



wwPDB X-ray Structure Validation Summary Report ⓘ

Feb 15, 2017 – 12:14 am GMT

PDB ID : 2RFC
Title : Ligand bound (4-phenylimidazole) Crystal Structure of a Cytochrome P450 from the Thermoacidophilic Archaeon *Picrophilus Torridus*
Authors : Ho, W.W.; Li, H.; Poulos, T.L.; Nishida, C.R.; Ortiz de Montellano, P.R.
Deposited on : 2007-09-28
Resolution : 3.10 Å(reported)

This is a wwPDB X-ray Structure Validation Summary Report for a publicly released PDB entry.

We welcome your comments at validation@mail.wwpdb.org

A user guide is available at

<http://wwpdb.org/validation/2016/XrayValidationReportHelp>

with specific help available everywhere you see the ⓘ symbol.

The following versions of software and data (see [references ⓘ](#)) were used in the production of this report:

MolProbity	:	4.02b-467
Mogul	:	1.7.2 (RC1), CSD as538be (2017)
Xtriage (Phenix)	:	1.9-1692
EDS	:	trunk28620
Percentile statistics	:	20161228.v01 (using entries in the PDB archive December 28th 2016)
Refmac	:	5.8.0135
CCP4	:	6.5.0
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	recalc28949

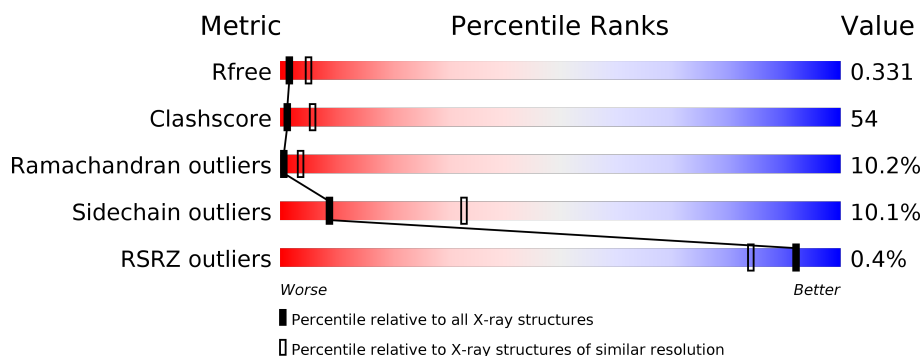
1 Overall quality at a glance ⓘ

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 3.10 Å.

Percentile scores (ranging between 0-100) for global validation metrics of the entry are shown in the following graphic. The table shows the number of entries on which the scores are based.



Metric	Whole archive (#Entries)	Similar resolution (#Entries, resolution range(Å))
R_{free}	100719	1001 (3.12-3.08)
Clashscore	112137	1099 (3.12-3.08)
Ramachandran outliers	110173	1057 (3.12-3.08)
Sidechain outliers	110143	1057 (3.12-3.08)
RSRZ outliers	101464	1006 (3.12-3.08)

The table below summarises the geometric issues observed across the polymeric chains and their fit to the electron density. The red, orange, yellow and green segments on the lower bar indicate the fraction of residues that contain outliers for ≥ 3 , 2, 1 and 0 types of geometric quality criteria. A grey segment represents the fraction of residues that are not modelled. The numeric value for each fraction is indicated below the corresponding segment, with a dot representing fractions $\leq 5\%$. The upper red bar (where present) indicates the fraction of residues that have poor fit to the electron density. The numeric value is given above the bar.

