Full wwPDB X-ray Structure Validation Report ⓘ

Mar 12, 2026 – 06:33 PM UTC

PDB ID	:	9JYU / pdb_00009jyu
Title	:	Structural analysis of yak hemoglobin
Authors	:	Dachuan, Y.; Xiaoqian, J.
Deposited on	:	2024-10-12
Resolution	:	1.48 Å(reported)

This is a Full wwPDB X-ray Structure Validation 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:

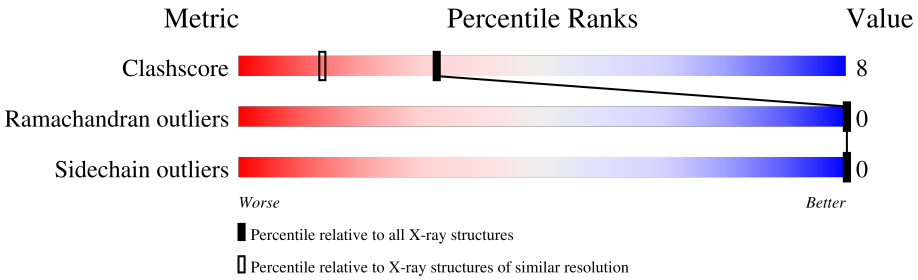
MolProbity	:	4-5-2 with Phenix2.0
Mogul	:	NOT EXECUTED
Xtriage (Phenix)	:	2.0
EDS	:	NOT EXECUTED
Buster-report	:	NOT EXECUTED
Percentile statistics	:	20250101.v01 (using entries in the PDB archive January 1st 2025)
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.49

1 Overall quality at a glance (i)

The following experimental techniques were used to determine the structure:
X-RAY DIFFRACTION

The reported resolution of this entry is 1.48 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))
Clashscore	190562	7025 (1.50-1.46)
Ramachandran outliers	187476	6917 (1.50-1.46)
Sidechain outliers	187428	6914 (1.50-1.46)

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 <=5%

Note EDS was not executed.

Mol	Chain	Length	Quality of chain
1	A	141	91% 9%
1	C	141	92% 7%
2	B	145	86% 14%
2	D	145	78% 22%

2 Entry composition

There are 5 unique types of molecules in this entry. The entry contains 5020 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.

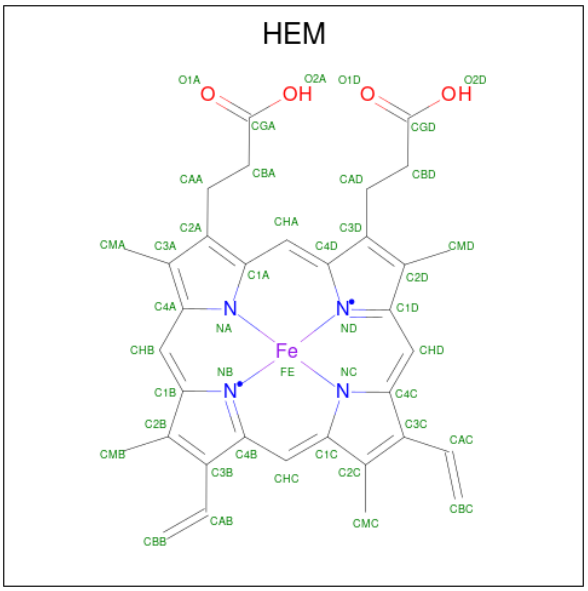
- Molecule 1 is a protein called Hemoglobin subunit alpha-2.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	141	Total	C	N	O	S	0	0	0
			1061	680	186	194	1			
1	C	141	Total	C	N	O	S	0	0	0
			1061	680	186	194	1			

- Molecule 2 is a protein called Hemoglobin subunit beta.

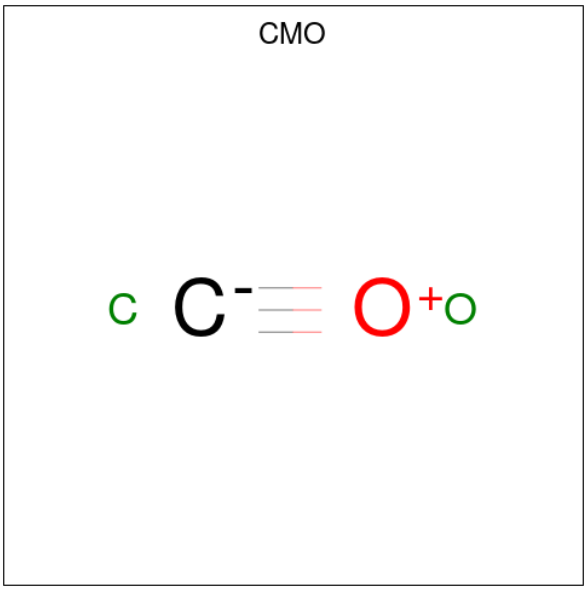
Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	B	145	Total	C	N	O	S	0	0	0
			1130	729	195	202	4			
2	D	145	Total	C	N	O	S	0	0	0
			1130	729	195	202	4			

- Molecule 3 is PROTOPORPHYRIN IX CONTAINING FE (CCD ID: HEM) (formula: $C_{34}H_{32}FeN_4O_4$) (labeled as "Ligand of Interest" by depositor).



