



wwPDB X-ray Structure Validation Summary Report ⓘ

Mar 5, 2026 – 02:59 PM UTC

PDB ID : 3QI8 / pdb_00003qi8
Title : Evolved variant of cytochrome P450 (BM3, CYP102A1)
Authors : Rentmeister, A.; Brown, T.R.; Snow, C.D.; Carbone, M.N.; Arnold, F.H.
Deposited on : 2011-01-26
Resolution : 3.20 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

<https://www.wwpdb.org/validation/2017/XrayValidationReportHelp>

with specific help available everywhere you see the ⓘ symbol.

The types of validation reports are described at

<http://www.wwpdb.org/validation/2017/FAQs#types>.

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

MolProbity	:	4-5-2 with Phenix2.0
Mogul	:	2022.3.0, CSD as543be (2022)
Xtriage (Phenix)	:	2.0
EDS	:	3.0
Buster-report	:	wwPDB partial adaption of 1.1.7 (2018)
Percentile statistics	:	20250101.v01 (using entries in the PDB archive January 1st 2025)
CCP4	:	9.0.010 (Gargrove)
Density-Fitness	:	1.0.12
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.49

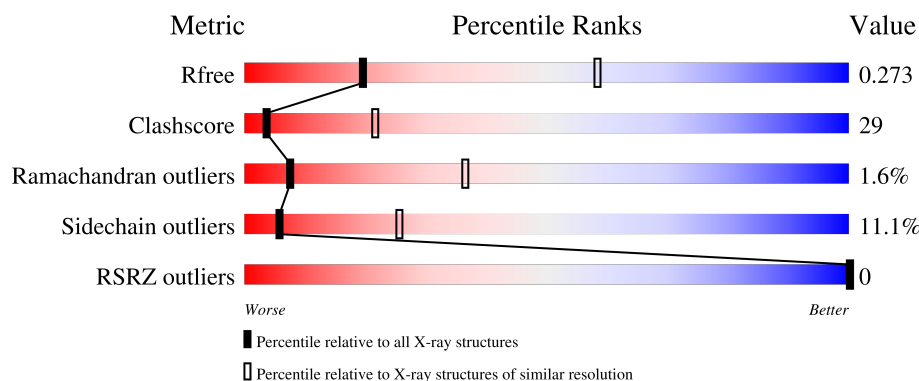
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 3.20 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}	180053	1466 (3.20-3.20)
Clashscore	190562	1573 (3.20-3.20)
Ramachandran outliers	187476	1548 (3.20-3.20)
Sidechain outliers	187428	1547 (3.20-3.20)
RSRZ outliers	180081	1466 (3.20-3.20)

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 of the lower bar indicate the fraction of residues that contain outliers for ≥ 3 , 2, 1 and 0 types of geometric quality criteria respectively. 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	472	
1	B	472	

2 Entry composition [i](#)

There are 2 unique types of molecules in this entry. The entry contains 7080 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 Evolved Cytochrome P450 variant (22A3).

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	B	452	Total	C	N	O	S	0	0	0
			3626	2310	626	672	18			
1	A	424	Total	C	N	O	S	0	0	0
			3368	2153	576	621	18			

