W O R L D W I D E
wwPDB
P R O T E I N   D A T A   B A N K

Full wwPDB X-ray Structure Validation Report (i)

Dec 15, 2025 – 03:16 PM JST

PDB ID	:	9L51 / pdb_00009l51
Title	:	The structure of the ring expansion oxygenase SpoC
Authors	:	Liu, M.; He, X.
Deposited on	:	2024-12-21
Resolution	:	1.90 Å(reported)

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

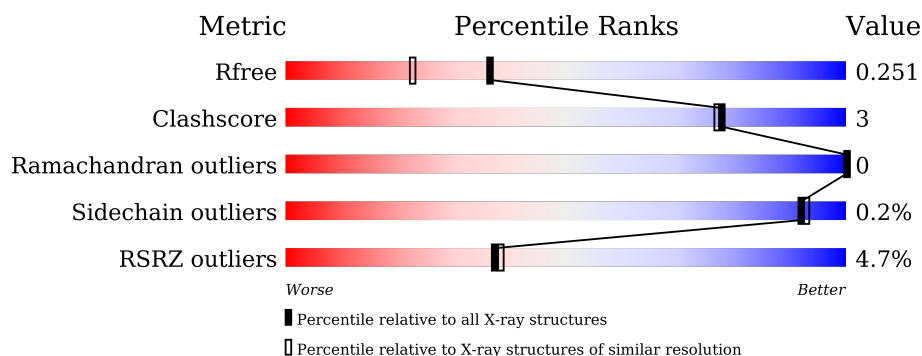|		
MolProbity	:	4-5-2 with Phenix2.0
Xtriage (Phenix)	:	2.0
EDS	:	3.0
Percentile statistics	:	20231227.v01 (using entries in the PDB archive December 27th 2023)
CCP4	:	9.0.010 (Gargrove)
Density-Fitness	:	1.0.12
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.47

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 1.90 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	Percentile Ranks	Value
Rfree		0.251
Clashscore		3
Ramachandran outliers		0
Sidechain outliers		0.2%
RSRZ outliers		4.7%

Worse   *Better*

▌ Percentile relative to all X-ray structures

▯ Percentile relative to X-ray structures of similar resolution

Metric	Whole archive (#Entries)	Similar resolution (#Entries, resolution range(Å))
R_{free}	164625	7293 (1.90-1.90)
Clashscore	180529	8090 (1.90-1.90)
Ramachandran outliers	177936	8022 (1.90-1.90)
Sidechain outliers	177891	8022 (1.90-1.90)
RSRZ outliers	164620	7292 (1.90-1.90)

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% 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	374	3% — 77% 5% 18%
1	B	374	4% — 77% 5% 18%

2 Entry composition (i)

There are 4 unique types of molecules in this entry. The entry contains 5404 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 ring expansion oxygenase SpoC.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	308	Total	C	N	O	S	0	1	0
			2430	1557	410	449	14			
1	B	307	Total	C	N	O	S	0	1	0
			2422	1551	409	448	14			

- Molecule 2 is FE (III) ION (CCD ID: FE) (formula: Fe) (labeled as "Ligand of Interest" by depositor).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	A	1	Total	Fe	0	0
			1	1		
2	B	1	Total	Fe	0	0
			1	1		

- Molecule 3 is CHLORIDE ION (CCD ID: CL) (formula: Cl).

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

- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	264	Total	O	0	0
			264	264		
4	B	284	Total	O	0	0
			284	284		

# 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: ring expansion oxygenase SpoC

Chain A:

• Molecule 1: ring expansion oxygenase SpoC

Chain B:
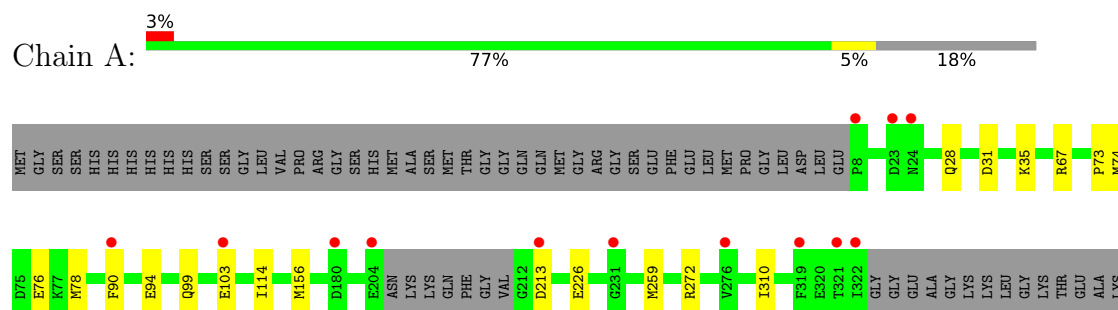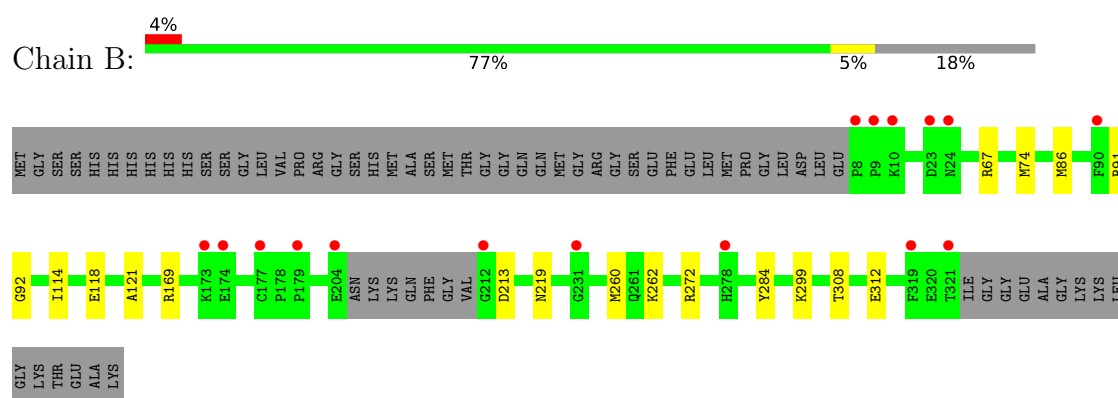
4 Data and refinement statistics (i)

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α, β, γ	81.44Å 84.99Å 104.63Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	42.50 – 1.90 42.50 – 1.90	Depositor EDS
% Data completeness (in resolution range)	89.7 (42.50-1.90) 89.7 (42.50-1.90)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
$< I/\sigma(I) >$ [1]	1.85 (at 1.89Å)	Xtriage
Refinement program	PHENIX (1.20.1_4487: ???)	Depositor
R, R_{free}	0.207 , 0.250 0.209 , 0.251	Depositor DCC
R_{free} test set	2726 reflections (4.72%)	wwPDB-VP
Wilson B-factor (Å^2)	17.5	Xtriage
Anisotropy	0.064	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.36 , 44.9	EDS
L-test for twinning[2]	$< |L| > = 0.46, < L^2 > = 0.29$	Xtriage
Estimated twinning fraction	0.024 for k,h,-l	Xtriage
F_o,F_c correlation	0.95	EDS
Total number of atoms	5404	wwPDB-VP
Average B, all atoms (Å^2)	25.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The analyses of the Patterson function reveals a significant off-origin peak that is 53.27 % of the origin peak, indicating pseudo-translational symmetry. The chance of finding a peak of this or larger height randomly in a structure without pseudo-translational symmetry is equal to 4.3182e-05. The detected translational NCS is most likely also responsible for the elevated intensity ratio.*

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[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: CL, FE

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	0.28	0/2500	0.51	0/3395
1	B	0.28	0/2492	0.51	0/3384
All	All	0.28	0/4992	0.51	0/6779

There are no bond length outliers.

There are no bond angle outliers.

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	2430	0	2387	12	0
1	B	2422	0	2376	12	0
2	A	1	0	0	0	0
2	B	1	0	0	0	0
3	A	1	0	0	1	0
3	B	1	0	0	1	0
4	A	264	0	0	2	0
4	B	284	0	0	5	0
All	All	5404	0	4763	26	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 3.

