 (11) | $Co3^{vii}$—Ge3—$Co4^{xxi}$ | 62.880 (8) |

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| $Co6^{vii}—Co1—Mn4$ | 116.276 (13) | $Co3^{xx}—Ge3—Co4^{xxi}$ | 62.880 (8) |
| $Mn1^{i}—Co1—Mn4$ | 73.558 (13) | $Co3^{xix}—Ge3—Co4^{xxi}$ | 117.120 (8) |
| $Co1^{xv}—Co1—Mn4$ | 115.129 (6) | $Co4—Ge3—Co4^{xxi}$ | 180.0 |
| $Mn7^{vii}—Co1—Mn4$ | 65.811 (10) | $Co3^{xvii}—Ge3—Mn6^{vi}$ | 63.733 (9) |
| $Co1^{ix}—Co1—Mn5$ | 65.694 (6) | $Co3^{vii}—Ge3—Mn6^{vi}$ | 116.267 (9) |
| $Ge2^{vii}—Co1—Mn5$ | 65.659 (9) | $Co3^{xx}—Ge3—Mn6^{vi}$ | 62.997 (9) |
| $Co5^{vii}—Co1—Mn5$ | 171.409 (11) | $Co3^{xix}—Ge3—Mn6^{vi}$ | 117.003 (9) |
| $Ge1^{vii}—Co1—Mn5$ | 112.691 (12) | $Co4—Ge3—Mn6^{vi}$ | 116.262 (7) |
| $Co6^{vii}—Co1—Mn5$ | 63.679 (9) | $Co4^{xxi}—Ge3—Mn6^{vi}$ | 63.737 (7) |
| $Mn1^{i}—Co1—Mn5$ | 124.506 (11) | $Co3^{xvii}—Ge3—Mn6^{xviii}$ | 116.267 (9) |
| $Co1^{xv}—Co1—Mn5$ | 114.305 (6) | $Co3^{vii}—Ge3—Mn6^{xviii}$ | 63.733 (9) |
| $Mn7^{vii}—Co1—Mn5$ | 120.081 (12) | $Co3^{xx}—Ge3—Mn6^{xviii}$ | 117.003 (9) |
| $Mn4—Co1—Mn5$ | 65.484 (12) | $Co3^{xix}—Ge3—Mn6^{xviii}$ | 62.997 (9) |
| $Co1^{ix}—Co1—Mn2^{i}$ | 65.842 (6) | $Co4—Ge3—Mn6^{xviii}$ | 63.738 (7) |
| $Ge2^{vii}—Co1—Mn2^{i}$ | 169.331 (11) | $Co4^{xxi}—Ge3—Mn6^{xviii}$ | 116.263 (7) |
| $Co5^{vii}—Co1—Mn2^{i}$ | 66.896 (11) | $Mn6^{vi}—Ge3—Mn6^{xviii}$ | 180.000 (18) |
| $Ge1^{vii}—Co1—Mn2^{i}$ | 64.798 (9) | $Co3^{xvii}—Ge3—Mn6^{xvii}$ | 62.997 (9) |
| $Co6^{vii}—Co1—Mn2^{i}$ | 112.689 (13) | $Co3^{vii}—Ge3—Mn6^{xvii}$ | 117.003 (9) |
| $Mn1^{i}—Co1—Mn2^{i}$ | 59.687 (12) | $Co3^{xx}—Ge3—Mn6^{xvii}$ | 63.733 (9) |
| $Co1^{xv}—Co1—Mn2^{i}$ | 114.160 (5) | $Co3^{xix}—Ge3—Mn6^{xvii}$ | 116.267 (9) |
| $Mn7^{vii}—Co1—Mn2^{i}$ | 118.741 (12) | $Co4—Ge3—Mn6^{xvii}$ | 63.738 (7) |
| $Mn4—Co1—Mn2^{i}$ | 122.778 (11) | $Co4^{xxi}—Ge3—Mn6^{xvii}$ | 116.263 (7) |
| $Mn5—Co1—Mn2^{i}$ | 116.052 (11) | $Mn6^{vi}—Ge3—Mn6^{xvii}$ | 62.626 (13) |
| $Co1^{ix}—Co1—Mn3$ | 66.002 (5) | $Mn6^{xviii}—Ge3—Mn6^{xvii}$ | 117.374 (13) |
| $Ge2^{vii}—Co1—Mn3$ | 112.894 (11) | $Co3^{xvii}—Ge3—Mn6^{vii}$ | 117.003 (9) |
| $Co5^{vii}—Co1—Mn3$ | 116.565 (13) | $Co3^{vii}—Ge3—Mn6^{vii}$ | 62.997 (9) |
| $Ge1^{vii}—Co1—Mn3$ | 64.889 (9) | $Co3^{xx}—Ge3—Mn6^{vii}$ | 116.267 (9) |
| $Co6^{vii}—Co1—Mn3$ | 63.475 (9) | $Co3^{xix}—Ge3—Mn6^{vii}$ | 63.733 (9) |
| $Mn1^{i}—Co1—Mn3$ | 114.054 (11) | $Co4—Ge3—Mn6^{vii}$ | 116.262 (7) |
| $Co1^{xv}—Co1—Mn3$ | 113.999 (5) | $Co4^{xxi}—Ge3—Mn6^{vii}$ | 63.737 (7) |
| $Mn7^{vii}—Co1—Mn3$ | 175.160 (9) | $Mn6^{vi}—Ge3—Mn6^{vii}$ | 117.374 (13) |
| $Mn4—Co1—Mn3$ | 117.981 (11) | $Mn6^{xviii}—Ge3—Mn6^{vii}$ | 62.626 (13) |
| $Mn5—Co1—Mn3$ | 61.207 (11) | $Mn6^{xvii}—Ge3—Mn6^{vii}$ | 180.000 (18) |
| $Mn2^{i}—Co1—Mn3$ | 62.387 (11) | $Co3^{xvii}—Ge3—Mn3$ | 115.316 (9) |
| $Co6^{vii}—Co2—Co4$ | 118.573 (14) | $Co3^{vii}—Ge3—Mn3$ | 64.684 (9) |
| $Co6^{vii}—Co2—Co5$ | 120.310 (13) | $Co3^{xx}—Ge3—Mn3$ | 64.684 (9) |
| $Co4—Co2—Co5$ | 108.778 (11) | $Co3^{xix}—Ge3—Mn3$ | 115.316 (9) |
| $Co6^{vii}—Co2—Co2^{xv}$ | 59.614 (6) | $Co4—Ge3—Mn3$ | 62.532 (10) |
| $Co4—Co2—Co2^{xv}$ | 121.291 (6) | $Co4^{xxi}—Ge3—Mn3$ | 117.469 (10) |
| $Co5—Co2—Co2^{xv}$ | 121.096 (6) | $Mn6^{vi}—Ge3—Mn3$ | 116.485 (7) |
| $Co6^{vii}—Co2—Co2^{ix}$ | 120.385 (7) | $Mn6^{xviii}—Ge3—Mn3$ | 63.515 (7) |
| $Co4—Co2—Co2^{ix}$ | 58.708 (6) | $Mn6^{xvii}—Ge3—Mn3$ | 63.515 (7) |
| $Co5—Co2—Co2^{ix}$ | 58.905 (6) | $Mn6^{vii}—Ge3—Mn3$ | 116.485 (7) |
| $Co2^{xv}—Co2—Co2^{ix}$ | 179.999 (17) | $Co3^{xvii}—Ge3—Mn3^{xxi}$ | 64.683 (9) |
| $Co6^{vii}—Co2—Mn1^{xviii}$ | 109.476 (11) | $Co3^{vii}—Ge3—Mn3^{xxi}$ | 115.317 (9) |
| $Co4—Co2—Mn1^{xviii}$ | 124.958 (13) | $Co3^{xx}—Ge3—Mn3^{xxi}$ | 115.316 (9) |
| $Co5—Co2—Mn1^{xviii}$ | 63.309 (10) | $Co3^{xix}—Ge3—Mn3^{xxi}$ | 64.684 (9) |
| $Co2^{xv}—Co2—Mn1^{xviii}$ | 63.402 (6) | $Co4—Ge3—Mn3^{xxi}$ | 117.467 (10) |