Mol	Chain	Length	Quality of chain
1	A	343	<div> <div>29%</div> <div>59%</div> <div>11%</div> <div>.</div> </div>
1	B	343	<div> <div>28%</div> <div>56%</div> <div>13%</div> <div>..</div> </div>
1	C	343	<div> <div>25%</div> <div>58%</div> <div>15%</div> <div>..</div> </div>
1	D	343	<div> <div>27%</div> <div>59%</div> <div>13%</div> <div>.</div> </div>

The following table lists non-polymeric compounds, carbohydrate monomers and non-standard residues in protein, DNA, RNA chains that are outliers for geometric or electron-density-fit crite-

ria:

Mol	Type	Chain	Res	Chirality	Geometry	Clashes	Electron density
3	PIM	B	411	-	-	-	X

2 Entry composition i

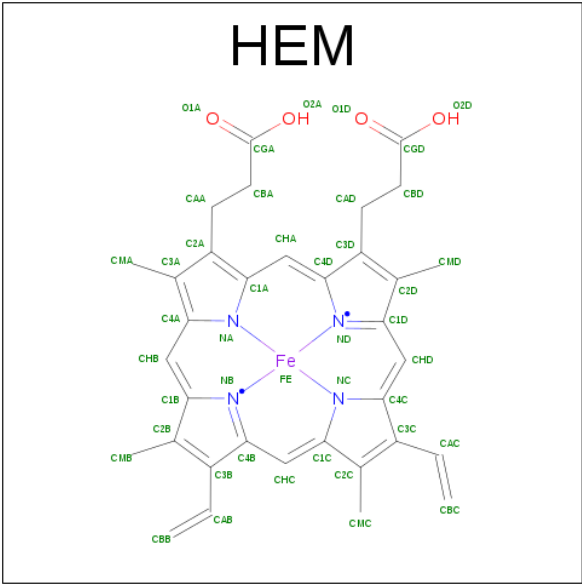
There are 4 unique types of molecules in this entry. The entry contains 11230 atoms, of which 0 are hydrogens and 0 are deuteriums.

In the tables below, the ZeroOcc column contains the number of atoms modelled with zero occupancy, the AltConf column contains the number of residues with at least one atom in alternate conformation and the Trace column contains the number of residues modelled with at most 2 atoms.

- Molecule 1 is a protein called Cytochrome P450.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	338	Total	C	N	O	S	0	0	0
			2752	1763	467	511	11			
1	B	338	Total	C	N	O	S	0	0	0
			2752	1763	467	511	11			
1	C	338	Total	C	N	O	S	0	0	0
			2752	1763	467	511	11			
1	D	338	Total	C	N	O	S	0	0	0
			2739	1756	462	510	11			

- Molecule 2 is PROTOPORPHYRIN IX CONTAINING FE (three-letter code: HEM) (formula: $C_{34}H_{32}FeN_4O_4$).



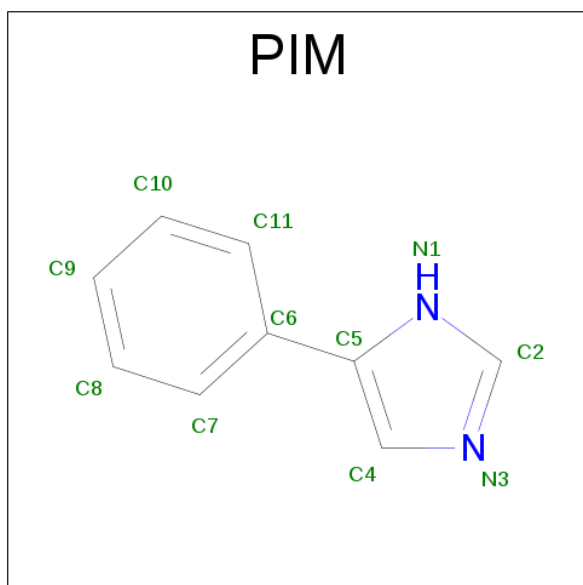
Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
2	A	1	Total	C	Fe	N O	0	0
			43	34	1	4 4		
2	B	1	Total	C	Fe	N O	0	0
			43	34	1	4 4		

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Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
2	C	1	Total	C	Fe	N	O	
			43	34	1	4	4	
2	D	1	Total	C	Fe	N	O	
			43	34	1	4	4	

- Molecule 3 is 4-PHENYL-1H-IMIDAZOLE (three-letter code: PIM) (formula: C₉H₈N₂).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
3	A	1	Total	C	N		
			11	9	2	0	0
3	B	1	Total	C	N		
			11	9	2	0	0
3	C	1	Total	C	N		
			11	9	2	0	0
3	D	1	Total	C	N		
			11	9	2	0	0

