



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 8, 2026 – 02:25 PM UTC

PDB ID : 9MHN / pdb_00009mhn
Title : The structure of Zcp with cobalt bound
Authors : Bera, A.K.; Liyayi, I.K.; Criss, A.K.; Noinaj, N.
Deposited on : 2024-12-12
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
Mogul	:	2022.3.0, CSD as543be (2022)
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

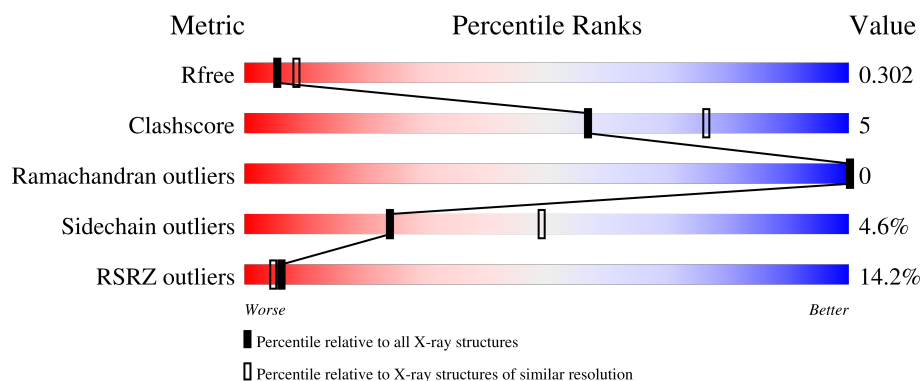
1 Overall quality at a glance

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	274	11% 75% 10% • 15%
1	B	274	13% 69% 14% • 15%

2 Entry composition [i](#)

There are 3 unique types of molecules in this entry. The entry contains 3712 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 Phosphoribosylglycinamide formyltransferase.

Mol	Chain	Residues	Atoms						ZeroOcc	AltConf	Trace
1	A	234	Total	C	N	O	S	Se	0	0	0
			1859	1172	325	357	2	3			
1	B	232	Total	C	N	O	S	Se	0	0	0
			1831	1156	318	352	2	3			

There are 52 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	-5	SER	-	expression tag	UNP Q5F7W6
A	-4	TYR	-	expression tag	UNP Q5F7W6
A	-3	TYR	-	expression tag	UNP Q5F7W6
A	-2	HIS	-	expression tag	UNP Q5F7W6
A	-1	HIS	-	expression tag	UNP Q5F7W6
A	0	HIS	-	expression tag	UNP Q5F7W6
A	1	HIS	-	expression tag	UNP Q5F7W6
A	2	HIS	-	expression tag	UNP Q5F7W6
A	3	HIS	-	expression tag	UNP Q5F7W6
A	4	ASP	-	expression tag	UNP Q5F7W6
A	5	TYR	-	expression tag	UNP Q5F7W6
A	6	ASP	-	expression tag	UNP Q5F7W6
A	7	ILE	-	expression tag	UNP Q5F7W6
A	8	PRO	-	expression tag	UNP Q5F7W6
A	9	THR	-	expression tag	UNP Q5F7W6
A	10	THR	-	expression tag	UNP Q5F7W6
A	11	GLU	-	expression tag	UNP Q5F7W6
A	12	ASN	-	expression tag	UNP Q5F7W6
A	13	LEU	-	expression tag	UNP Q5F7W6
A	14	TYR	-	expression tag	UNP Q5F7W6
A	15	PHE	-	expression tag	UNP Q5F7W6
A	16	GLN	-	expression tag	UNP Q5F7W6
A	17	GLY	-	expression tag	UNP Q5F7W6
A	18	ALA	-	expression tag	UNP Q5F7W6
A	19	MSE	-	expression tag	UNP Q5F7W6