All (26) 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)
3:B:402:CL:CL	4:B:747:HOH:O	2.30	0.85
3:A:402:CL:CL	4:A:730:HOH:O	2.38	0.77
1:A:74:MET:HE3	1:A:99:GLN:HE21	1.51	0.76
1:A:67:ARG:NH2	1:A:226:GLU:OE2	2.26	0.63
1:B:213:ASP:OD2	1:B:272:ARG:NH2	2.21	0.59
1:A:73:PRO:HG2	1:A:76:GLU:HG3	1.84	0.58
1:B:169:ARG:NH1	4:B:511:HOH:O	2.39	0.56
1:B:118:GLU:HG2	4:B:732:HOH:O	2.05	0.56
1:B:219:ASN:HD22	1:B:260:MET:HE2	1.71	0.55
1:B:74:MET:HE2	1:B:74:MET:HA	1.90	0.54
1:A:67:ARG:NH2	4:A:504:HOH:O	2.39	0.51
1:A:156:MET:HA	1:A:156:MET:HE2	1.95	0.48
1:A:259:MET:HE2	1:A:310:ILE:HG12	1.97	0.47
1:B:262:LYS:NZ	1:B:308:THR:OG1	2.49	0.45
1:A:31:ASP:O	1:A:35:LYS:HD3	2.15	0.45
1:B:299:LYS:HE3	4:B:721:HOH:O	2.17	0.45
1:B:67:ARG:HG2	1:B:284:TYR:CE1	2.52	0.44
1:A:90[A]:PHE:HE2	1:A:94:GLU:OE1	2.01	0.42
1:B:92:GLY:O	1:B:114:ILE:HG22	2.18	0.42
1:A:103:GLU:H	1:A:103:GLU:CD	2.27	0.42
1:B:91:ARG:HA	1:B:114:ILE:HG23	2.00	0.42
1:A:78:MET:HE3	1:A:78:MET:HB3	1.96	0.42
1:A:213:ASP:OD1	1:A:272:ARG:NE	2.53	0.42
1:B:312:GLU:OE2	4:B:501:HOH:O	2.21	0.42
1:A:28:GLN:NE2	1:A:28:GLN:HA	2.34	0.41
1:B:86:MET:HE1	1:B:121:ALA:HB1	2.02	0.40

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	305/374 (82%)	298 (98%)	7 (2%)	0	100	100
1	B	304/374 (81%)	299 (98%)	5 (2%)	0	100	100
All	All	609/748 (81%)	597 (98%)	12 (2%)	0	100	100

There are no Ramachandran outliers to report.

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	267/316 (84%)	266 (100%)	1 (0%)	89	90
1	B	266/316 (84%)	266 (100%)	0	100	100
All	All	533/632 (84%)	532 (100%)	1 (0%)	92	93

All (1) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	114	ILE

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (8) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	28	GLN
1	A	201	GLN
1	A	219	ASN
1	A	313	HIS
1	B	28	GLN
1	B	201	GLN
1	B	219	ASN
1	B	313	HIS

5.3.3 RNA ⓘ

There are no RNA molecules in this entry.

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

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

5.5 Carbohydrates ⓘ

There are no oligosaccharides in this entry.

5.6 Ligand geometry ⓘ

Of 4 ligands modelled in this entry, 4 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 ⓘ

There are no such residues in this entry.

5.8 Polymer linkage issues ⓘ

There are no chain breaks in this entry.

6 Fit of model and data ⓘ

6.1 Protein, DNA and RNA chains ⓘ

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(Å²)	Q<0.9
1	A	308/374 (82%)	-0.08	13 (4%)	41	43	11, 22, 42, 87	1 (0%)
1	B	307/374 (82%)	0.01	16 (5%)	34	35	10, 22, 49, 88	1 (0%)
All	All	615/748 (82%)	-0.03	29 (4%)	37	38	10, 22, 47, 88	2 (0%)

All (29) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	319	PHE	4.4
1	B	319	PHE	4.1
1	B	24	ASN	3.8
1	B	8	PRO	3.7
1	B	321	THR	3.7
1	A	321	THR	3.5
1	A	8	PRO	3.5
1	A	322	ILE	3.5
1	A	204	GLU	3.3
1	A	231	GLY	3.1
1	B	177	CYS	2.9
1	A	24	ASN	2.9
1	B	9	PRO	2.8
1	B	212	GLY	2.8
1	B	173	LYS	2.8
1	A	23	ASP	2.7
1	B	23	ASP	2.7
1	B	10	LYS	2.5
1	B	231	GLY	2.4
1	A	180	ASP	2.4
1	A	213	ASP	2.2
1	A	276	VAL	2.2
1	B	174	GLU	2.2
1	A	103	GLU	2.1

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Mol	Chain	Res	Type	RSRZ
1	B	90[A]	PHE	2.1
1	B	278	HIS	2.1
1	B	179	PRO	2.1
1	B	204	GLU	2.1
1	A	90[A]	PHE	2.0

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

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

6.3 Carbohydrates ⓘ

There are no oligosaccharides in this entry.