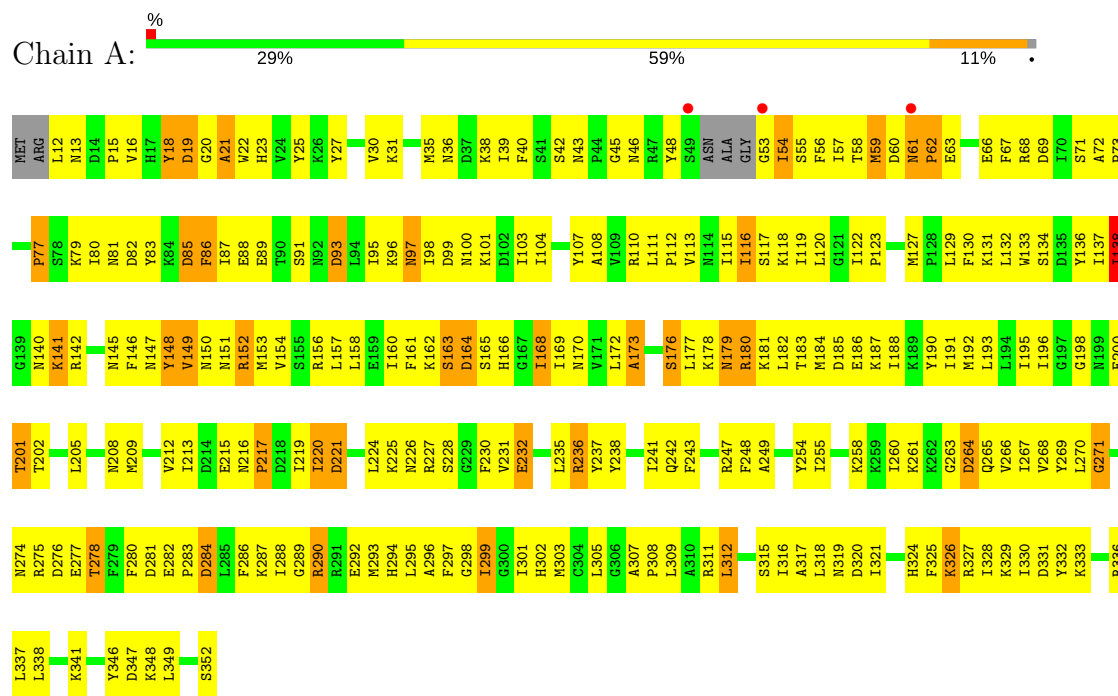
- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	5	Total	O		
			5	5	0	0
4	B	5	Total	O		
			5	5	0	0
4	C	9	Total	O		
			9	9	0	0