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

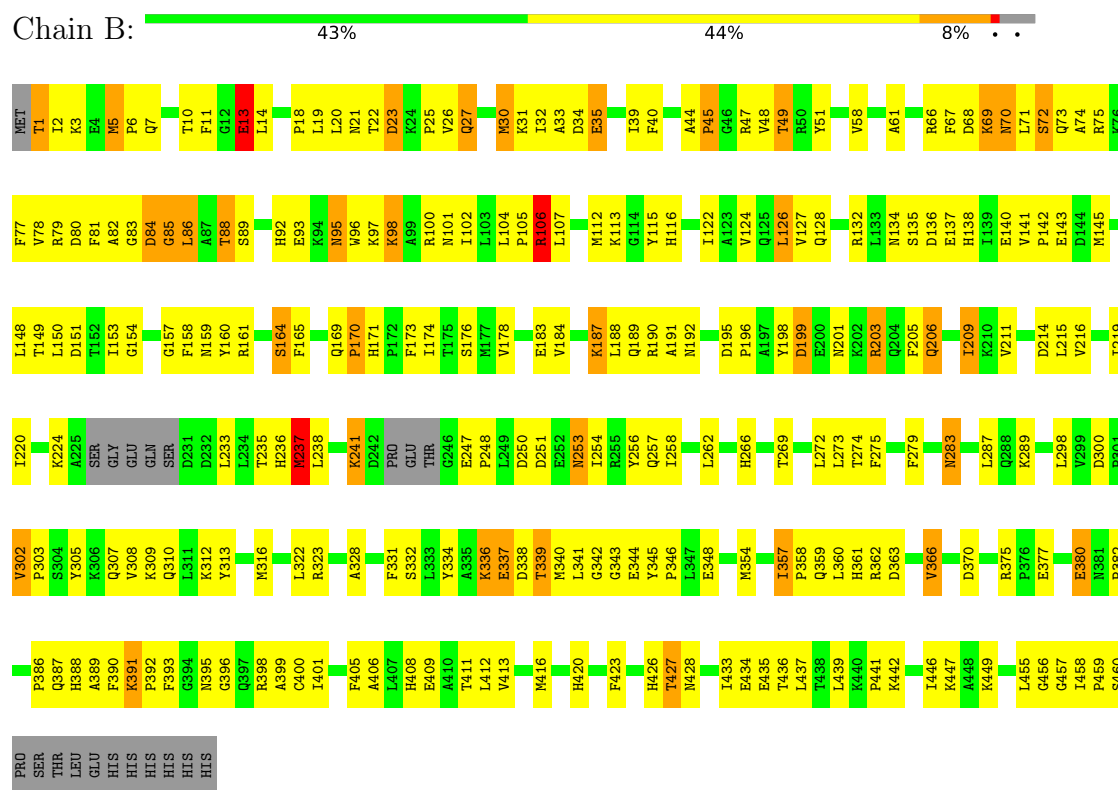


Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
2	B	1	Total	C	Fe	N	O	0	0
			43	34	1	4	4		
2	A	1	Total	C	Fe	N	O	0	0
			43	34	1	4	4		

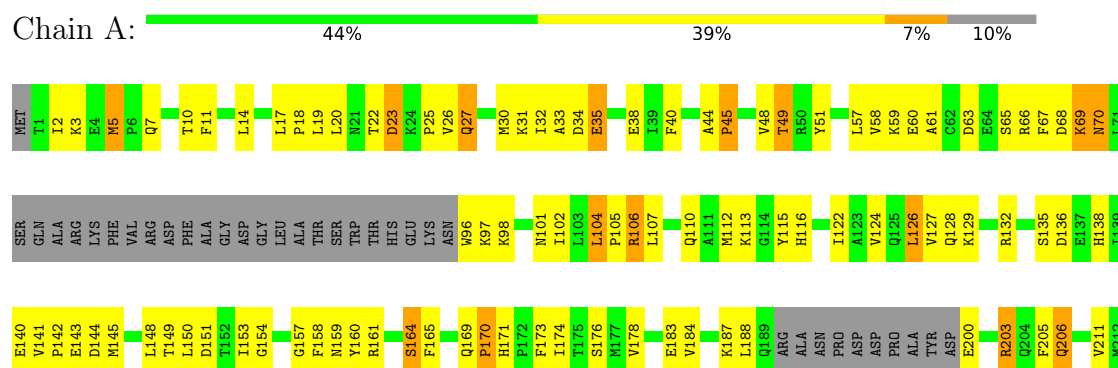
3 Residue-property plots

These plots are drawn for all protein, RNA, DNA and oligosaccharide 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: Evolved Cytochrome P450 variant (22A3)



• Molecule 1: Evolved Cytochrome P450 variant (22A3)



GLU	H888	S304	N213
HIS	A389	X305	D214
HIS	F390	K306	L215
HIS	K391	Q307	V216
HIS	P392	V308	
HIS	F393	K309	T219
HIS	G394	Q310	L220
	N395	L311	A221
	G396	K312	D222
	Q397	X313	R223
	K398		K224
	A399	M316	A225
	C400	L322	S226
	T401	R323	Q229
	G402		
	Q403	P326	L233
	G404	T327	L234
	F405	A328	T235
	A406		H236
	L407	F331	M237
	H408	S332	L238
	E409	F333	H239
		L333	
	L412	X334	D242
	V413	A335	P243
		K336	E244
	N416	E337	
		D338	E247
	F421	T339	P248
	D422	M340	
	F423	L341	
		G342	D251
	H426	G343	E252
	T427	E344	N253
		F345	L254
			H255
	T433		
	E434	I357	V256
	E435	P358	Q257
	T436	Q359	L258
	L437	L360	L259
	T438	H361	
	L439	R362	L262
	F440		
	P441	V366	G265
		W367	H266
	T446		
	K447	D370	G271
		V371	L272
	K451		
	L455	R375	L273
	G456	P376	T274
	G457	E377	F275
	T458		
		E380	M283
PRO		N381	
SER		P382	K289
PRO			
SER		I385	L298
THR		P386	V302
LEU		C287	P203