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| Co2$^{ix}$—Co2—Mn1$^{xviii}$ | 116.599 (6) | Co4$^{xxi}$—Ge3—Mn3$^{xxi}$ | 62.532 (10) |
| Co6$^{vii}$—Co2—Mn4$^{xviii}$ | 113.425 (11) | Mn6$^{vi}$—Ge3—Mn3$^{xxi}$ | 63.516 (7) |
| Co4—Co2—Mn4$^{xviii}$ | 66.261 (9) | Mn6$^{xviii}$—Ge3—Mn3$^{xxi}$ | 116.484 (7) |
| Co5—Co2—Mn4$^{xviii}$ | 117.773 (12) | Mn6$^{xvii}$—Ge3—Mn3$^{xxi}$ | 116.484 (7) |
| Co2$^{xv}$—Co2—Mn4$^{xviii}$ | 64.343 (5) | Mn6$^{vii}$—Ge3—Mn3$^{xxi}$ | 63.516 (7) |
| Co2$^{ix}$—Co2—Mn4$^{xviii}$ | 115.657 (6) | Mn3—Ge3—Mn3$^{xxi}$ | 180.0 |
| Mn1$^{xviii}$—Co2—Mn4$^{xviii}$ | 71.342 (11) | | |

Symmetry codes: (i) −*x*, −*y*+1, −*z*; (ii) −*x*, −*y*+1, *z*; (iii) −*x*+1/2, *y*+1/2, *z*+1/2; (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*+1, −*z*; (ix) *x*, *y*, −*z*; (x) −*x*+1, −*y*+1, *z*; (xi) −*x*+1, −*y*, −*z*; (xii) *x*+1/2, −*y*+1/2, −*z*+1/2; (xiii) *x*+1/2, −*y*+1/2, *z*−1/2; (xiv) −*x*+1, −*y*, *z*; (xv) *x*, *y*, −*z*+1; (xvi) *x*+1/2, −*y*+1/2, −*z*−1/2; (xvii) −*x*+1/2, *y*−1/2, *z*−1/2; (xviii) −*x*+1/2, *y*−1/2, *z*+1/2; (xix) −*x*+1/2, *y*−1/2, −*z*+1/2; (xx) *x*−1/2, −*y*+1/2, *z*−1/2; (xxi) −*x*, −*y*, −*z*.