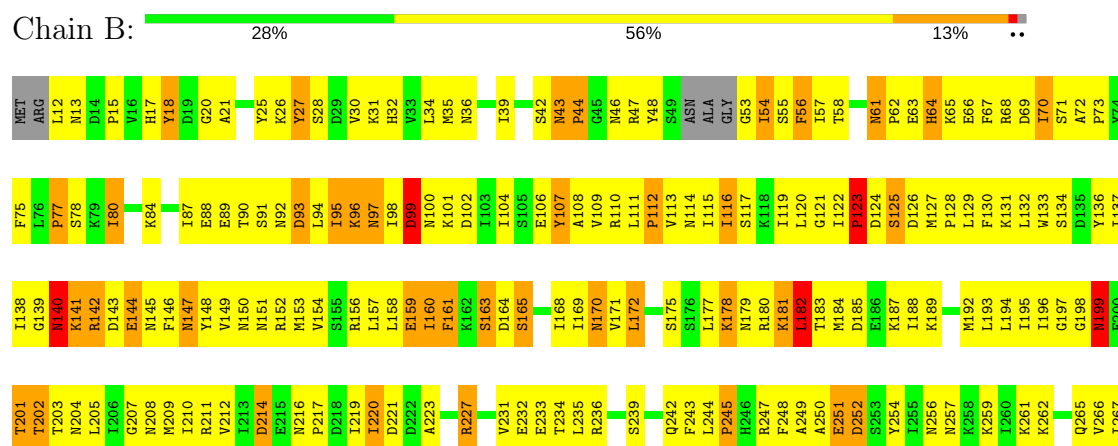
3 Residue-property plots

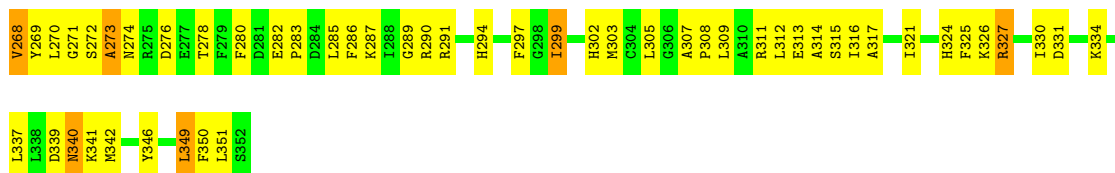
These plots are drawn for all protein, RNA and DNA chains in the entry. The first graphic for a chain summarises the proportions of the various outlier classes displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry and electron density. Residues are color-coded according to the number of geometric quality criteria for which they contain at least one outlier: green = 0, yellow = 1, orange = 2 and red = 3 or more. A red dot above a residue indicates a poor fit to the electron density ($RSRZ > 2$). Stretches of 2 or more consecutive residues without any outlier are shown as a green connector. Residues present in the sample, but not in the model, are shown in grey.