4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α , β , γ	82.35Å 83.77Å 143.02Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	45.38 – 3.20 45.38 – 3.20	Depositor EDS
% Data completeness (in resolution range)	95.5 (45.38-3.20) 95.5 (45.38-3.20)	Depositor EDS
R_{merge}	0.14	Depositor
R_{sym}	0.14	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.70 (at 3.12Å)	Xtriage
Refinement program	PHENIX (phenix.refine)	Depositor
R, R_{free}	0.208 , 0.274 0.203 , 0.273	Depositor DCC
R_{free} test set	915 reflections (4.93%)	wwPDB-VP
Wilson B-factor (Å ²)	66.2	Xtriage
Anisotropy	0.043	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.31 , 74.0	EDS
L-test for twinning ²	$\langle L \rangle = 0.45$, $\langle L^2 \rangle = 0.27$	Xtriage
Estimated twinning fraction	0.038 for k,h,-l	Xtriage
F_o, F_c correlation	0.93	EDS
Total number of atoms	7080	wwPDB-VP
Average B, all atoms (Å ²)	83.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 3.74% 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 [i](#)

5.1 Standard geometry [i](#)

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

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	0.58	0/3440	1.04	21/4650 (0.5%)
1	B	0.61	0/3706	1.03	17/5007 (0.3%)
All	All	0.60	0/7146	1.03	38/9657 (0.4%)

There are no bond length outliers.

The worst 5 of 38 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	B	247	GLU	CA-C-N	-10.11	110.51	120.21
1	B	247	GLU	C-N-CA	-10.11	110.51	120.21
1	A	455	LEU	N-CA-C	-9.73	96.15	110.06
1	A	247	GLU	CA-C-N	8.91	130.98	119.84
1	A	247	GLU	C-N-CA	8.91	130.98	119.84

There are no chirality outliers.

There are no planarity outliers.

5.2 Too-close contacts [i](#)

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	3368	0	3343	199	0
1	B	3626	0	3597	231	0
2	A	43	0	30	5	0
2	B	43	0	30	6	0

Continued on next page...

Continued from previous page...

Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
All	All	7080	0	7000	411	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 29.

The worst 5 of 411 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:A:237:MET:HE2	1:A:257:GLN:HB3	1.42	1.02
1:B:237:MET:HE2	1:B:257:GLN:HB3	1.43	1.00
1:A:223:ARG:HH22	1:A:229:GLN:HA	1.25	0.98
1:B:95:ASN:ND2	1:B:95:ASN:H	1.56	0.95
1:B:95:ASN:N	1:B:95:ASN:HD22	1.58	0.95

There are no symmetry-related clashes.

5.3 Torsion angles [i](#)

5.3.1 Protein backbone [i](#)

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	418/472 (89%)	365 (87%)	47 (11%)	6 (1%)	9	39
1	B	446/472 (94%)	390 (87%)	48 (11%)	8 (2%)	6	34
All	All	864/944 (92%)	755 (87%)	95 (11%)	14 (2%)	7	36

5 of 14 Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	B	72	SER
1	B	237	MET
1	B	251	ASP
1	A	237	MET

Continued on next page...

Continued from previous page...

Mol	Chain	Res	Type
1	A	251	ASP

5.3.2 Protein sidechains [i](#)

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	360/415 (87%)	324 (90%)	36 (10%)	7	30
1	B	390/415 (94%)	343 (88%)	47 (12%)	5	22
All	All	750/830 (90%)	667 (89%)	83 (11%)	6	25

5 of 83 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	124	VAL
1	A	302	VAL
1	A	135	SER
1	A	206	GLN
1	A	339	THR

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 37 such sidechains are listed below:

Mol	Chain	Res	Type
1	A	201	ASN
1	A	403	GLN
1	A	206	GLN
1	A	283	ASN
1	B	283	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 oligosaccharides in this entry.