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

- Molecule 4 is CARBON MONOXIDE (CCD ID: CMO) (formula: CO) (labeled as "Ligand of Interest" by depositor).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
4	A	1	Total	C	O	2	0
			2	1	1		
4	B	1	Total	C	O	2	0
			2	1	1		
4	D	1	Total	C	O	2	0
			2	1	1		

- Molecule 5 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
5	A	147	Total	O	0	0
			147	147		
5	B	108	Total	O	0	0
			108	108		

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Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
5	C	128	Total O 128 128	0	0
5	D	77	Total O 77 77	0	0

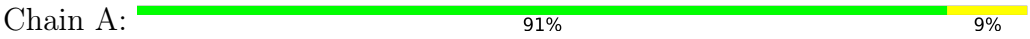
3 Residue-property plots (i)

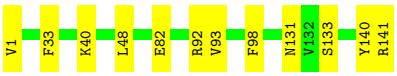
These plots are drawn for all protein, RNA, DNA and oligosaccharide chains in the entry. The first graphic for a chain summarises the proportions of the various outlier classes displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry. Residues are color-coded 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. 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.

Note EDS was not executed.

• Molecule 1: Hemoglobin subunit alpha-2

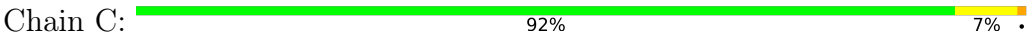
Chain A:





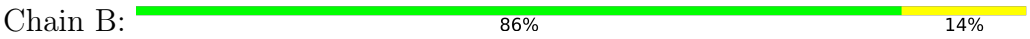
• Molecule 1: Hemoglobin subunit alpha-2

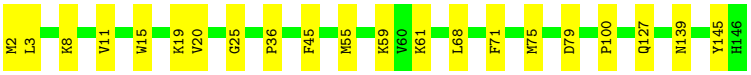
Chain C:



• Molecule 2: Hemoglobin subunit beta

Chain B:





• Molecule 2: Hemoglobin subunit beta

Chain D:

4 Data and refinement statistics (i)

EDS was not executed - this section is therefore incomplete.

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α, β, γ	63.48Å 77.30Å 108.59Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	27.15 – 1.48	Depositor
% Data completeness (in resolution range)	100.0 (27.15-1.48)	Depositor
R_{merge}	0.07	Depositor
R_{sym}	(Not available)	Depositor
$< I/\sigma(I) >$ [1]	2.19 (at 1.48Å)	Xtriage
Refinement program	PHENIX 1.17.1_3660, PHENIX 1.17.1_3660	Depositor
R, R_{free}	0.240 , 0.282	Depositor
Wilson B-factor (Å^2)	22.1	Xtriage
Anisotropy	0.178	Xtriage
L-test for twinning[2]	$< \|L\| > = 0.48$, $< L^2 > = 0.31$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
Total number of atoms	5020	wwPDB-VP
Average B, all atoms (Å^2)	29.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 10.65% of the height of the origin peak. No significant pseudotranslation is detected.*

[1] Intensities estimated from amplitudes.

[2] Theoretical values of $< |L| >$, $< L^2 >$ 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, CMO

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	0.31	0/1088	0.57	0/1476
1	C	0.40	0/1088	0.66	3/1476 (0.2%)
2	B	0.31	0/1156	0.52	0/1561
2	D	0.33	0/1156	0.57	0/1561
All	All	0.34	0/4488	0.58	3/6074 (0.0%)

There are no bond length outliers.

All (3) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
1	C	80	LEU	CA-C-N	6.85	131.17	120.89
1	C	80	LEU	C-N-CA	6.85	131.17	120.89
1	C	82	GLU	N-CA-C	-5.66	105.25	111.82

There are no chirality outliers.

There are no planarity outliers.

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	1061	0	1066	12	0
1	C	1061	0	1066	12	0
2	B	1130	0	1132	27	0
2	D	1130	0	1132	24	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
3	A	43	0	30	0	0
3	B	43	0	30	0	0
3	C	43	0	30	0	0
3	D	43	0	30	0	0
4	A	2	0	0	0	0
4	B	2	0	0	0	0
4	D	2	0	0	0	0
5	A	147	0	0	2	0
5	B	108	0	0	3	0
5	C	128	0	0	2	0
5	D	77	0	0	2	0
All	All	5020	0	4516	69	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 8.