• Molecule 1: Cytochrome P450



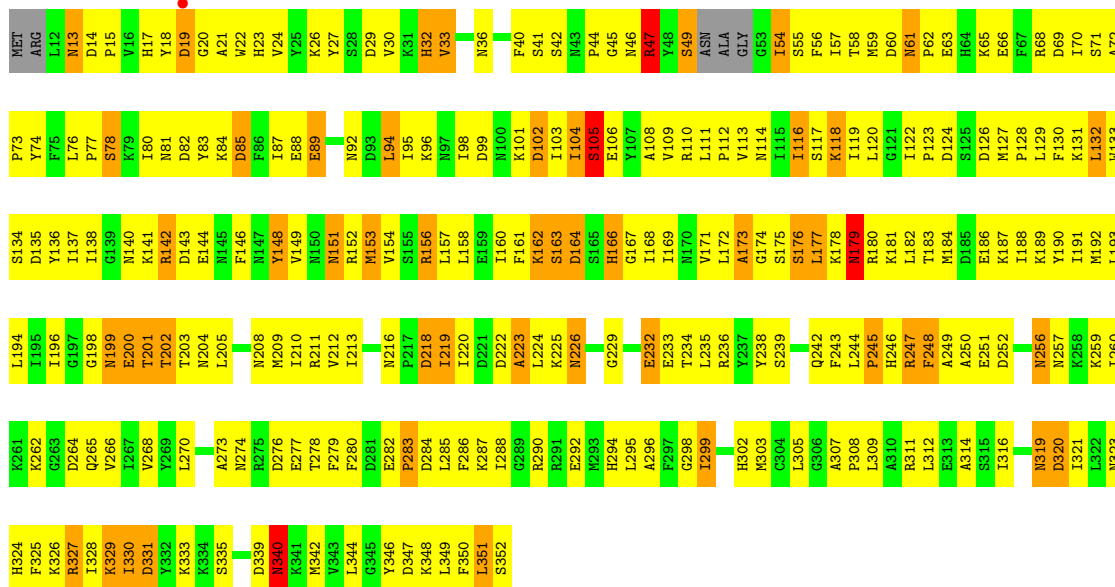
• Molecule 1: Cytochrome P450





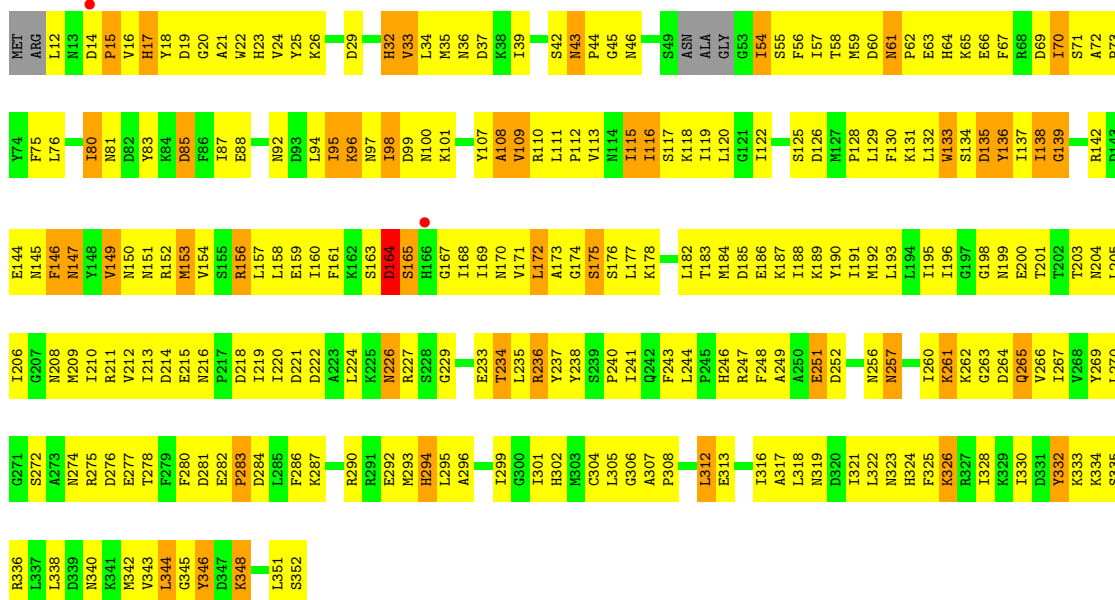
• Molecule 1: Cytochrome P450

Chain C: 25% 58% 15% ..



• Molecule 1: Cytochrome P450

Chain D: 27% 59% 13% ..



4 Data and refinement statistics

Property	Value	Source
Space group	P 1 21 1	Depositor
Cell constants a, b, c, α , β , γ	48.52Å 141.01Å 101.03Å 90.00° 90.30° 90.00°	Depositor
Resolution (Å)	41.85 – 3.10 41.85 – 3.08	Depositor EDS
% Data completeness (in resolution range)	95.5 (41.85-3.10) 94.3 (41.85-3.08)	Depositor EDS
R_{merge}	0.12	Depositor
R_{sym}	0.12	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.82 (at 3.06Å)	Xtriage
Refinement program	CNS 1.2	Depositor
R, R_{free}	0.229 , 0.334 0.229 , 0.331	Depositor DCC
R_{free} test set	1141 reflections (5.09%)	DCC
Wilson B-factor (Å ²)	49.3	Xtriage
Anisotropy	0.232	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.34 , 54.1	EDS
L-test for twinning ²	$\langle L \rangle = 0.49$, $\langle L^2 \rangle = 0.32$	Xtriage
Estimated twinning fraction	0.029 for h,-k,-l	Xtriage
F_o, F_c correlation	0.90	EDS
Total number of atoms	11230	wwPDB-VP
Average B, all atoms (Å ²)	42.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 10.88% of the height of the origin peak. No significant pseudotranslation is detected.*

¹Intensities estimated from amplitudes.

²Theoretical values of $\langle |L| \rangle$, $\langle L^2 \rangle$ for acentric reflections are 0.5, 0.333 respectively for untwinned datasets, and 0.375, 0.2 for perfectly twinned datasets.

5 Model quality

5.1 Standard geometry

Bond lengths and bond angles in the following residue types are not validated in this section: HEM, PIM

The Z score for a bond length (or angle) is the number of standard deviations the observed value is removed from the expected value. A bond length (or angle) with $|Z| > 5$ is considered an outlier worth inspection. RMSZ is the root-mean-square of all Z scores of the bond lengths (or angles).