5.6 Ligand geometry [i](#)

2 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	472	1	50,50,50	2.02	9 (18%)	67,82,82	2.06	17 (25%)
2	HEM	B	472	1	50,50,50	1.95	10 (20%)	67,82,82	1.77	16 (23%)

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	472	1	-	4/14/54/54	-
2	HEM	B	472	1	-	6/14/54/54	-

The worst 5 of 19 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	472	HEM	C3D-C2D	7.91	1.53	1.36
2	B	472	HEM	C3D-C2D	7.44	1.52	1.36
2	B	472	HEM	FE-NC	6.08	2.15	1.95
2	A	472	HEM	FE-NC	5.71	2.14	1.95
2	A	472	HEM	FE-NB	5.34	2.11	1.94

The worst 5 of 33 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
2	A	472	HEM	C4D-ND-C1D	6.97	113.47	105.21
2	B	472	HEM	C4D-ND-C1D	5.04	111.18	105.21
2	A	472	HEM	CHD-C1D-ND	4.99	129.79	124.42
2	A	472	HEM	CAA-C2A-C1A	4.57	133.87	124.94
2	B	472	HEM	C3B-C4B-NB	-4.21	106.44	109.47

There are no chirality outliers.

5 of 10 torsion outliers are listed below:

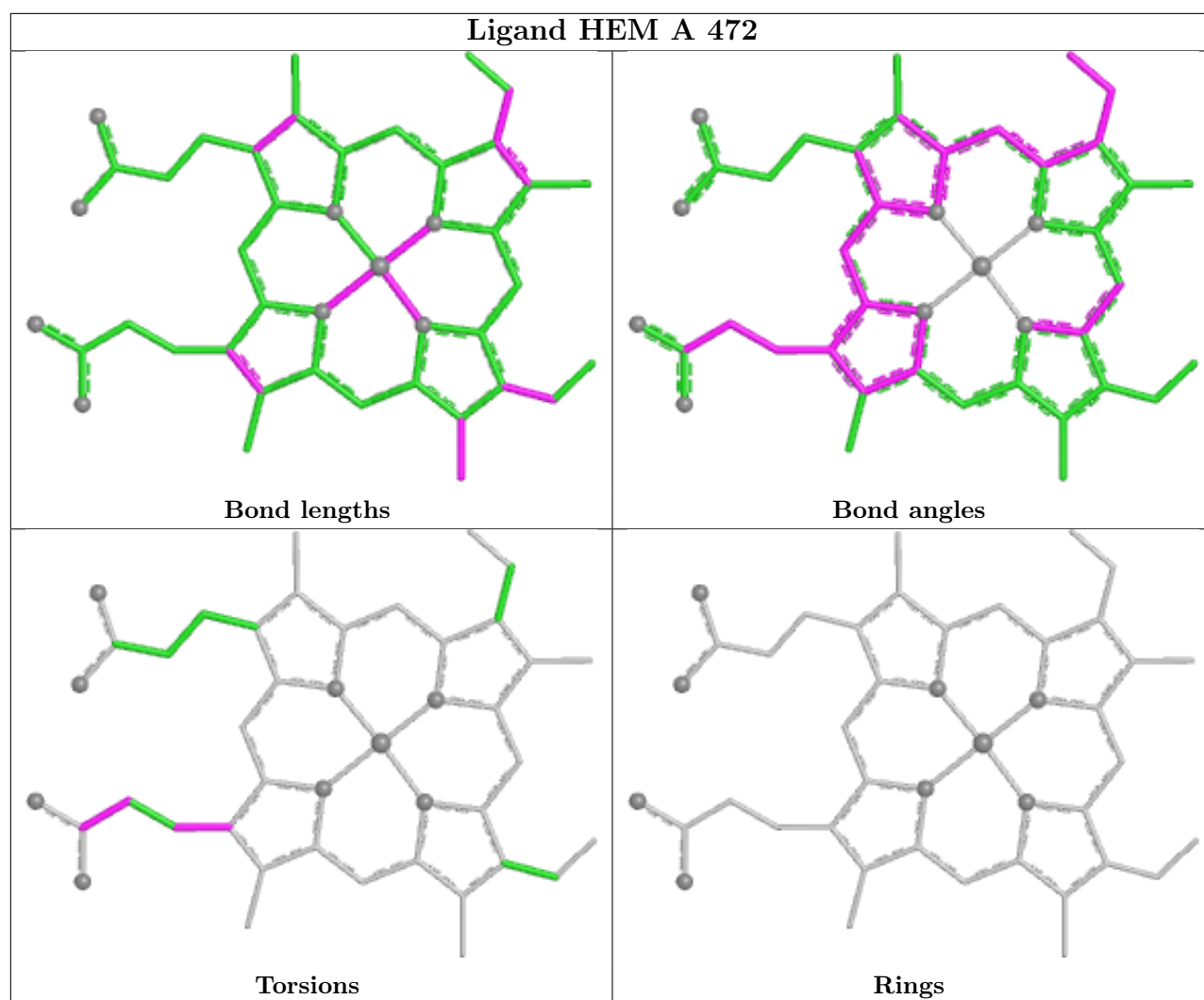
Mol	Chain	Res	Type	Atoms
2	A	472	HEM	C1A-C2A-CAA-CBA
2	B	472	HEM	C4D-C3D-CAD-CBD
2	A	472	HEM	C3A-C2A-CAA-CBA
2	B	472	HEM	C2D-C3D-CAD-CBD
2	B	472	HEM	C4B-C3B-CAB-CBB