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Chain	Residue	Modelled	Actual	Comment	Reference
A	20	VAL	-	expression tag	UNP Q5F7W6
B	-5	SER	-	expression tag	UNP Q5F7W6
B	-4	TYR	-	expression tag	UNP Q5F7W6
B	-3	TYR	-	expression tag	UNP Q5F7W6
B	-2	HIS	-	expression tag	UNP Q5F7W6
B	-1	HIS	-	expression tag	UNP Q5F7W6
B	0	HIS	-	expression tag	UNP Q5F7W6
B	1	HIS	-	expression tag	UNP Q5F7W6
B	2	HIS	-	expression tag	UNP Q5F7W6
B	3	HIS	-	expression tag	UNP Q5F7W6
B	4	ASP	-	expression tag	UNP Q5F7W6
B	5	TYR	-	expression tag	UNP Q5F7W6
B	6	ASP	-	expression tag	UNP Q5F7W6
B	7	ILE	-	expression tag	UNP Q5F7W6
B	8	PRO	-	expression tag	UNP Q5F7W6
B	9	THR	-	expression tag	UNP Q5F7W6
B	10	THR	-	expression tag	UNP Q5F7W6
B	11	GLU	-	expression tag	UNP Q5F7W6
B	12	ASN	-	expression tag	UNP Q5F7W6
B	13	LEU	-	expression tag	UNP Q5F7W6
B	14	TYR	-	expression tag	UNP Q5F7W6
B	15	PHE	-	expression tag	UNP Q5F7W6
B	16	GLN	-	expression tag	UNP Q5F7W6
B	17	GLY	-	expression tag	UNP Q5F7W6
B	18	ALA	-	expression tag	UNP Q5F7W6
B	19	MSE	-	expression tag	UNP Q5F7W6
B	20	VAL	-	expression tag	UNP Q5F7W6

- Molecule 2 is COBALT (II) ION (CCD ID: CO) (formula: Co) (labeled as "Ligand of Interest" by depositor).

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

- Molecule 3 is water.

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
3	A	13	Total O 13 13	0	0

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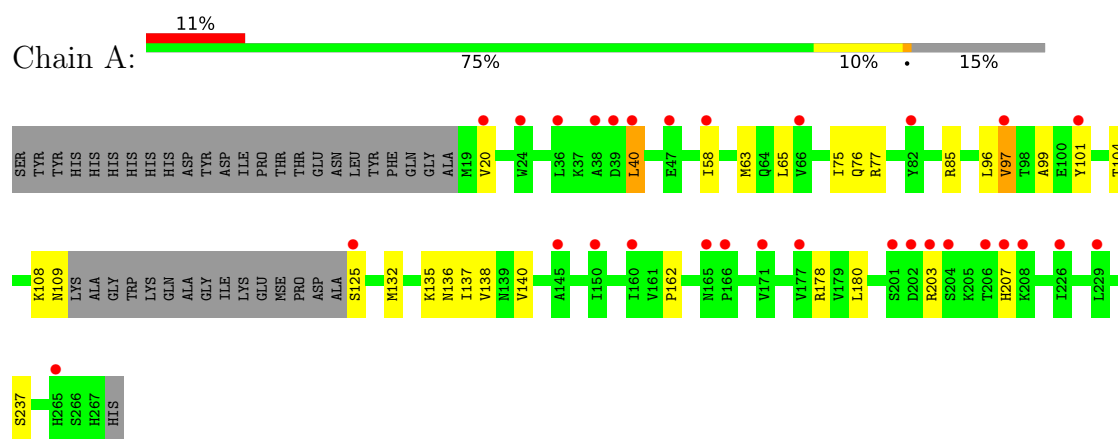
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Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	B	7	Total	O	0	0
			7	7		

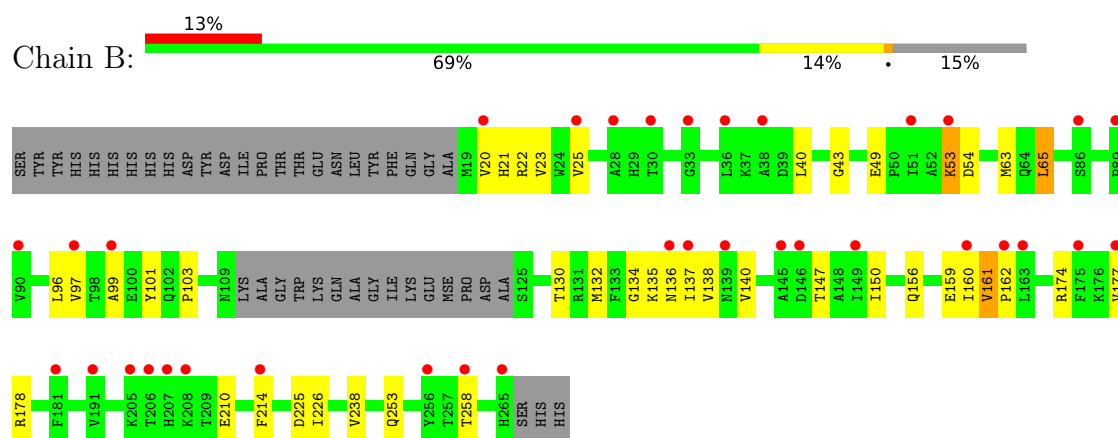
3 Residue-property plots [i](#)