Mol	Chain	Bond lengths		Bond angles	
		RMSZ	# Z >5	RMSZ	# Z >5
1	A	0.48	0/2809	0.72	2/3785 (0.1%)
1	B	0.49	0/2809	0.69	0/3785
1	C	0.50	0/2809	0.71	1/3785 (0.0%)
1	D	0.47	0/2796	0.72	1/3770 (0.0%)
All	All	0.48	0/11223	0.71	4/15125 (0.0%)

Chiral center outliers are detected by calculating the chiral volume of a chiral center and verifying if the center is modelled as a planar moiety or with the opposite hand. A planarity outlier is detected by checking planarity of atoms in a peptide group, atoms in a mainchain group or atoms of a sidechain that are expected to be planar.

Mol	Chain	#Chirality outliers	#Planarity outliers
1	A	0	1

There are no bond length outliers.

All (4) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	D	304	CYS	CA-CB-SG	-6.37	102.53	114.00
1	A	149	VAL	N-CA-C	-6.08	94.58	111.00
1	C	199	ASN	N-CA-C	5.23	125.12	111.00
1	A	224	LEU	CA-CB-CG	5.14	127.12	115.30

There are no chirality outliers.

All (1) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	A	148	TYR	Sidechain

5.2 Too-close contacts

In the following table, the Non-H and H(model) columns list the number of non-hydrogen atoms and hydrogen atoms in the chain respectively. The H(added) column lists the number of hydrogen atoms added and optimized by MolProbity. The Clashes column lists the number of clashes within the asymmetric unit, whereas Symm-Clashes lists symmetry related clashes.

Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
1	A	2752	0	2756	280	0
1	B	2752	0	2756	311	0
1	C	2752	0	2756	315	0
1	D	2739	0	2730	307	0
2	A	43	0	30	6	0
2	B	43	0	30	6	0
2	C	43	0	30	10	0
2	D	43	0	30	11	0
3	A	11	0	8	1	0
3	B	11	0	8	0	0
3	C	11	0	8	0	0
3	D	11	0	8	1	0
4	A	5	0	0	0	0
4	B	5	0	0	0	0
4	C	9	0	0	0	0
All	All	11230	0	11150	1202	0

The all-atom clashscore is defined as the number of clashes found per 1000 atoms (including hydrogen atoms). The all-atom clashscore for this structure is 54.

The worst 5 of 1202 close contacts within the same asymmetric unit are listed below, sorted by their clash magnitude.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:C:184:MET:HA	1:C:187:LYS:HE3	1.23	1.14
1:A:274:ASN:HD21	1:A:294:HIS:HB2	0.98	1.12
1:B:183:THR:HG22	1:B:185:ASP:H	1.17	1.06
1:A:236:ARG:HA	1:A:274:ASN:ND2	1.71	1.06
1:A:236:ARG:HA	1:A:274:ASN:HD22	1.11	1.05

There are no symmetry-related clashes.

5.3 Torsion angles ⓘ

5.3.1 Protein backbone ⓘ

In the following table, the Percentiles column shows the percent Ramachandran outliers of the chain as a percentile score with respect to all X-ray entries followed by that with respect to entries of similar resolution.

The Analysed column shows the number of residues for which the backbone conformation was analysed, and the total number of residues.

Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles	
1	A	334/343 (97%)	242 (72%)	59 (18%)	33 (10%)	1	4
1	B	334/343 (97%)	216 (65%)	81 (24%)	37 (11%)	0	2
1	C	334/343 (97%)	230 (69%)	73 (22%)	31 (9%)	1	4
1	D	334/343 (97%)	229 (69%)	70 (21%)	35 (10%)	0	3
All	All	1336/1372 (97%)	917 (69%)	283 (21%)	136 (10%)	1	4

5 of 136 Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	19	ASP
1	A	61	ASN
1	A	163	SER
1	A	164	ASP
1	A	173	ALA

5.3.2 Protein sidechains ⓘ

In the following table, the Percentiles column shows the percent sidechain outliers of the chain as a percentile score with respect to all X-ray entries followed by that with respect to entries of similar resolution.