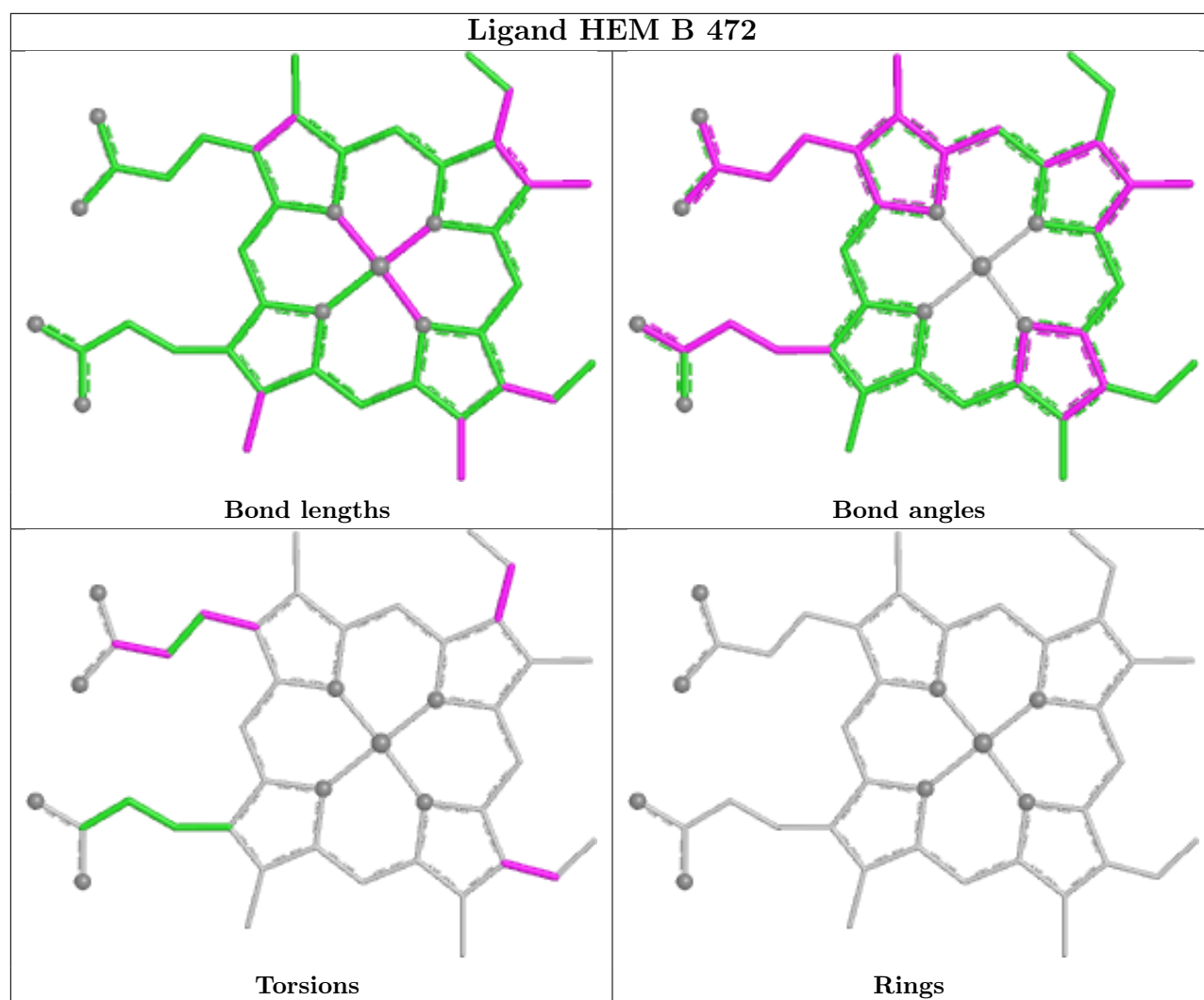
There are no ring outliers.

