



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 1, 2026 – 06:26 PM UTC

PDB ID : 8P4G / pdb_00008p4g
Title : Crystal structure of a multicopper oxidase 3F3 variant from *Pyrobaculum aerophilum*
Authors : Borges, P.T.; Brissos, V.; Frazao, C.; Martins, L.O.
Deposited on : 2023-05-21
Resolution : 2.59 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
Xtriage (Phenix)	:	2.0
EDS	:	3.0
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

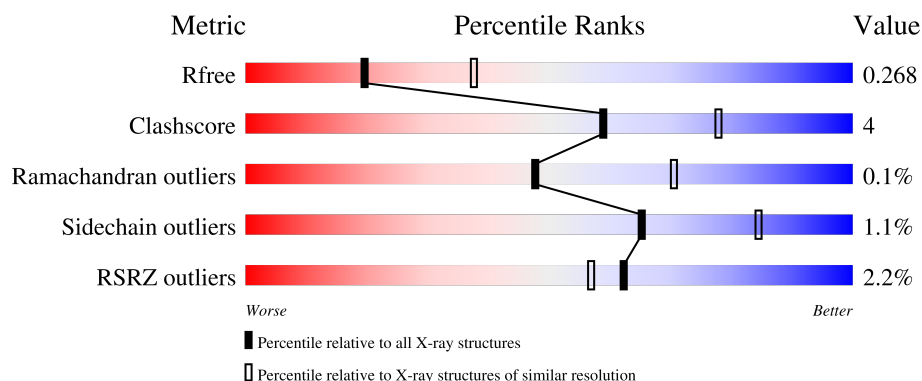
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

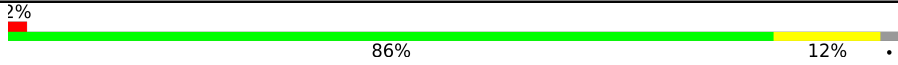
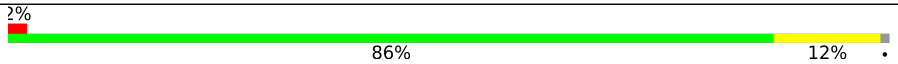
The reported resolution of this entry is 2.59 Å.

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	4008 (2.60-2.60)
Clashscore	190562	4347 (2.60-2.60)
Ramachandran outliers	187476	4277 (2.60-2.60)
Sidechain outliers	187428	4277 (2.60-2.60)
RSRZ outliers	180081	4008 (2.60-2.60)

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	440	
1	B	440	

2 Entry composition

There are 4 unique types of molecules in this entry. The entry contains 6949 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 Multicopper oxidase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	433	Total	C	N	O	S	0	2	0
			3400	2184	587	613	16			
1	B	434	Total	C	N	O	S	0	1	0
			3398	2183	585	614	16			

There are 12 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	206	ILE	VAL	engineered mutation	UNP Q8ZWA8
A	292	HIS	PRO	engineered mutation	UNP Q8ZWA8
A	331	PRO	SER	engineered mutation	UNP Q8ZWA8
A	361	SER	PHE	engineered mutation	UNP Q8ZWA8
A	390	THR	PRO	engineered mutation	UNP Q8ZWA8
A	393	VAL	MET	engineered mutation	UNP Q8ZWA8
B	206	ILE	VAL	engineered mutation	UNP Q8ZWA8
B	292	HIS	PRO	engineered mutation	UNP Q8ZWA8
B	331	PRO	SER	engineered mutation	UNP Q8ZWA8
B	361	SER	PHE	engineered mutation	UNP Q8ZWA8
B	390	THR	PRO	engineered mutation	UNP Q8ZWA8
B	393	VAL	MET	engineered mutation	UNP Q8ZWA8

- Molecule 2 is COPPER (II) ION (CCD ID: CU) (formula: Cu) (labeled as "Ligand of Interest" by depositor).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	A	4	Total	Cu	0	0
			4	4		
2	B	4	Total	Cu	0	0
			4	4		

- Molecule 3 is CHLORIDE ION (CCD ID: CL) (formula: Cl) (labeled as "Ligand of Interest" by depositor).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	A	1	Total 1	Cl 1	0	0

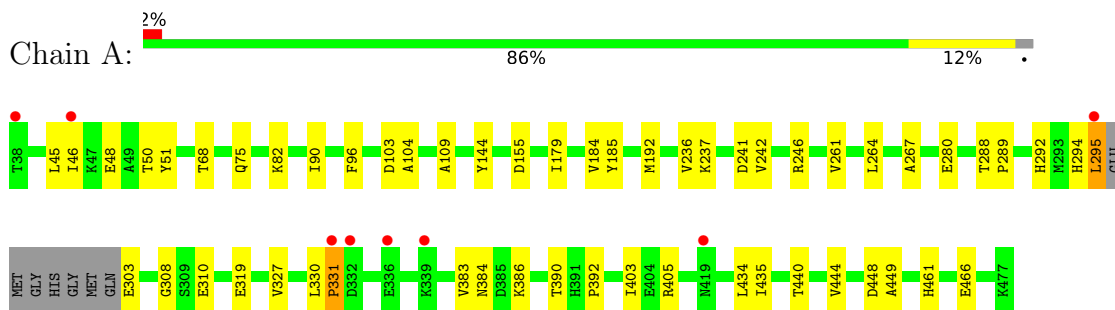
- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	80	Total 80	O 80	0	0
4	B	62	Total 62	O 62	0	0

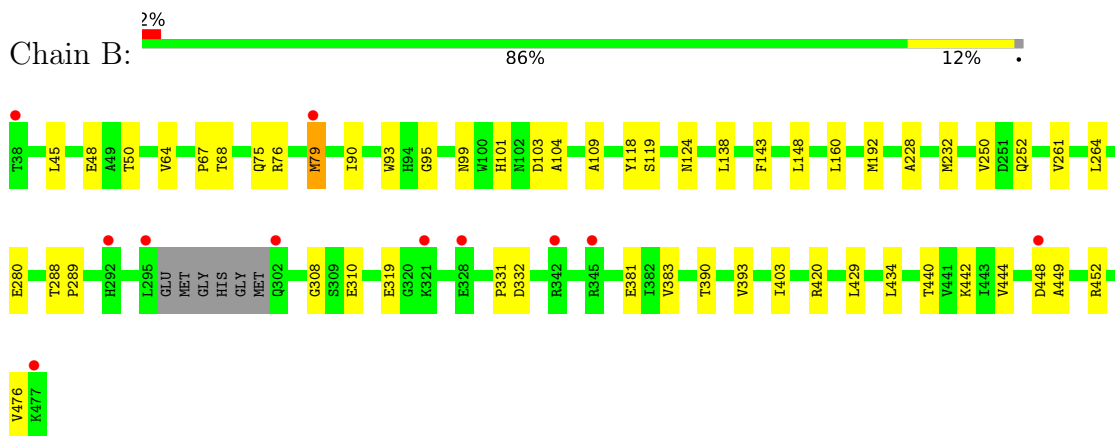
3 Residue-property plots [i](#)