The Analysed column shows the number of residues for which the sidechain conformation was analysed, and the total number of residues.

Mol	Chain	Analysed	Rotameric	Outliers	Percentiles	
1	A	307/310 (99%)	281 (92%)	26 (8%)	12	44
1	B	307/310 (99%)	268 (87%)	39 (13%)	5	21
1	C	307/310 (99%)	273 (89%)	34 (11%)	7	29
1	D	304/310 (98%)	279 (92%)	25 (8%)	13	45
All	All	1225/1240 (99%)	1101 (90%)	124 (10%)	9	33

5 of 124 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	B	227	ARG
1	C	89	GLU
1	D	226	ASN
1	B	245	PRO
1	B	340	ASN

Some sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 46 such sidechains are listed below:

Mol	Chain	Res	Type
1	C	17	HIS
1	C	140	ASN
1	D	256	ASN
1	C	32	HIS
1	C	46	ASN

5.3.3 RNA [i](#)

There are no RNA molecules in this entry.

5.4 Non-standard residues in protein, DNA, RNA chains [i](#)

There are no non-standard protein/DNA/RNA residues in this entry.

5.5 Carbohydrates [i](#)

There are no carbohydrates in this entry.

5.6 Ligand geometry [i](#)

8 ligands are modelled in this entry.

In the following table, the Counts columns list the number of bonds (or angles) for which Mogul statistics could be retrieved, the number of bonds (or angles) that are observed in the model and the number of bonds (or angles) that are defined in the chemical component dictionary. The Link column lists molecule types, if any, to which the group is linked. The Z score for a bond length (or angle) is the number of standard deviations the observed value is removed from the expected value. A bond length (or angle) with $|Z| > 2$ is considered an outlier worth inspection. RMSZ is the root-mean-square of all Z scores of the bond lengths (or angles).

Mol	Type	Chain	Res	Link	Bond lengths			Bond angles		
					Counts	RMSZ	# Z > 2	Counts	RMSZ	# Z > 2
2	HEM	A	410	1,3	28,50,50	2.40	8 (28%)	17,82,82	1.87	6 (35%)
3	PIM	A	411	2	10,12,12	2.46	5 (50%)	12,15,15	1.64	1 (8%)
2	HEM	B	410	1,3	28,50,50	1.82	6 (21%)	17,82,82	1.48	3 (17%)
3	PIM	B	411	2	10,12,12	3.00	6 (60%)	12,15,15	1.56	2 (16%)
2	HEM	C	410	1,3	28,50,50	2.02	10 (35%)	17,82,82	1.67	3 (17%)
3	PIM	C	411	2	10,12,12	2.57	6 (60%)	12,15,15	1.74	3 (25%)
2	HEM	D	410	1,3	28,50,50	1.81	7 (25%)	17,82,82	2.07	5 (29%)
3	PIM	D	411	2	10,12,12	2.55	6 (60%)	12,15,15	1.62	3 (25%)

In the following table, the Chirals column lists the number of chiral outliers, the number of chiral centers analysed, the number of these observed in the model and the number defined in the chemical component dictionary. Similar counts are reported in the Torsion and Rings columns. '-' means no outliers of that kind were identified.

Mol	Type	Chain	Res	Link	Chirals	Torsions	Rings
2	HEM	A	410	1,3	-	0/6/54/54	0/0/8/8
3	PIM	A	411	2	-	0/4/4/4	0/2/2/2
2	HEM	B	410	1,3	-	0/6/54/54	0/0/8/8
3	PIM	B	411	2	-	0/4/4/4	0/2/2/2
2	HEM	C	410	1,3	-	0/6/54/54	0/0/8/8
3	PIM	C	411	2	-	0/4/4/4	0/2/2/2
2	HEM	D	410	1,3	-	0/6/54/54	0/0/8/8
3	PIM	D	411	2	-	0/4/4/4	0/2/2/2