2 monomers are involved in 11 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	A	472	HEM	5	0
2	B	472	HEM	6	0

The following is a two-dimensional graphical depiction of Mogul quality analysis of bond lengths, bond angles, torsion angles, and ring geometry for all instances of the Ligand of Interest. In addition, ligands with molecular weight > 250 and outliers as shown on the validation Tables will also be included. For torsion angles, if less than 5% of the Mogul distribution of torsion angles is within 10 degrees of the torsion angle in question, then that torsion angle is considered an outlier. Any bond that is central to one or more torsion angles identified as an outlier by Mogul will be highlighted in the graph. For rings, the root-mean-square deviation (RMSD) between the ring in question and similar rings identified by Mogul is calculated over all ring torsion angles. If the average RMSD is greater than 60 degrees and the minimal RMSD between the ring in question and any Mogul-identified rings is also greater than 60 degrees, then that ring is considered an outlier. The outliers are highlighted in purple. The color gray indicates Mogul did not find sufficient equivalents in the CSD to analyse the geometry.





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	424/472 (89%)	-0.39	0 100 100	44, 80, 146, 180	0
1	B	452/472 (95%)	-0.41	0 100 100	40, 74, 126, 153	0
All	All	876/944 (92%)	-0.40	0 100 100	40, 77, 136, 180	0

There are no RSRZ outliers to report.

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 oligosaccharides in this entry.

6.4 Ligands [i](#)

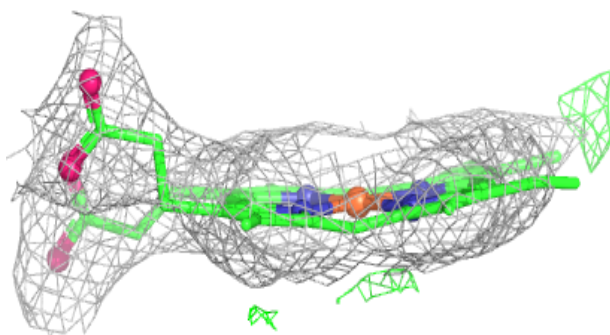
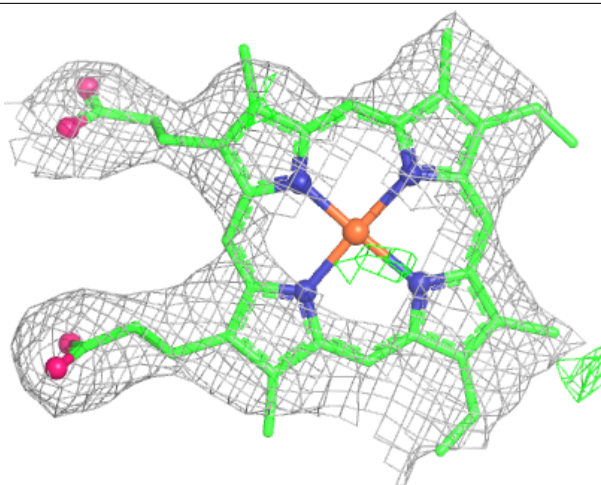
In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. The B-factors column lists the minimum, median, 95th percentile and maximum values of B factors of atoms in the group. The column labelled ‘Q< 0.9’ lists the number of atoms with occupancy less than 0.9.