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 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: Multicopper oxidase



- Molecule 1: Multicopper oxidase



4 Data and refinement statistics

Property	Value	Source
Space group	P 41 21 2	Depositor
Cell constants a, b, c, α , β , γ	128.40Å 128.40Å 124.97Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	73.45 – 2.59 73.45 – 2.59	Depositor EDS
% Data completeness (in resolution range)	99.0 (73.45-2.59) 99.1 (73.45-2.59)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	0.96 (at 2.58Å)	Xtriage
Refinement program	PHENIX (1.17.1_3660: ???)	Depositor
R, R_{free}	0.213 , 0.260 0.224 , 0.268	Depositor DCC
R_{free} test set	500 reflections (1.53%)	wwPDB-VP
Wilson B-factor (Å ²)	53.5	Xtriage
Anisotropy	0.271	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.37 , 43.3	EDS
L-test for twinning ²	$\langle L \rangle = 0.50$, $\langle L^2 \rangle = 0.33$	Xtriage
Estimated twinning fraction	0.001 for -h,-l,-k 0.000 for l,-k,h	Xtriage
F_o, F_c correlation	0.94	EDS
Total number of atoms	6949	wwPDB-VP
Average B, all atoms (Å ²)	49.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 6.21% 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: CL, CU

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	0.11	0/3495	0.35	2/4757 (0.0%)
1	B	0.11	0/3493	0.33	0/4755
All	All	0.11	0/6988	0.34	2/9512 (0.0%)

There are no bond length outliers.

All (2) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	331	PRO	CA-C-N	-5.10	115.72	122.56
1	A	331	PRO	C-N-CA	-5.10	115.72	122.56

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	3400	0	3385	31	1
1	B	3398	0	3382	31	1
2	A	4	0	0	0	0
2	B	4	0	0	0	0
3	A	1	0	0	0	0
4	A	80	0	0	6	0
4	B	62	0	0	3	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
All	All	6949	0	6767	60	1

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 4.

All (60) 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:B:250:VAL:O	4:B:901:HOH:O	1.88	0.91
1:A:292:HIS:HD2	1:A:308:GLY:H	1.35	0.73
1:A:246:ARG:NH2	1:A:327:VAL:O	2.24	0.70
1:A:292:HIS:O	1:A:292:HIS:ND1	2.27	0.69
1:A:289:PRO:HG3	1:A:310:GLU:HB2	1.77	0.67
1:A:96:PHE:O	4:A:801:HOH:O	2.13	0.66
1:A:303:GLU:OE1	4:A:802:HOH:O	2.15	0.64
1:B:232:MET:HE3	1:B:288:THR:HB	1.78	0.64
1:A:184:VAL:HG23	1:B:138:LEU:HD11	1.83	0.60
1:B:76:ARG:NH1	1:B:119:SER:OG	2.38	0.57
1:B:452:ARG:HA	1:B:476:VAL:HB	1.87	0.56
1:B:289:PRO:HG3	1:B:310:GLU:HB2	1.88	0.56
1:B:381:GLU:HG2	1:B:442:LYS:HG2	1.90	0.54
1:A:390:THR:HB	1:A:434:LEU:HD11	1.89	0.54
1:B:280:GLU:HG3	1:B:319:GLU:HA	1.90	0.54
1:B:160:LEU:HD21	1:B:331:PRO:HD3	1.89	0.54
1:A:261:VAL:HG21	1:A:264:LEU:HD23	1.91	0.53
1:B:228:ALA:N	4:B:902:HOH:O	2.21	0.52
1:A:280:GLU:HG3	1:A:319:GLU:HA	1.91	0.52
1:B:420:ARG:NH1	4:B:907:HOH:O	2.41	0.52
1:A:48:GLU:HG2	1:A:75:GLN:HE22	1.74	0.51
1:B:261:VAL:HG21	1:B:264:LEU:HD23	1.90	0.51
1:A:246:ARG:NE	4:A:811:HOH:O	2.41	0.51
1:B:390:THR:HB	1:B:434:LEU:HD11	1.91	0.51
1:A:466:GLU:OE1	4:A:803:HOH:O	2.19	0.50
1:A:237:LYS:HD2	1:A:241:ASP:HB2	1.93	0.49
1:B:252:GLN:HB2	1:B:429:LEU:HB3	1.95	0.49
1:B:448:ASP:OD1	1:B:449:ALA:N	2.46	0.49
1:A:103:ASP:N	1:A:104:ALA:HA	2.27	0.48
1:B:103:ASP:N	1:B:104:ALA:HA	2.27	0.48
1:B:48:GLU:HG2	1:B:75:GLN:HE22	1.79	0.48
1:B:90:ILE:HB	1:B:109:ALA:HA	1.95	0.48
1:A:448:ASP:OD1	1:A:449:ALA:N	2.48	0.47