The worst 5 of 54 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	410	HEM	C3B-C2B	-6.06	1.32	1.40
2	A	410	HEM	C3C-C2C	-5.32	1.33	1.40
2	A	410	HEM	C3B-CAB	-5.21	1.37	1.47
2	C	410	HEM	C3C-CAC	-5.03	1.37	1.47
2	B	410	HEM	C3C-C2C	-5.00	1.33	1.40

The worst 5 of 26 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	D	410	HEM	C4C-C3C-C2C	-4.95	103.44	106.90
2	D	410	HEM	C1D-C2D-C3D	-4.70	103.73	107.00
2	C	410	HEM	C1D-C2D-C3D	-3.74	104.40	107.00
3	A	411	PIM	C4-C5-C6	-3.55	124.60	129.46

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	B	411	PIM	C4-C5-C6	-3.46	124.72	129.46

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

6 monomers are involved in 34 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	A	410	HEM	6	0
3	A	411	PIM	1	0
2	B	410	HEM	6	0
2	C	410	HEM	10	0
2	D	410	HEM	11	0
3	D	411	PIM	1	0

5.7 Other polymers [i](#)

There are no such residues in this entry.

5.8 Polymer linkage issues [i](#)

There are no chain breaks in this entry.

6 Fit of model and data [i](#)

6.1 Protein, DNA and RNA chains [i](#)

In the following table, the column labelled ‘#RSRZ> 2’ contains the number (and percentage) of RSRZ outliers, followed by percent RSRZ outliers for the chain as percentile scores relative to all X-ray entries and entries of similar resolution. The OWAB column contains the minimum, median, 95th percentile and maximum values of the occupancy-weighted average B-factor per residue. The column labelled ‘Q< 0.9’ lists the number of (and percentage) of residues with an average occupancy less than 0.9.

Mol	Chain	Analysed	<RSRZ>	#RSRZ>2	OWAB(Å ²)	Q<0.9
1	A	338/343 (98%)	-0.31	3 (0%) 84 69	16, 39, 65, 101	0
1	B	338/343 (98%)	-0.36	0 100 100	14, 41, 61, 92	0
1	C	338/343 (98%)	-0.32	1 (0%) 93 86	15, 41, 65, 89	0
1	D	338/343 (98%)	-0.31	2 (0%) 89 77	10, 41, 66, 103	0
All	All	1352/1372 (98%)	-0.33	6 (0%) 92 84	10, 40, 64, 103	0

The worst 5 of 6 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	53	GLY	4.1
1	D	166	HIS	2.9
1	A	49	SER	2.6
1	D	14	ASP	2.4
1	C	19	ASP	2.1

6.2 Non-standard residues in protein, DNA, RNA chains [i](#)

There are no non-standard protein/DNA/RNA residues in this entry.

6.3 Carbohydrates [i](#)

There are no carbohydrates in this entry.

6.4 Ligands [i](#)

In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. LLDF column lists the quality of electron density of the group with respect to its neighbouring residues in protein, DNA or RNA chains. The B-factors column lists the minimum, median, 95th percentile and maximum values of B factors

of atoms in the group. The column labelled 'Q< 0.9' lists the number of atoms with occupancy less than 0.9.

Mol	Type	Chain	Res	Atoms	RSCC	RSR	LLDF	B-factors(\AA^2)	Q<0.9
3	PIM	B	411	11/11	0.94	0.24	2.39	42,42,42,42	0
2	HEM	B	410	43/43	0.97	0.22	1.18	42,42,42,42	0
2	HEM	C	410	43/43	0.96	0.21	0.82	42,42,42,42	0
3	PIM	D	411	11/11	0.96	0.20	0.48	42,42,42,42	0
3	PIM	C	411	11/11	0.94	0.23	0.46	42,42,42,42	0
2	HEM	D	410	43/43	0.95	0.20	0.44	42,42,42,42	0
2	HEM	A	410	43/43	0.97	0.20	0.34	42,42,42,42	0
3	PIM	A	411	11/11	0.97	0.18	-0.31	42,42,42,42	0

6.5 Other polymers [i](#)

There are no such residues in this entry.