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: Phosphoribosylglycinamide formyltransferase



- Molecule 1: Phosphoribosylglycinamide formyltransferase



4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α , β , γ	56.04Å 94.47Å 129.14Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	28.30 – 2.59 28.30 – 2.59	Depositor EDS
% Data completeness (in resolution range)	99.2 (28.30-2.59) 99.2 (28.30-2.59)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	0.34	Depositor
$\langle I/\sigma(I) \rangle$ ¹	0.99 (at 2.57Å)	Xtriage
Refinement program	PHENIX (1.21.2_5419: ???)	Depositor
R, R_{free}	0.248 , 0.283 (Not available) , 0.302	Depositor DCC
R_{free} test set	2000 reflections (8.99%)	wwPDB-VP
Wilson B-factor (Å ²)	78.2	Xtriage
Anisotropy	0.273	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.28 , 53.3	EDS
L-test for twinning ²	$\langle L \rangle = 0.42$, $\langle L^2 \rangle = 0.24$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.92	EDS
Total number of atoms	3712	wwPDB-VP
Average B, all atoms (Å ²)	94.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 4.35% 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: CO

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	0.12	0/1899	0.32	0/2566
1	B	0.12	0/1871	0.30	0/2532
All	All	0.12	0/3770	0.31	0/5098

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	1859	0	1793	12	0
1	B	1831	0	1745	21	0
2	A	1	0	0	0	0
2	B	1	0	0	0	0
3	A	13	0	0	0	0
3	B	7	0	0	0	0
All	All	3712	0	3538	33	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 5.

All (33) 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:101:TYR:HB3	1:B:132:MSE:HB2	1.63	0.79
1:B:96:LEU:HD13	1:B:135:LYS:HD2	1.74	0.69
1:B:53:LYS:HZ2	1:B:54:ASP:N	1.98	0.60
1:B:22:ARG:HA	1:B:132:MSE:HE1	1.84	0.59
1:B:25:VAL:HG23	1:B:136:ASN:HB2	1.83	0.59
1:A:178:ARG:HD2	1:A:180:LEU:HD21	1.86	0.57
1:B:40:LEU:HB2	1:B:63:MSE:SE	2.55	0.56
1:A:108:LYS:O	1:A:125:SER:HA	2.06	0.55
1:B:160:ILE:HD11	1:B:238:VAL:HG12	1.87	0.55
1:B:137:ILE:HD11	1:B:162:PRO:HG3	1.88	0.55
1:A:101:TYR:HB3	1:A:132:MSE:HB2	1.89	0.54
1:B:63:MSE:HG2	1:B:99:ALA:HB2	1.89	0.54
1:A:96:LEU:HD13	1:A:135:LYS:HD2	1.89	0.53
1:B:161:VAL:HG13	1:B:178:ARG:HB3	1.91	0.52
1:B:134:GLY:HA2	1:B:258:THR:HG22	1.93	0.51
1:B:65:LEU:HD23	1:B:97:VAL:HG22	1.93	0.51
1:B:156:GLN:HE21	1:B:159:GLU:HG3	1.74	0.51
1:A:77:ARG:HD2	1:A:85:ARG:HE	1.77	0.50
1:B:174:ARG:HB3	1:B:225:ASP:HB3	1.94	0.50
1:A:97:VAL:HG13	1:A:136:ASN:HB3	1.93	0.49
1:B:162:PRO:HA	1:B:177:VAL:HG13	1.94	0.48
1:A:40:LEU:HB2	1:A:63:MSE:SE	2.65	0.47
1:B:22:ARG:HA	1:B:132:MSE:CE	2.44	0.47
1:B:23:VAL:HG21	1:B:101:TYR:HB2	1.97	0.46
1:B:147:THR:HA	1:B:150:ILE:HG12	1.97	0.45
1:B:21:HIS:HA	1:B:43:GLY:HA2	1.99	0.45
1:A:58:ILE:HG22	1:A:104:THR:HG21	1.99	0.44
1:A:75:ILE:HD11	1:A:85:ARG:CZ	2.48	0.43
1:B:103:PRO:HA	1:B:130:THR:O	2.19	0.43
1:A:137:ILE:HD11	1:A:162:PRO:HG3	2.01	0.41
1:A:203:ARG:HA	1:A:207:HIS:HB3	2.03	0.41
1:A:63:MSE:SE	1:A:99:ALA:HB2	2.71	0.41
1:B:214:PHE:CZ	1:B:226:ILE:HA	2.56	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	230/274 (84%)	226 (98%)	4 (2%)	0	100	100
1	B	228/274 (83%)	215 (94%)	13 (6%)	0	100	100
All	All	458/548 (84%)	441 (96%)	17 (4%)	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	200/231 (87%)	191 (96%)	9 (4%)	24	50
1	B	194/231 (84%)	185 (95%)	9 (5%)	24	49
All	All	394/462 (85%)	376 (95%)	18 (5%)	24	49