All (69) 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:76:LEU:HD12	1:C:131:ASN:ND2	1.67	1.09
2:B:19:LYS:H	2:B:19:LYS:HD2	1.39	0.87
2:B:2:MET:HE2	2:B:3:LEU:HD12	1.59	0.84
1:C:76:LEU:CD1	1:C:131:ASN:ND2	2.42	0.82
2:B:19:LYS:HE3	5:B:326:HOH:O	1.87	0.75
1:C:76:LEU:HD12	1:C:131:ASN:HD21	1.51	0.70
2:D:107:GLY:HA3	2:D:134:VAL:HG13	1.75	0.69
1:A:1:VAL:HG13	1:A:131:ASN:OD1	1.92	0.69
1:A:141:ARG:NH2	5:A:301:HOH:O	2.25	0.68
2:B:20:VAL:CG1	2:B:68:LEU:HB3	2.24	0.67
2:D:61:LYS:NZ	5:D:305:HOH:O	2.27	0.65
1:C:76:LEU:HD12	1:C:131:ASN:HD22	1.63	0.64
1:C:76:LEU:CD1	1:C:131:ASN:HD22	2.12	0.62
2:D:8:LYS:HG3	2:D:78:LEU:HD12	1.82	0.61
2:D:24:GLY:HA2	2:D:68:LEU:HD13	1.82	0.60
2:B:2:MET:HE2	2:B:3:LEU:CD1	2.30	0.60
2:D:131:GLN:O	2:D:135:VAL:HG13	2.02	0.60
1:C:82:GLU:OE2	1:C:82:GLU:HA	2.03	0.58
1:A:33:PHE:HB3	1:A:40:LYS:HE3	1.85	0.58
2:B:127:GLN:NE2	5:B:303:HOH:O	2.37	0.58
1:A:140:TYR:HB3	2:D:36:PRO:HG2	1.87	0.56
2:B:11:VAL:CG1	2:B:75:MET:HE1	2.35	0.56

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
2:B:19:LYS:HD2	2:B:19:LYS:N	2.15	0.55
2:B:20:VAL:HG13	2:B:68:LEU:HB3	1.88	0.55
1:C:93:VAL:O	1:C:140:TYR:OH	2.24	0.55
2:B:20:VAL:HG12	2:B:68:LEU:HB3	1.90	0.53
2:B:19:LYS:CE	5:B:326:HOH:O	2.50	0.53
2:D:87:ALA:O	2:D:90:GLU:HG3	2.09	0.53
2:D:107:GLY:HA3	2:D:134:VAL:CG1	2.38	0.53
2:B:2:MET:HG3	2:B:3:LEU:N	2.24	0.53
2:B:2:MET:HG3	2:B:3:LEU:H	1.74	0.52
2:D:14:PHE:CD1	2:D:126:LEU:HD21	2.45	0.52
1:A:93:VAL:O	1:A:140:TYR:OH	2.29	0.51
2:B:36:PRO:HG2	1:C:140:TYR:HB3	1.93	0.51
2:D:28:LEU:HD23	2:D:60:VAL:O	2.11	0.50
2:B:15:TRP:CG	2:B:75:MET:HE2	2.47	0.50
2:B:8:LYS:NZ	2:B:79:ASP:OD2	2.27	0.50
2:B:71:PHE:O	2:B:75:MET:HG2	2.13	0.49
2:B:2:MET:HG3	2:B:3:LEU:HD13	1.94	0.49
2:B:2:MET:N	2:B:79:ASP:OD1	2.47	0.48
2:B:55:MET:O	2:B:61:LYS:HE3	2.12	0.48
2:B:75:MET:HE3	2:B:75:MET:HB3	1.55	0.48
2:D:47:ASP:OD2	5:D:301:HOH:O	2.20	0.48
2:D:144:ARG:HA	2:D:144:ARG:HD2	1.61	0.47
2:D:100:PRO:HD3	2:D:145:TYR:CE2	2.50	0.47
2:B:45:PHE:HA	2:B:59:LYS:HD2	1.97	0.47
2:B:25:GLY:HA3	2:B:61:LYS:HD3	1.96	0.46
2:D:48:LEU:HB3	2:D:54:VAL:HG22	1.97	0.46
2:D:132:LYS:O	2:D:135:VAL:HG22	2.16	0.45
1:C:119:PRO:HG2	2:D:55:MET:HG3	1.97	0.45
1:A:131:ASN:ND2	5:A:305:HOH:O	2.38	0.44
1:A:140:TYR:CE1	2:D:37:TRP:HB3	2.52	0.44
2:D:75:MET:HE3	2:D:75:MET:HB3	1.86	0.44
2:B:11:VAL:HG13	2:B:75:MET:HE1	2.00	0.44
2:B:139:ASN:OD1	2:D:146:HIS:CG	2.71	0.44
2:D:93:CYS:SG	2:D:145:TYR:CE2	3.05	0.44
1:A:40:LYS:HG2	1:A:48:LEU:HD13	2.01	0.43
1:C:31:ARG:NH2	5:C:306:HOH:O	2.50	0.43
1:C:123:ALA:O	1:C:127:LYS:HG3	2.19	0.42
1:A:92:ARG:HB2	2:D:40:ARG:HB2	2.01	0.42
1:A:82:GLU:H	1:A:82:GLU:CD	2.24	0.42
1:A:33:PHE:CE2	1:A:48:LEU:HD22	2.54	0.42
2:B:100:PRO:HD3	2:B:145:TYR:CE2	2.55	0.41

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
2:D:47:ASP:O	2:D:48:LEU:HD23	2.21	0.41
1:A:98:PHE:HB3	1:A:133:SER:HB3	2.03	0.41
2:B:11:VAL:HG12	2:B:75:MET:HE1	2.01	0.41
2:D:50:SER:H	2:D:53:ALA:HB3	1.86	0.41
2:D:71:PHE:O	2:D:75:MET:HG2	2.21	0.41
1:C:139:LYS:HB2	5:C:320:HOH:O	2.20	0.40

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	139/141 (99%)	137 (99%)	2 (1%)	0	100	100
1	C	139/141 (99%)	132 (95%)	7 (5%)	0	100	100
2	B	143/145 (99%)	142 (99%)	1 (1%)	0	100	100
2	D	143/145 (99%)	142 (99%)	1 (1%)	0	100	100
All	All	564/572 (99%)	553 (98%)	11 (2%)	0	100	100

There are no Ramachandran outliers to report.