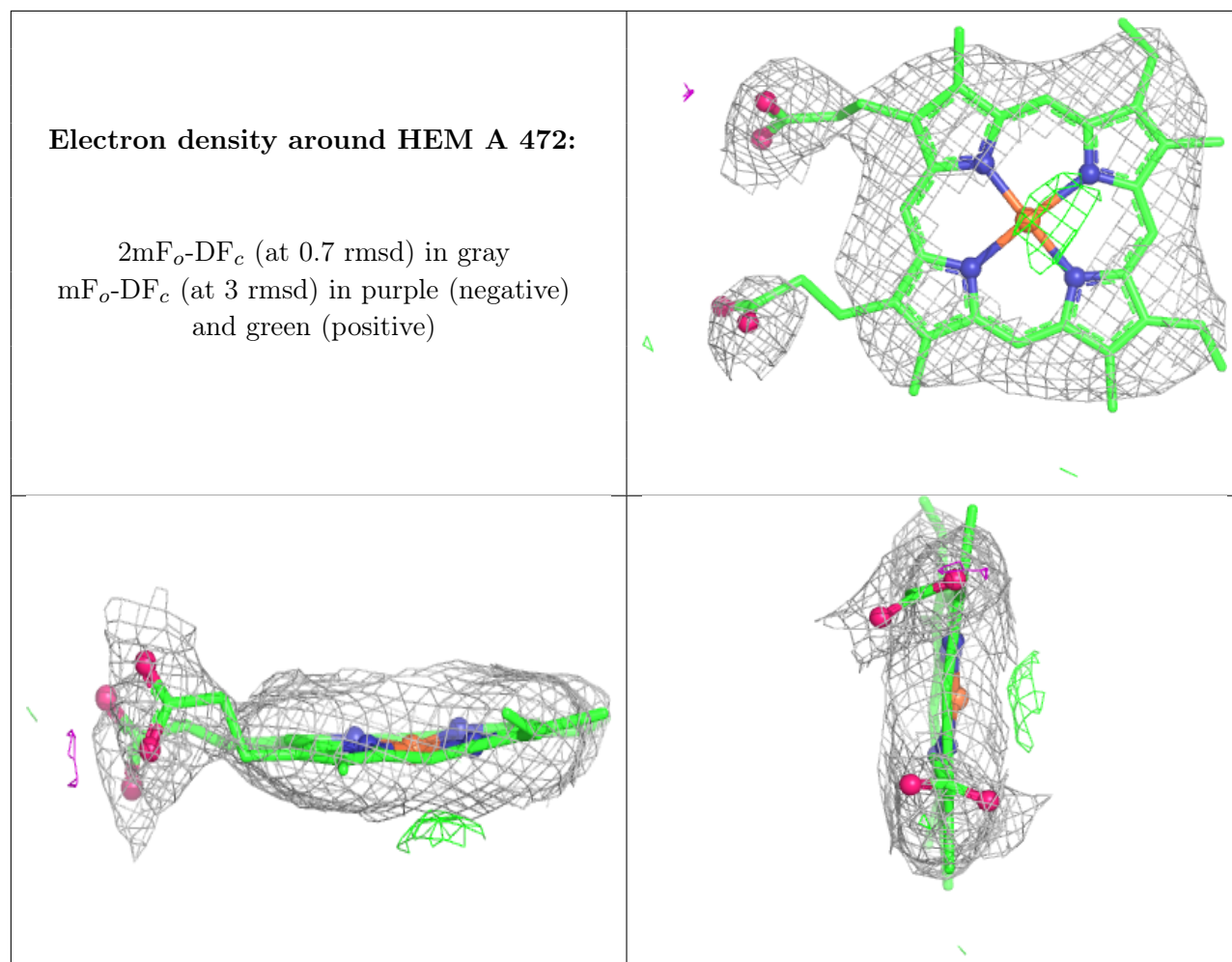
Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors(Å ²)	Q<0.9
2	HEM	B	472	43/43	0.97	0.07	20,59,70,75	0
2	HEM	A	472	43/43	0.98	0.07	39,59,86,95	0

The following is a graphical depiction of the model fit to experimental electron density of all instances of the Ligand of Interest. In addition, ligands with molecular weight > 250 and outliers as shown on the geometry validation Tables will also be included. Each fit is shown from different orientation to approximate a three-dimensional view.

Electron density around HEM B 472:

$2mF_o-DF_c$ (at 0.7 rmsd) in gray
 mF_o-DF_c (at 3 rmsd) in purple (negative)
and green (positive)





6.5 Other polymers ⓘ

There are no such residues in this entry.