All (18) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	20	VAL
1	A	40	LEU
1	A	65	LEU
1	A	76	GLN
1	A	97	VAL
1	A	109	ASN
1	A	138	VAL
1	A	140	VAL

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Mol	Chain	Res	Type
1	A	237	SER
1	B	20	VAL
1	B	49	GLU
1	B	53	LYS
1	B	65	LEU
1	B	138	VAL
1	B	140	VAL
1	B	161	VAL
1	B	210	GLU
1	B	253	GLN

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (6) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	83	GLN
1	B	21	HIS
1	B	142	HIS
1	B	156	GLN
1	B	170	HIS
1	B	212	GLN

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 2 ligands modelled in this entry, 2 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(Å ²)	Q<0.9
1	A	230/274 (83%)	0.92	30 (13%) 7 5	57, 84, 142, 258	0
1	B	228/274 (83%)	1.07	35 (15%) 5 4	63, 91, 154, 185	0
All	All	458/548 (83%)	0.99	65 (14%) 6 5	57, 88, 152, 258	0

All (65) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	97	VAL	5.6
1	B	90	VAL	4.5
1	B	20	VAL	4.3
1	B	137	ILE	3.7
1	B	86	SER	3.6
1	A	208	LYS	3.5
1	B	30	THR	3.4
1	A	201	SER	3.3
1	A	24	TRP	3.3
1	A	166	PRO	3.2
1	A	82	TYR	3.2
1	B	146	ASP	3.1
1	B	206	THR	3.0
1	B	207	HIS	3.0
1	B	160	ILE	3.0
1	A	204	SER	2.9
1	B	191	VAL	2.9
1	A	203	ARG	2.8
1	A	202	ASP	2.8
1	B	33	GLY	2.7
1	B	177	VAL	2.7
1	B	208	LYS	2.7
1	B	36	LEU	2.7
1	A	226	ILE	2.6

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Mol	Chain	Res	Type	RSRZ
1	A	20	VAL	2.6
1	A	265	HIS	2.6
1	B	265	HIS	2.5
1	A	145	ALA	2.5
1	A	125	SER	2.5
1	B	214	PHE	2.5
1	A	171	VAL	2.5
1	A	58	ILE	2.4
1	B	51	ILE	2.4
1	A	66	VAL	2.4
1	A	207	HIS	2.3
1	B	162	PRO	2.3
1	A	40	LEU	2.3
1	B	53	LYS	2.3
1	A	160	ILE	2.3
1	B	25	VAL	2.3
1	B	28	ALA	2.3
1	B	136	ASN	2.3
1	A	165	ASN	2.2
1	B	205	LYS	2.2
1	B	139	ASN	2.2
1	A	38	ALA	2.2
1	B	258	THR	2.1
1	A	47	GLU	2.1
1	B	149	ILE	2.1
1	B	175	PHE	2.1
1	B	38	ALA	2.1
1	B	256	TYR	2.1
1	A	177	VAL	2.1
1	A	229	LEU	2.1
1	B	163	LEU	2.1
1	B	97	VAL	2.0
1	B	181	PHE	2.0
1	A	36	LEU	2.0
1	A	150	ILE	2.0
1	A	39	ASP	2.0
1	B	99	ALA	2.0
1	B	145	ALA	2.0
1	A	206	THR	2.0
1	B	89	PRO	2.0
1	A	101	TYR	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](#)