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:403:ILE:HG13	1:B:444:VAL:HG23	1.98	0.46
1:B:383:VAL:HG22	1:B:440:THR:HG23	1.97	0.46
1:B:95:GLY:O	1:B:124:ASN:ND2	2.50	0.45
1:A:461:HIS:ND1	4:A:805:HOH:O	2.24	0.43
1:A:45:LEU:HD23	1:A:68:THR:HB	2.01	0.43
1:A:90:ILE:HB	1:A:109:ALA:HA	1.99	0.43
1:B:45:LEU:HD23	1:B:68:THR:HB	1.99	0.43
1:B:449:ALA:HB1	1:B:452:ARG:NH1	2.34	0.43
1:A:294:HIS:HB3	1:A:295:LEU:H	1.71	0.42
1:B:449:ALA:O	1:B:452:ARG:NH1	2.52	0.42
1:A:267:ALA:HB1	1:A:392:PRO:HB3	2.00	0.42
1:B:143:PHE:CZ	1:B:148:LEU:HD22	2.55	0.42
1:A:383:VAL:HG22	1:A:440:THR:HG23	2.00	0.42
1:A:179:ILE:HD12	1:A:184:VAL:HG11	2.02	0.41
1:A:384:ASN:HB2	1:A:435:ILE:HG22	2.02	0.41
1:A:403:ILE:HG13	1:A:444:VAL:HG23	2.01	0.41
1:A:155:ASP:HB3	4:A:853:HOH:O	2.21	0.41
1:A:192[A]:MET:HB2	1:B:192[A]:MET:HE1	2.03	0.41
1:B:64:VAL:HG23	1:B:67:PRO:HG3	2.03	0.41
1:B:79:MET:HE3	1:B:118:TYR:CD2	2.55	0.41
1:A:144:TYR:CD2	1:A:185:TYR:HB2	2.54	0.41
1:B:289:PRO:HA	1:B:308:GLY:O	2.21	0.41
1:A:51:TYR:OH	1:A:82:LYS:HD2	2.20	0.41
1:B:79:MET:HG2	1:B:93:TRP:HZ2	1.86	0.41
1:B:99:ASN:HD21	1:B:101:HIS:HB2	1.86	0.41
1:A:236:VAL:HG12	1:A:242:VAL:HG22	2.02	0.40
1:A:330:LEU:HA	1:A:331:PRO:HD3	1.95	0.40

All (1) symmetry-related close contacts are listed below. The label for Atom-2 includes the symmetry operator and encoded unit-cell translations to be applied.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:405:ARG:O	1:B:452:ARG:NH2[6_554]	2.10	0.10

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	431/440 (98%)	418 (97%)	13 (3%)	0	100	100
1	B	431/440 (98%)	417 (97%)	13 (3%)	1 (0%)	43	66
All	All	862/880 (98%)	835 (97%)	26 (3%)	1 (0%)	48	70

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	B	332	ASP

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	367/370 (99%)	362 (99%)	5 (1%)	59	81
1	B	367/370 (99%)	364 (99%)	3 (1%)	73	88
All	All	734/740 (99%)	726 (99%)	8 (1%)	65	84

All (8) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	46	ILE
1	A	50	THR
1	A	288	THR
1	A	295	LEU
1	A	386	LYS
1	B	50	THR
1	B	79	MET
1	B	393	VAL

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (3) such sidechains are listed below:

Mol	Chain	Res	Type
1	B	136	HIS
1	B	292	HIS
1	B	363	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](#)

Of 9 ligands modelled in this entry, 9 are monoatomic - leaving 0 for Mogul analysis.

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

No monomer is involved in short contacts.

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	433/440 (98%)	0.30	8 (1%) 67 63	21, 48, 65, 81	2 (0%)
1	B	434/440 (98%)	0.32	11 (2%) 58 52	34, 47, 67, 86	1 (0%)
All	All	867/880 (98%)	0.31	19 (2%) 62 57	21, 47, 67, 86	3 (0%)

All (19) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	295	LEU	5.5
1	B	295	LEU	3.5
1	A	419	ASN	3.4
1	A	331	PRO	2.5
1	B	38	THR	2.5
1	B	448	ASP	2.4
1	A	46	ILE	2.4
1	A	38	THR	2.3
1	B	477	LYS	2.2
1	A	336	GLU	2.2
1	A	332	ASP	2.2
1	B	328	GLU	2.1
1	B	292	HIS	2.1
1	B	302	GLN	2.1
1	B	342	ARG	2.1
1	B	79	MET	2.1
1	B	345	ARG	2.0
1	A	339	LYS	2.0
1	B	321	LYS	2.0

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](#)

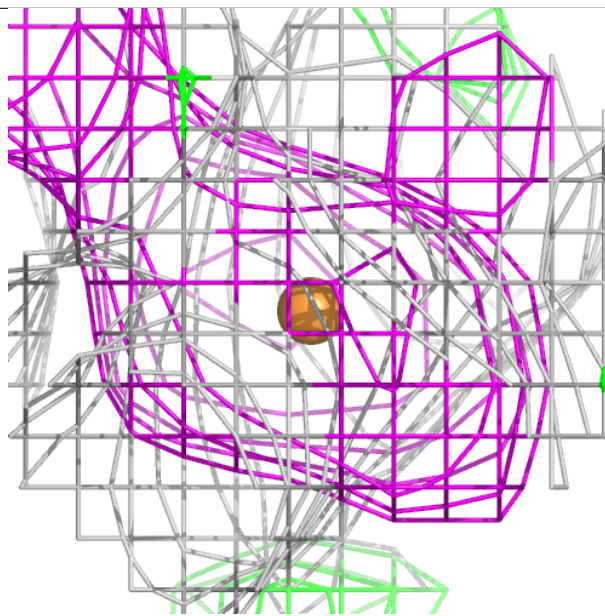
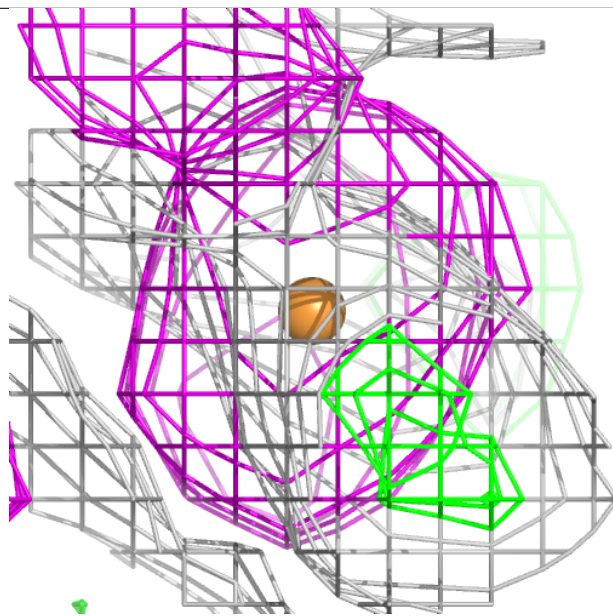
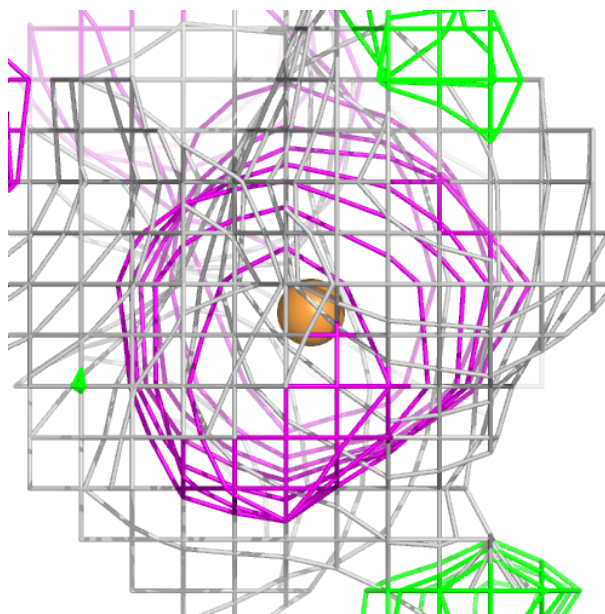
In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. The B-factors column lists the minimum, median, 95th percentile and maximum values of B factors of atoms in the group. The column labelled 'Q< 0.9' lists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

Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors($\text{\AA}^2$)	Q<0.9
2	CU	A	703	1/1	0.83	0.30	69,69,69,69	0
2	CU	B	803	1/1	0.88	0.33	61,61,61,61	0
3	CL	A	705	1/1	0.92	0.08	59,59,59,59	0
2	CU	B	802	1/1	0.96	0.17	64,64,64,64	0
2	CU	A	702	1/1	0.98	0.15	50,50,50,50	0
2	CU	A	701	1/1	0.99	0.07	44,44,44,44	0
2	CU	A	704	1/1	0.99	0.09	39,39,39,39	0
2	CU	B	804	1/1	0.99	0.09	40,40,40,40	0
2	CU	B	801	1/1	0.99	0.04	49,49,49,49	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.

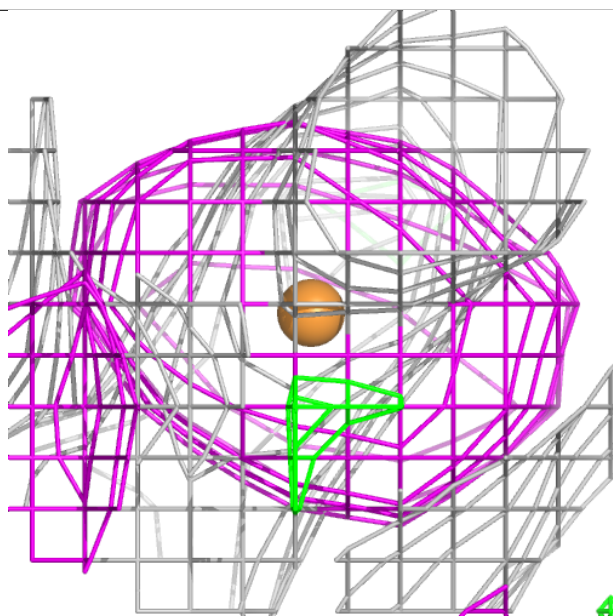
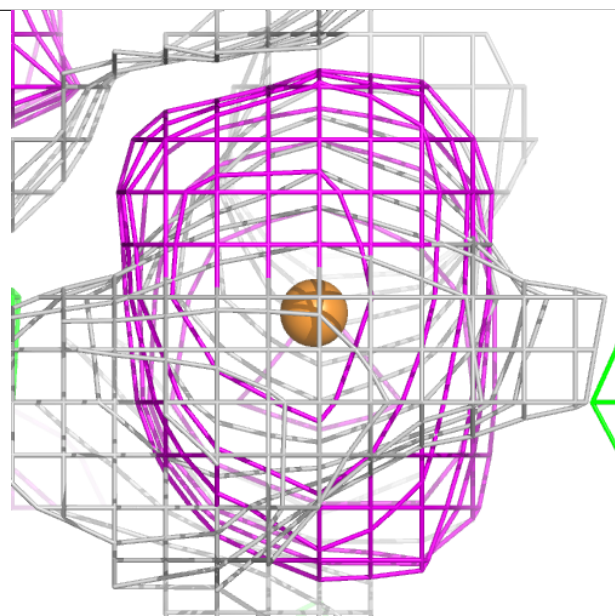
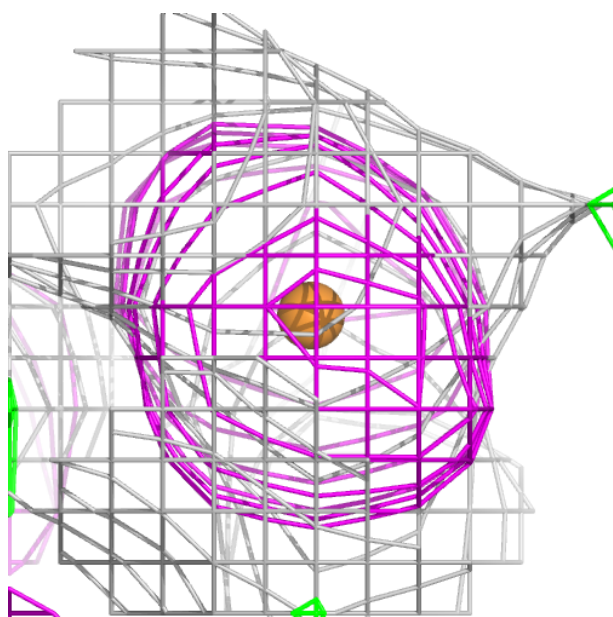
Electron density around CU A 703:

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



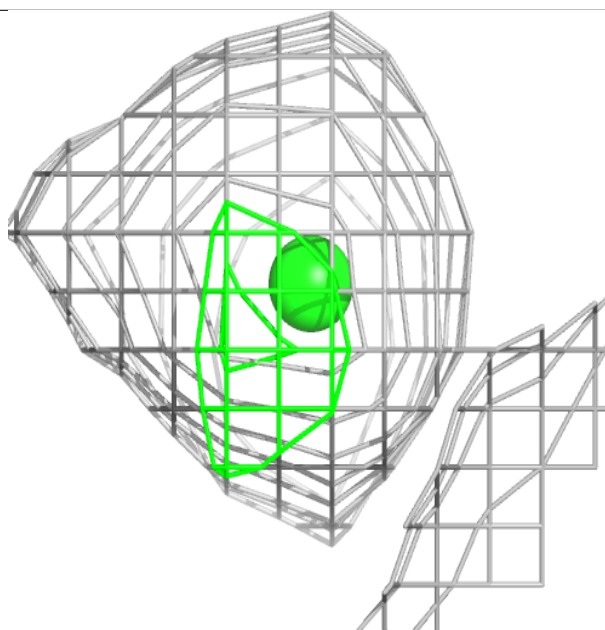
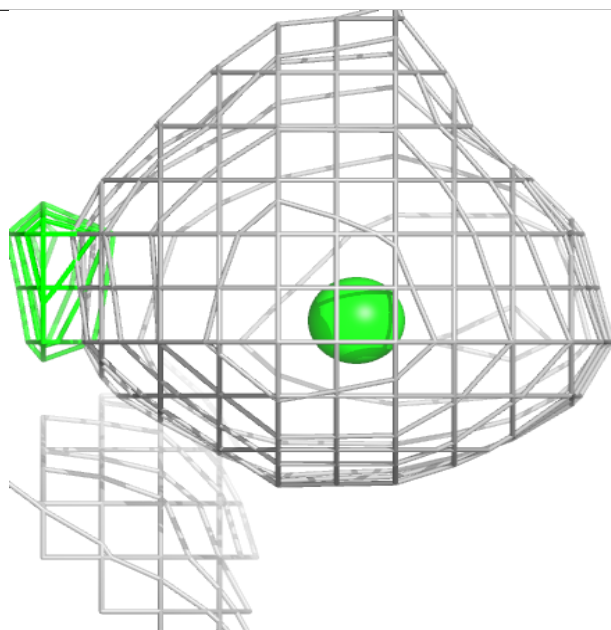
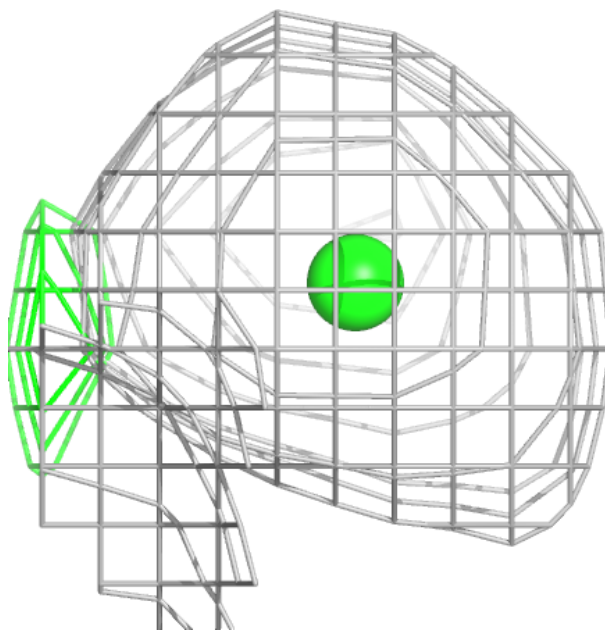
Electron density around CU B 803:

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



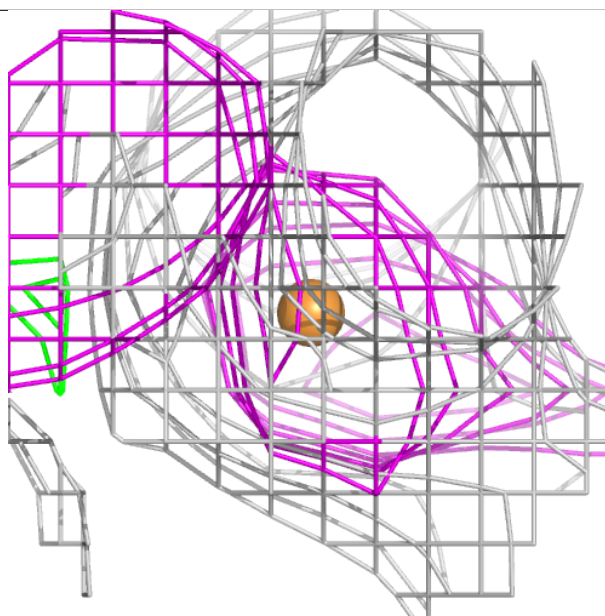
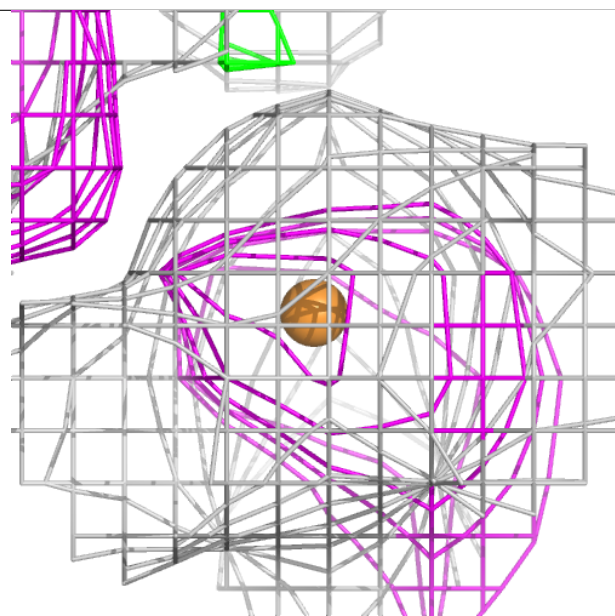
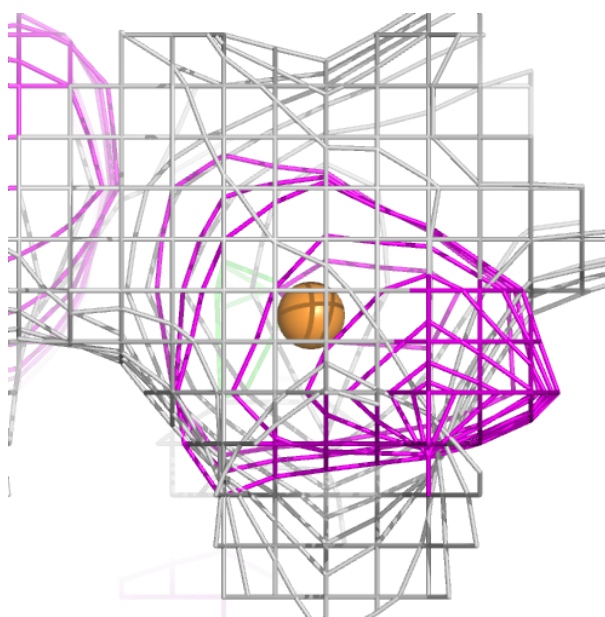
Electron density around CL A 705:

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



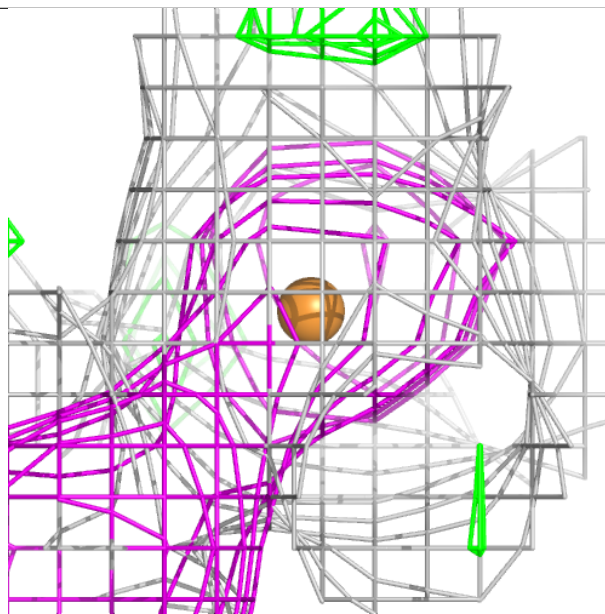
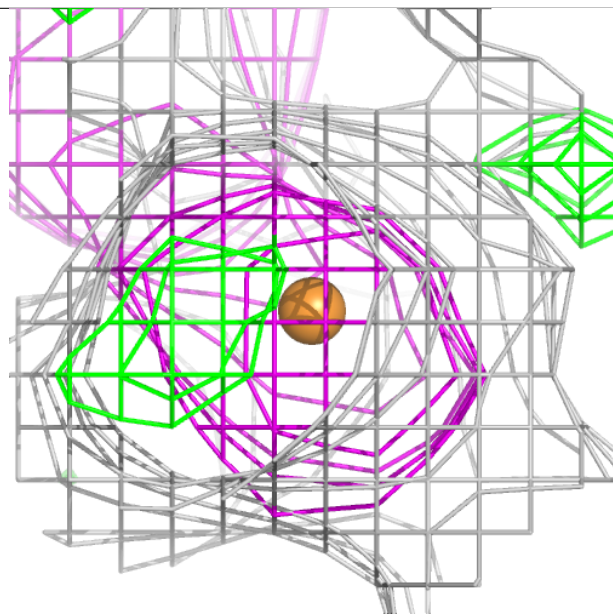
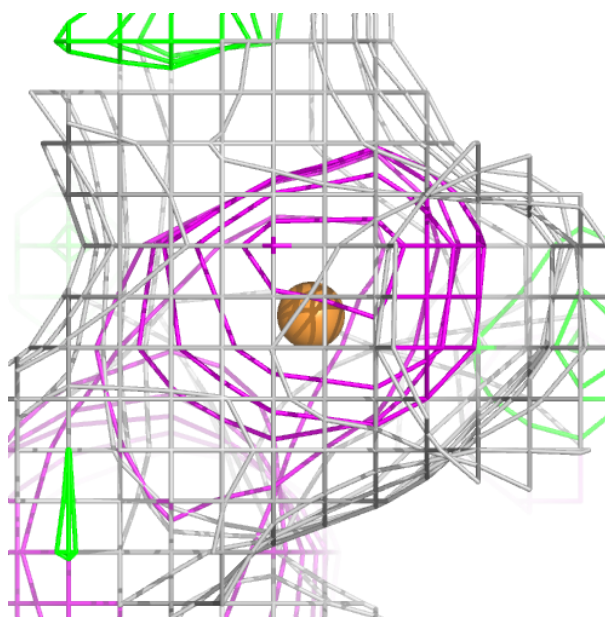
Electron density around CU B 802:

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



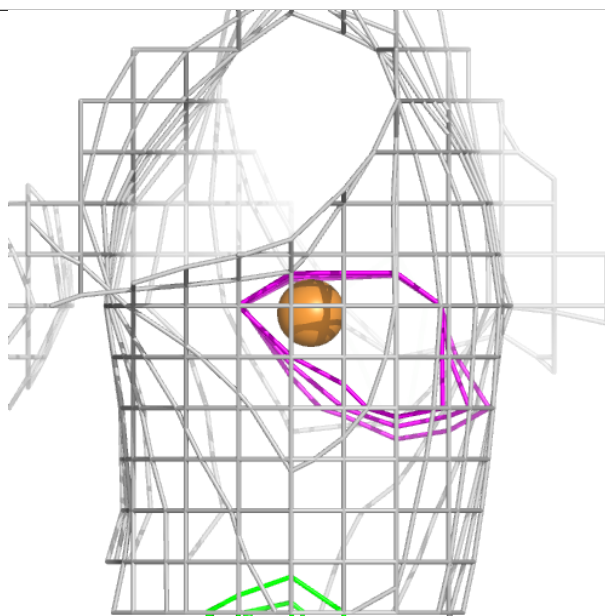
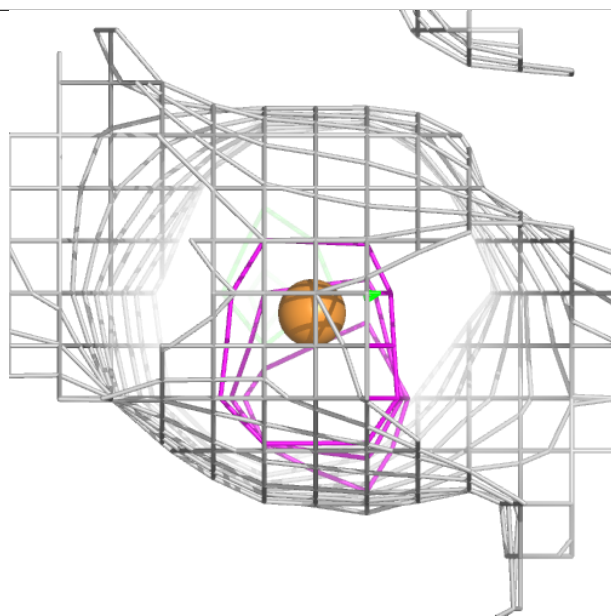
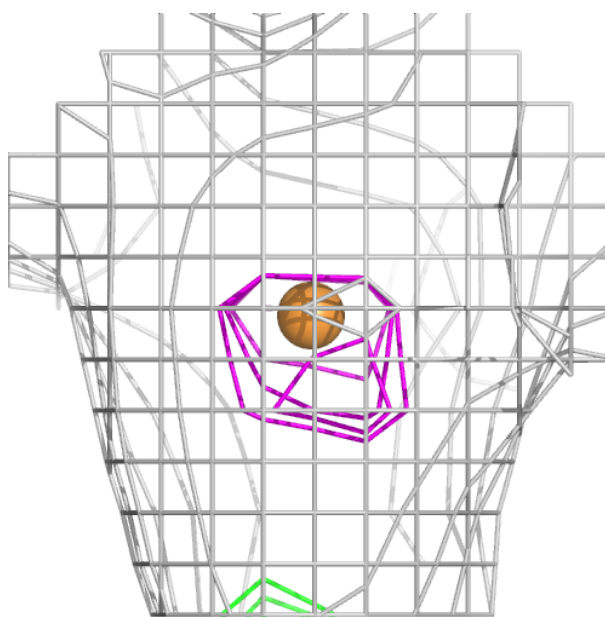
Electron density around CU A 702:

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



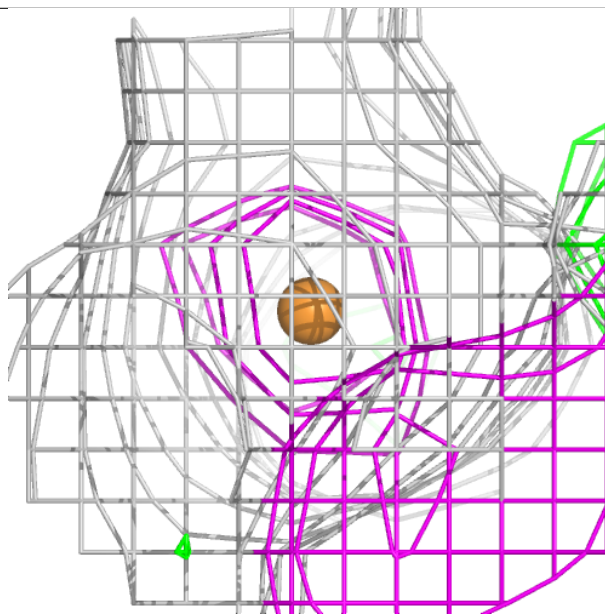
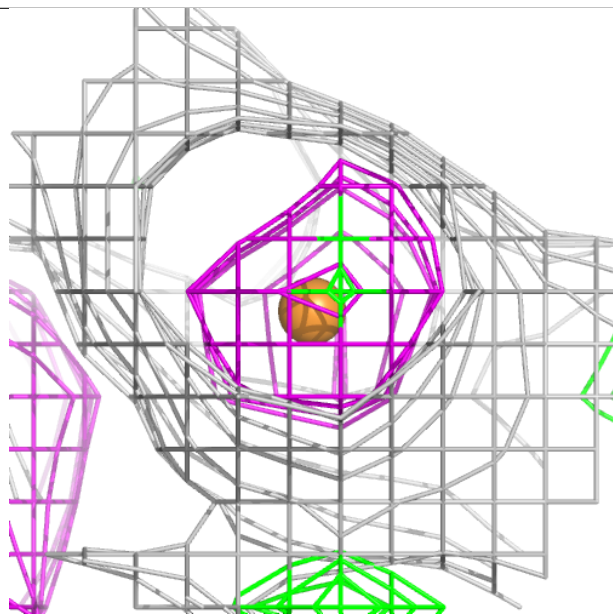
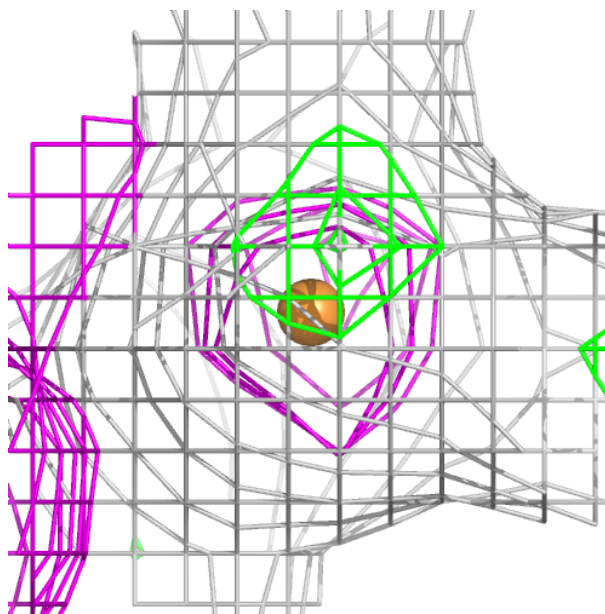
Electron density around CU A 701:

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



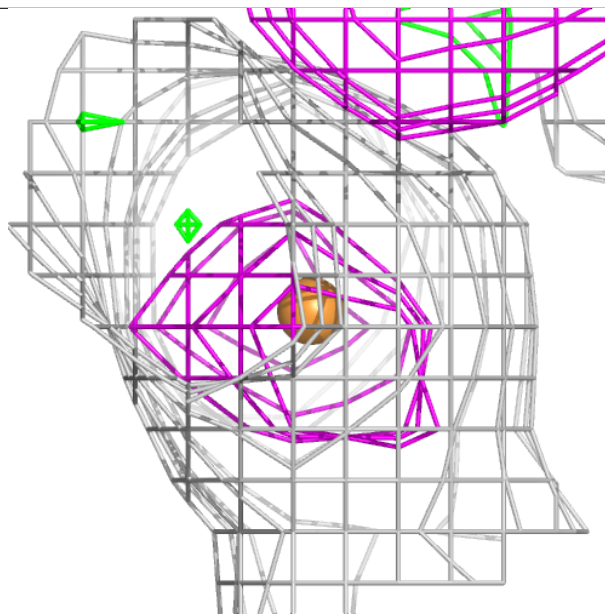
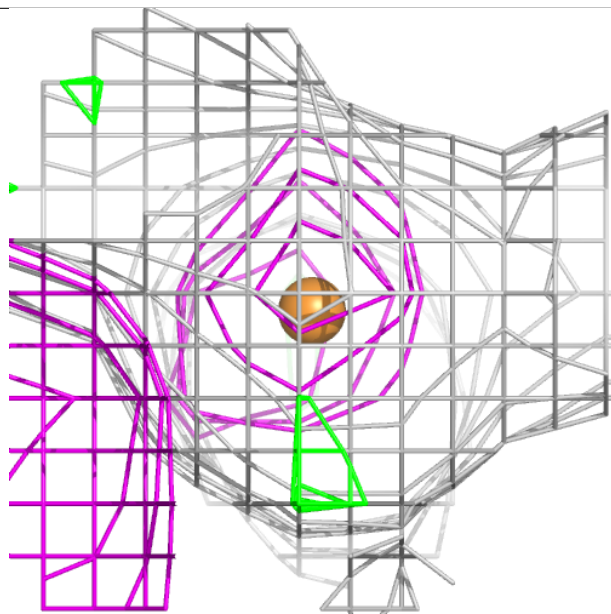
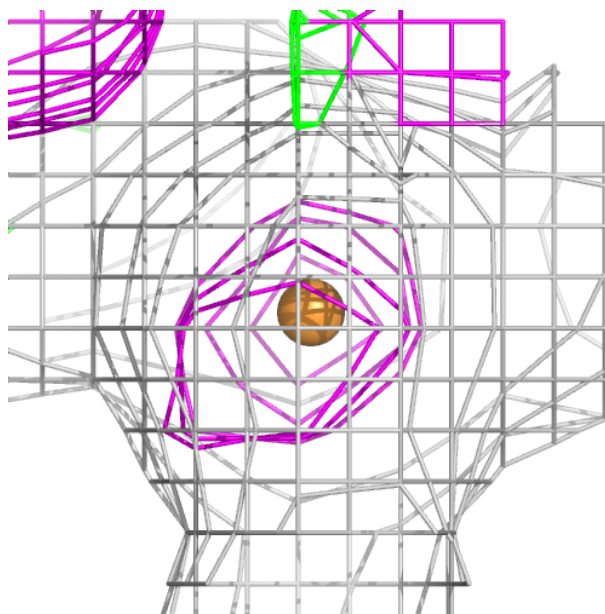
Electron density around CU A 704:

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



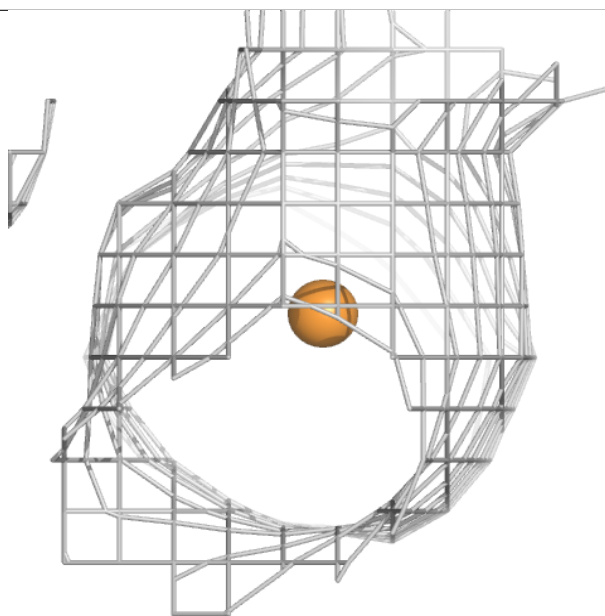
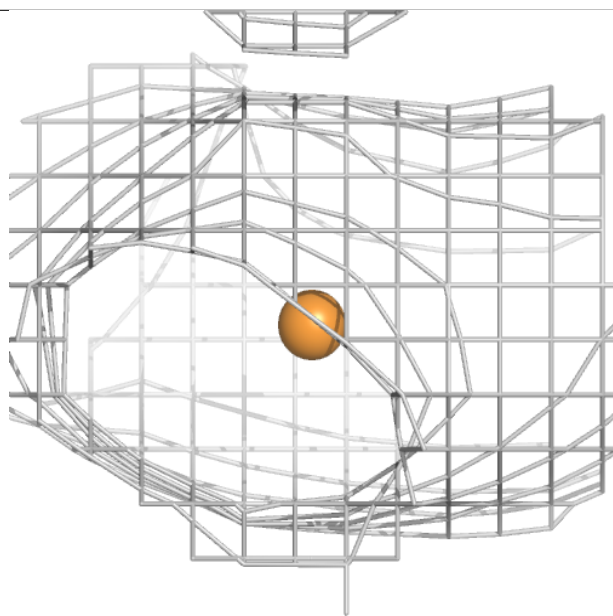
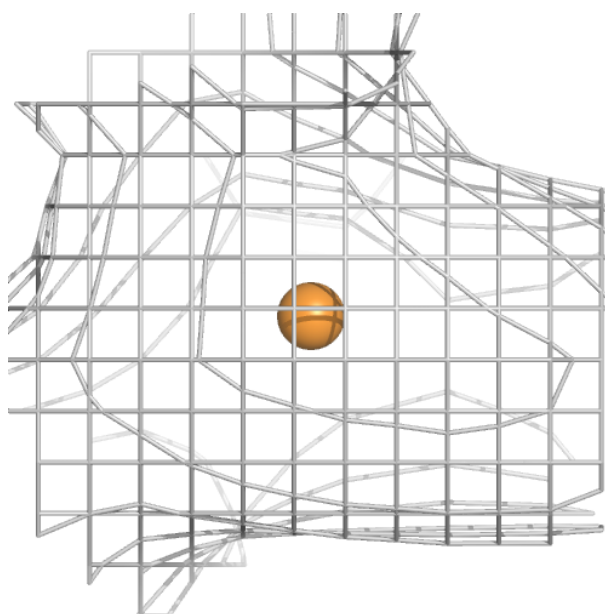
Electron density around CU B 804:

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



Electron density around CU B 801:

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



6.5 Other polymers [i](#)

There are no such residues in this entry.