6.4 Ligands ⓘ

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
3	CL	B	402	1/1	0.93	0.10	56,56,56,56	0
2	FE	A	401	1/1	0.96	0.06	31,31,31,31	0
3	CL	A	402	1/1	0.97	0.06	53,53,53,53	0
2	FE	B	401	1/1	0.99	0.04	31,31,31,31	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.
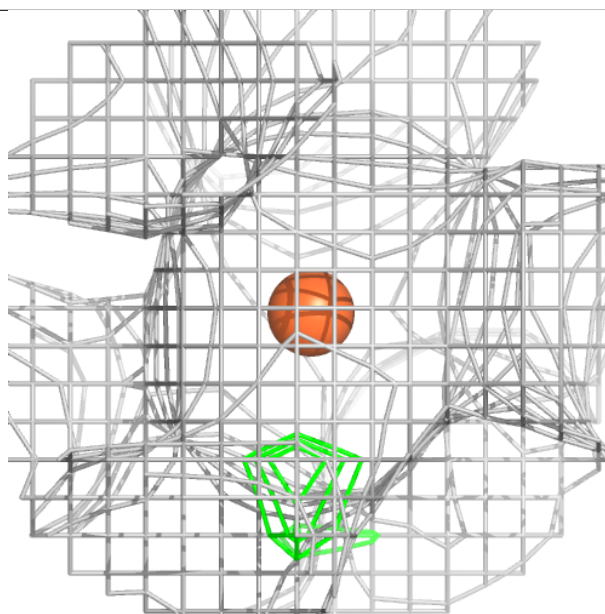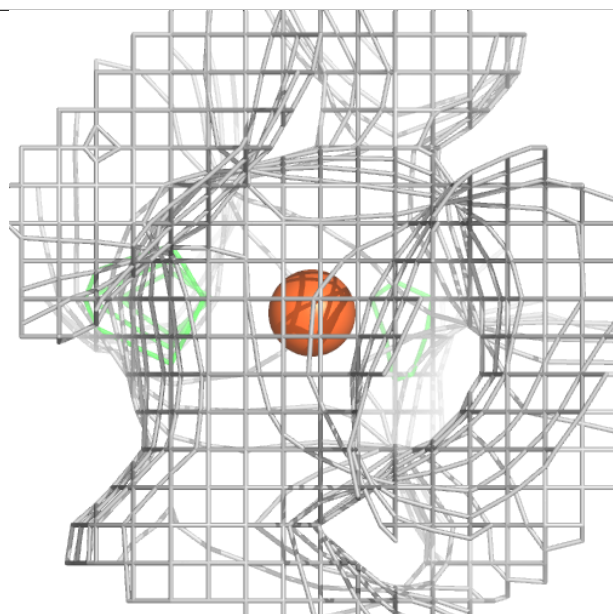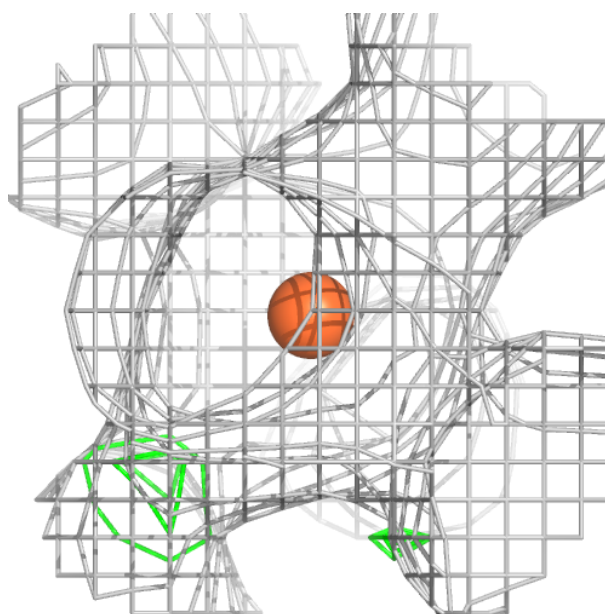
Electron density around FE A 401:

$2mF_o\text{-}DF_c$ (at 0.7 rmsd) in gray
$mF_o\text{-}DF_c$ (at 3 rmsd) in purple (negative)
and green (positive)
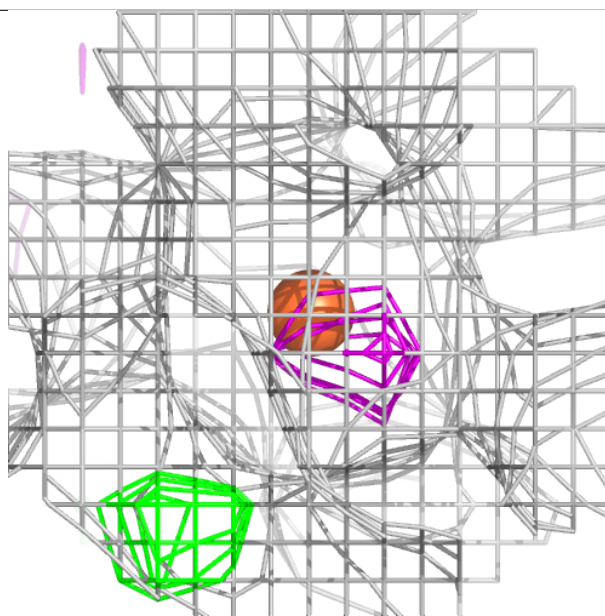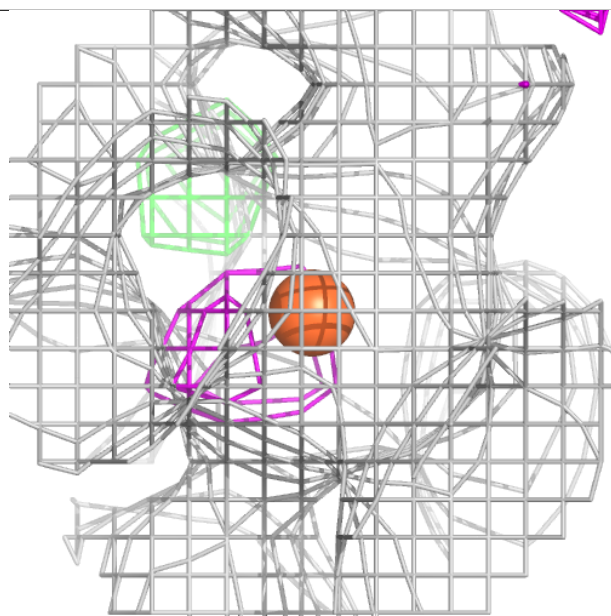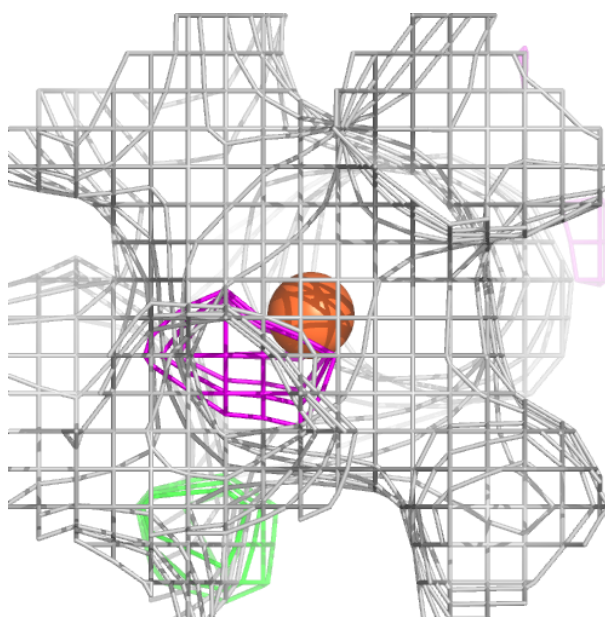
Electron density around FE B 401:

$2mF_o$-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.