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	111/111 (100%)	111 (100%)	0	100	100
1	C	111/111 (100%)	111 (100%)	0	100	100
2	B	119/119 (100%)	119 (100%)	0	100	100
2	D	119/119 (100%)	119 (100%)	0	100	100
All	All	460/460 (100%)	460 (100%)	0	100	100

There are no protein residues with a non-rotameric sidechain to report.

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (7) such sidechains are listed below:

Mol	Chain	Res	Type
2	B	77	HIS
2	B	97	HIS
1	C	131	ASN
2	D	56	ASN
2	D	77	HIS
2	D	131	GLN
2	D	146	HIS

5.3.3 RNA (i)

There are no RNA molecules in this entry.

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

Mogul was not executed - this section is therefore empty.

5.5 Carbohydrates (i)

Mogul was not executed - this section is therefore empty.

5.6 Ligand geometry (i)

Mogul was not executed - this section is therefore empty.

5.7 Other polymers (i)

Mogul was not executed - this section is therefore empty.

5.8 Polymer linkage issues (i)

There are no chain breaks in this entry.

6 Fit of model and data

6.1 Protein, DNA and RNA chains

EDS was not executed - this section is therefore empty.

6.2 Non-standard residues in protein, DNA, RNA chains

EDS was not executed - this section is therefore empty.

6.3 Carbohydrates

EDS was not executed - this section is therefore empty.

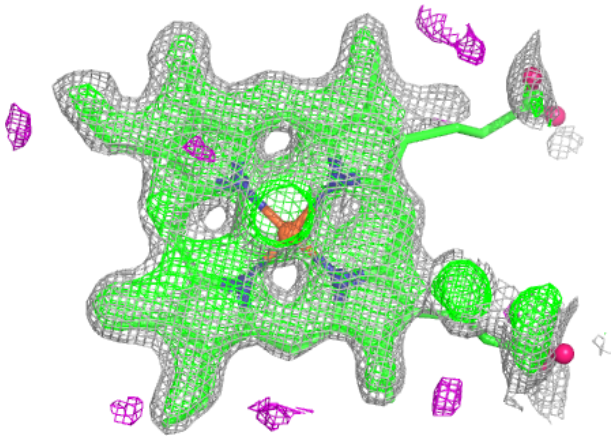
6.4 Ligands

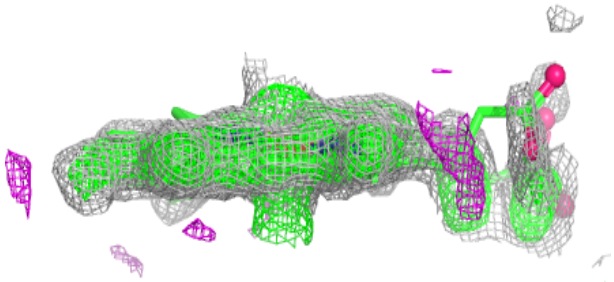
EDS was not executed - this section is therefore empty.

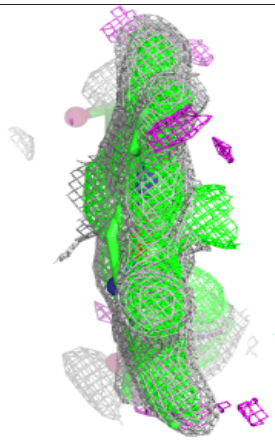
The following is a graphical depiction of the model fit to experimental electron density of all instances of the Ligand of Interest. In addition, ligands with molecular weight > 250 and outliers as shown on the geometry validation Tables will also be included. Each fit is shown from different orientation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

Electron density around HEM A 201:

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

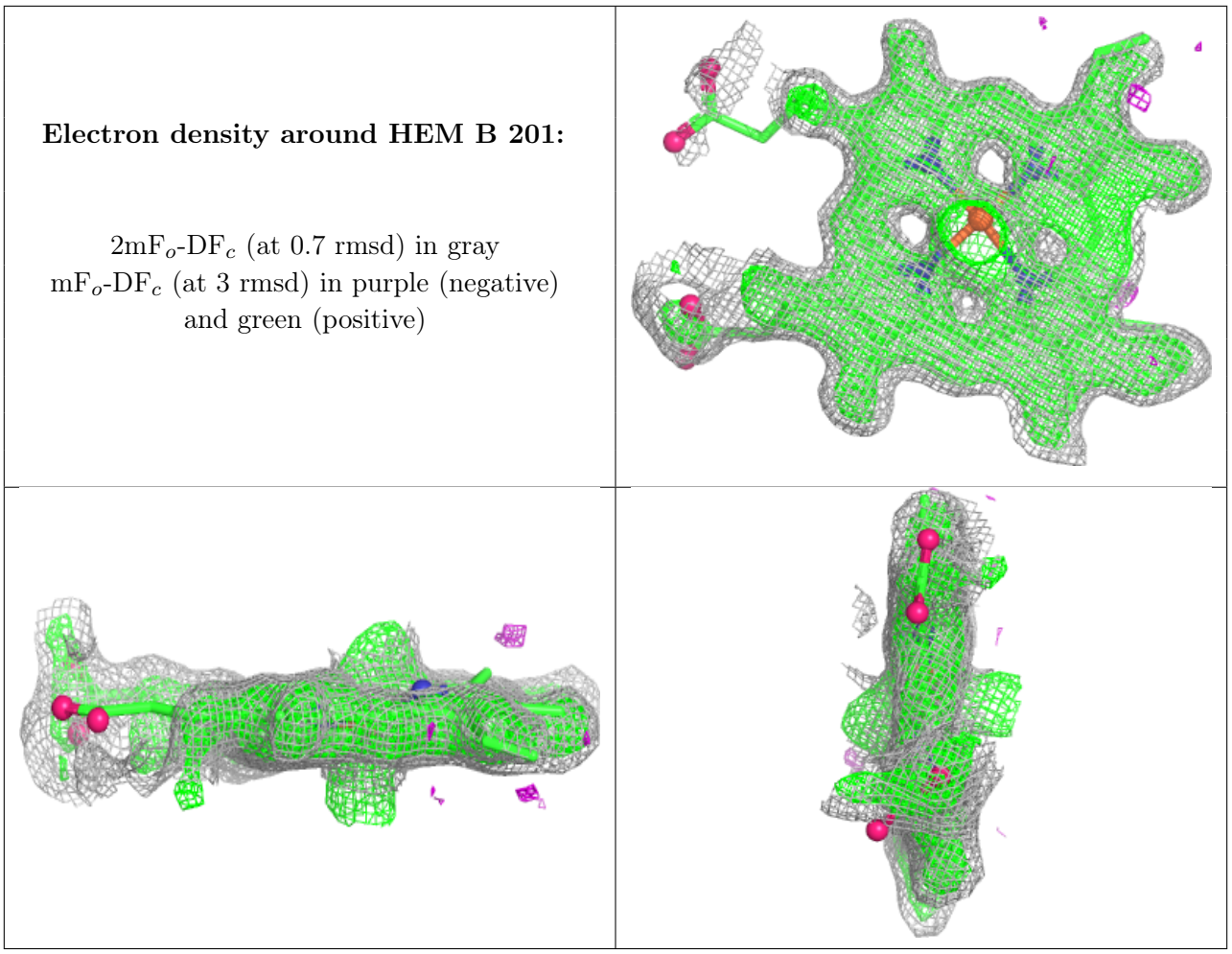






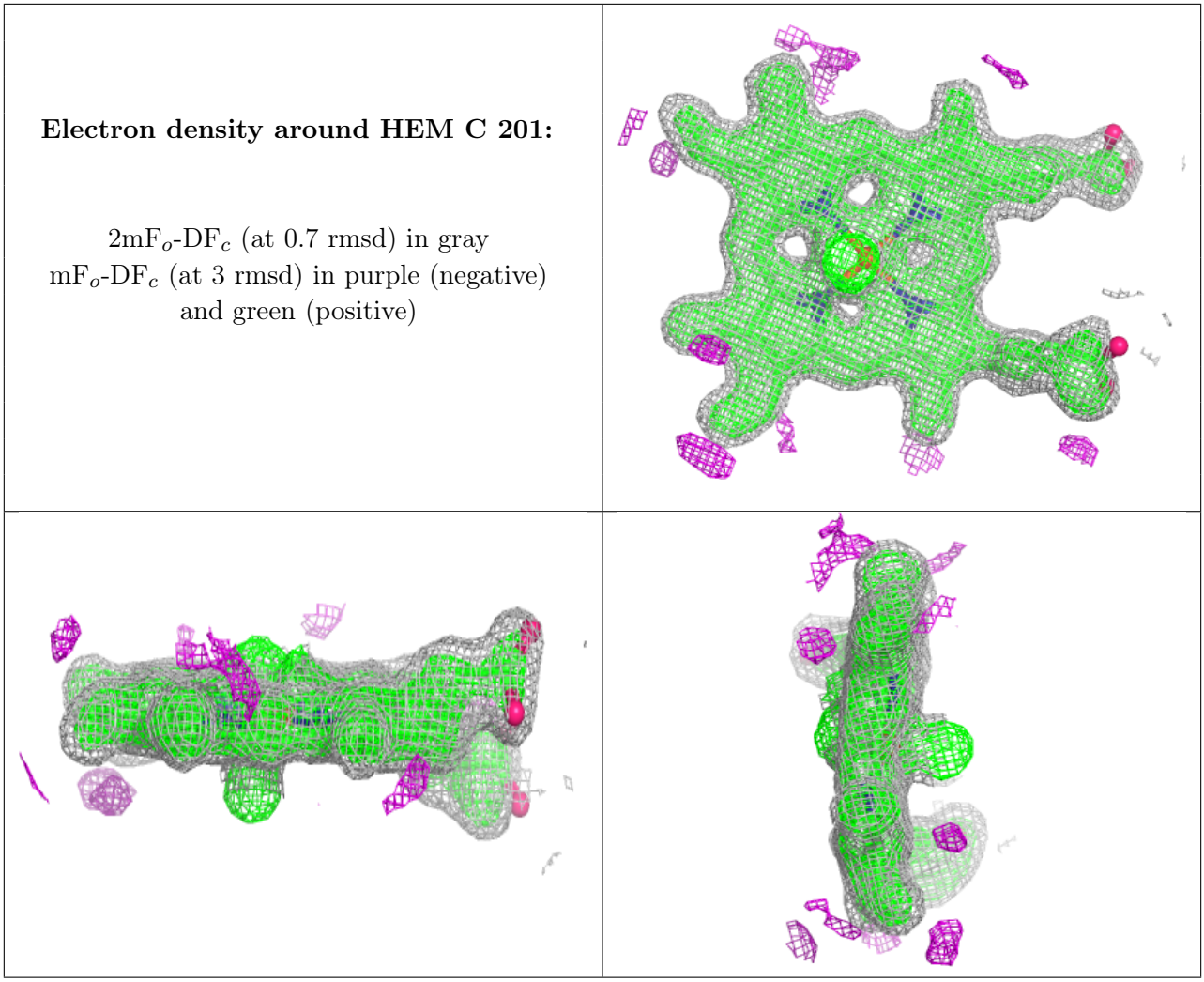
Electron density around HEM B 201:

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



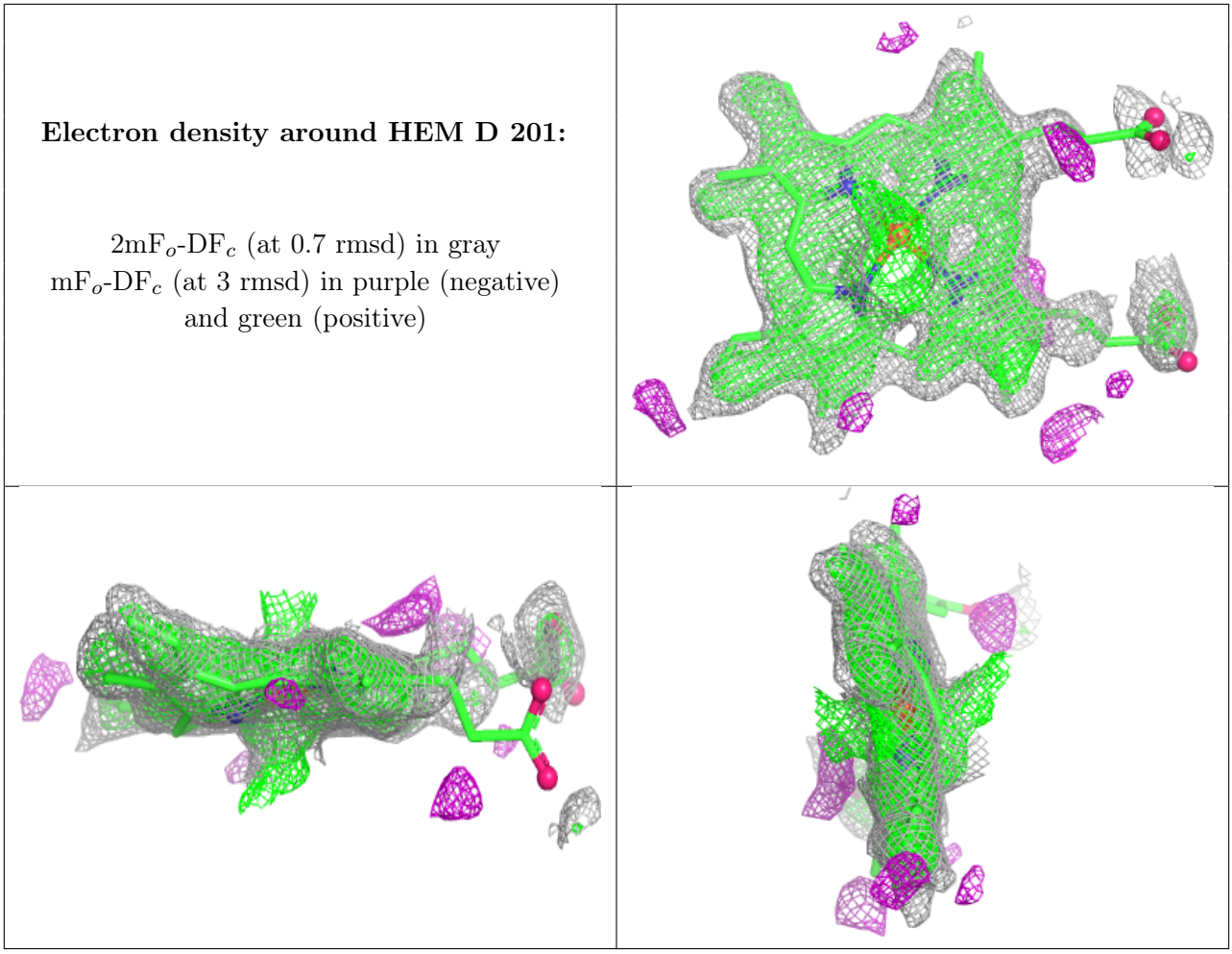
Electron density around HEM C 201:

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



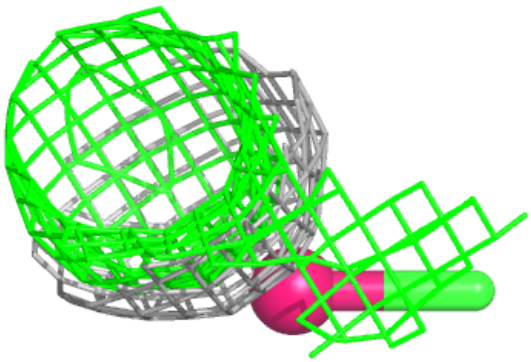
Electron density around HEM D 201:

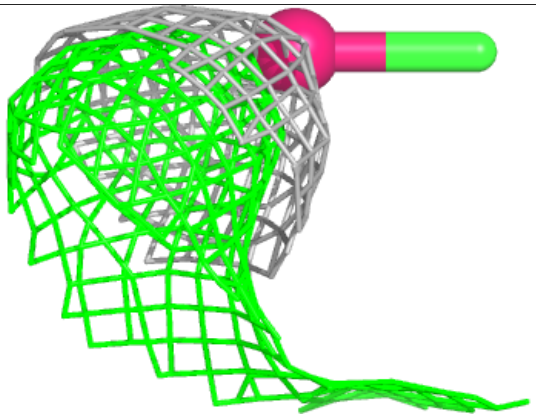
$2mF_o$-DF_c (at 0.7 rmsd) in gray
mF_o-DF_c (at 3 rmsd) in purple (negative) and green (positive)

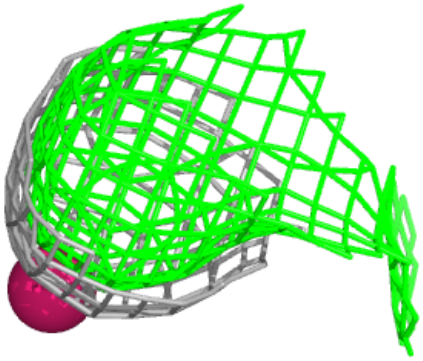


Electron density around CMO A 202:

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

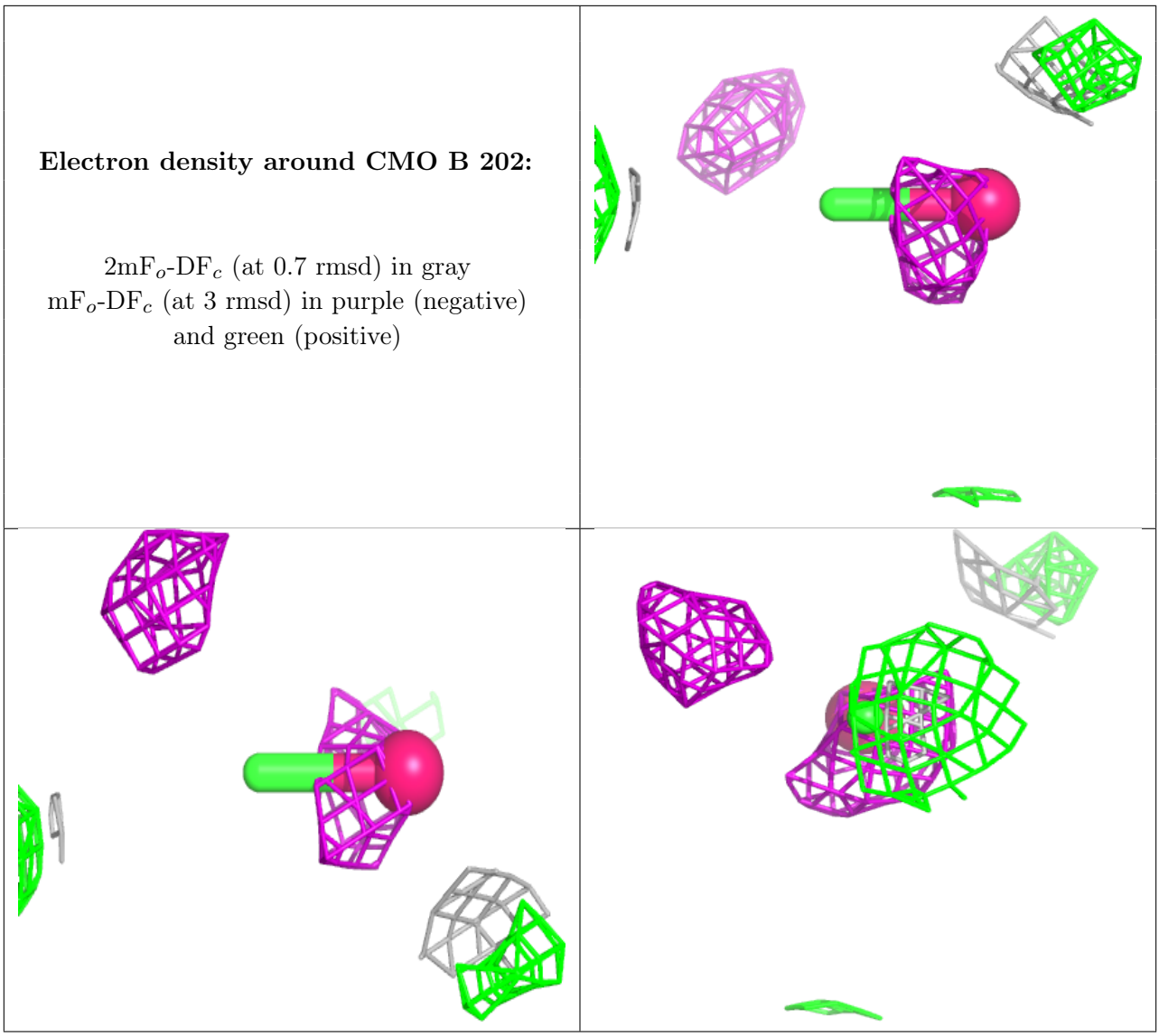






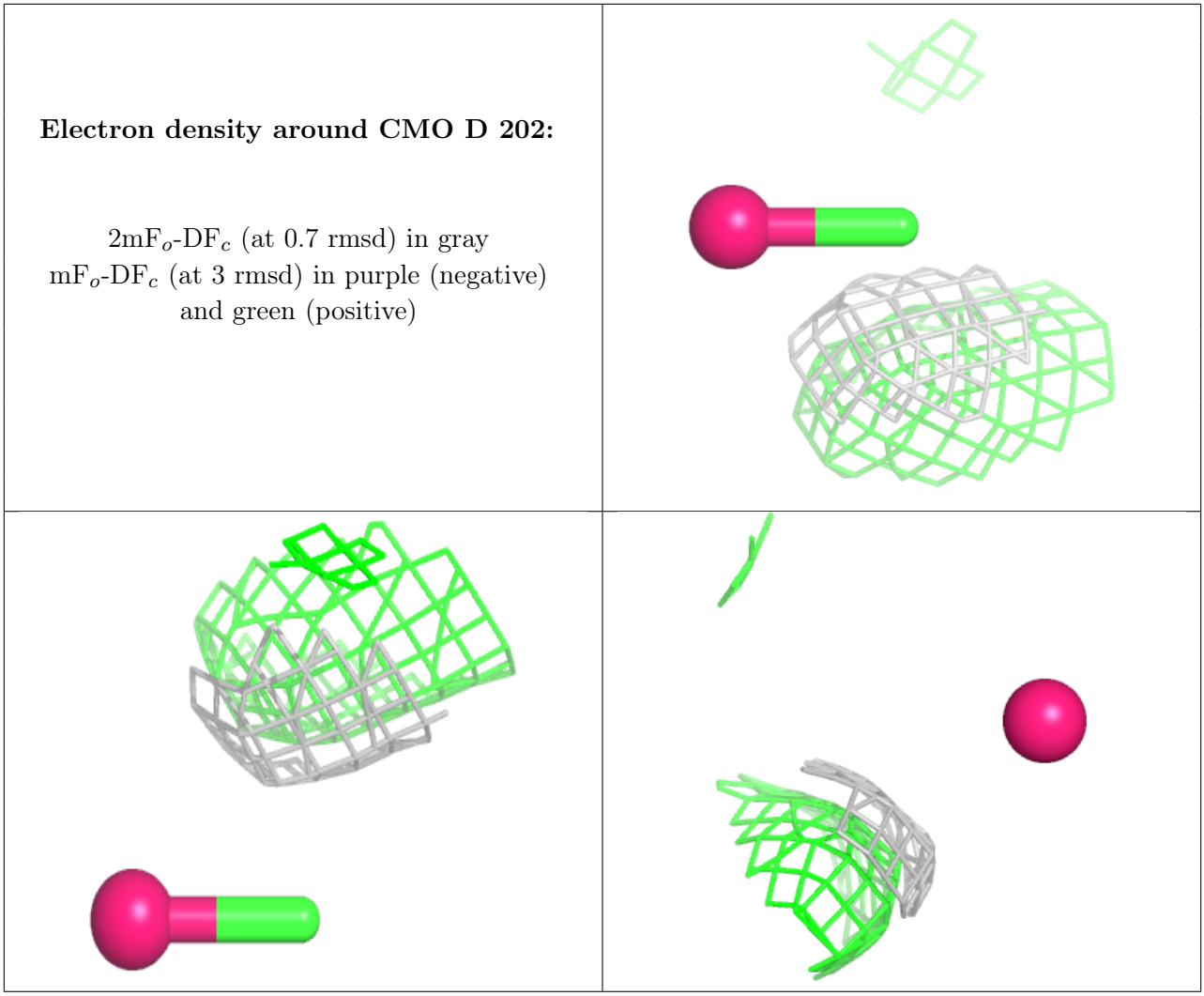
Electron density around CMO B 202:

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



Electron density around CMO D 202:

$2mF_o$-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

EDS was not executed - this section is therefore empty.