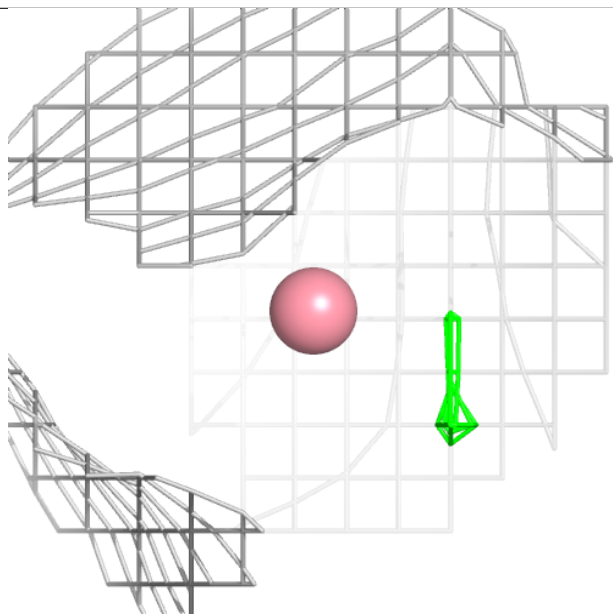
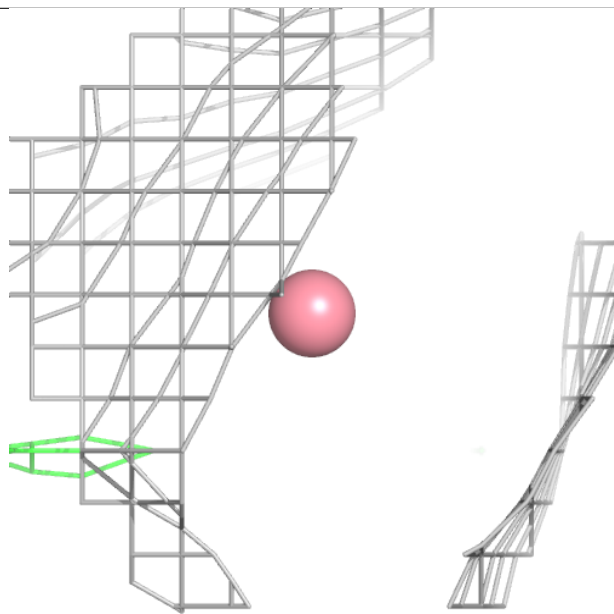
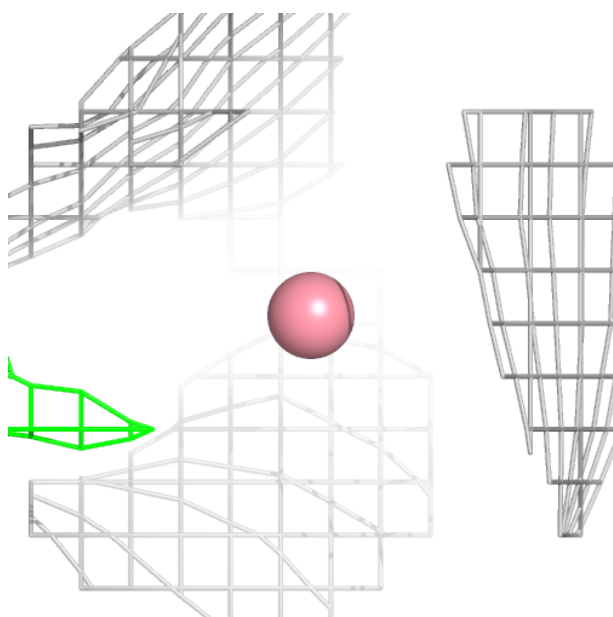
In the following table, the Atoms column lists the number of modelled atoms in the group and the number defined in the chemical component dictionary. The B-factors column lists the minimum, median, 95th percentile and maximum values of B factors of atoms in the group. The column labelled 'Q< 0.9' lists 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	CO	B	301	1/1	0.88	0.08	172,172,172,172	0
2	CO	A	301	1/1	0.90	0.07	170,170,170,170	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.

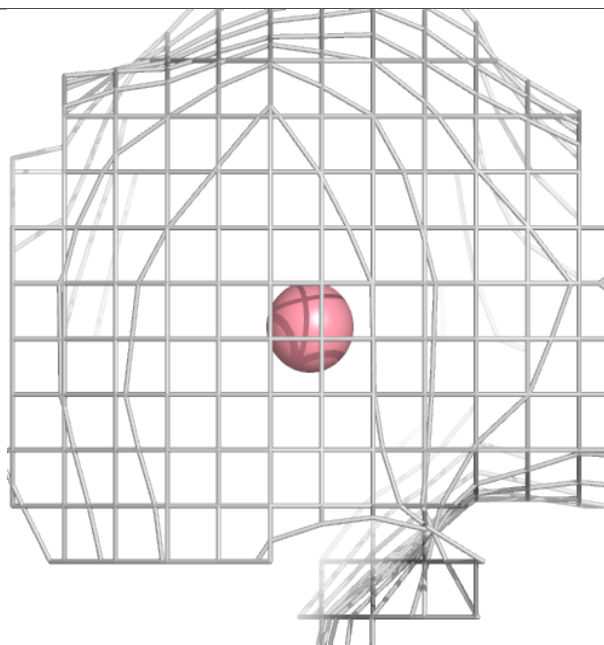
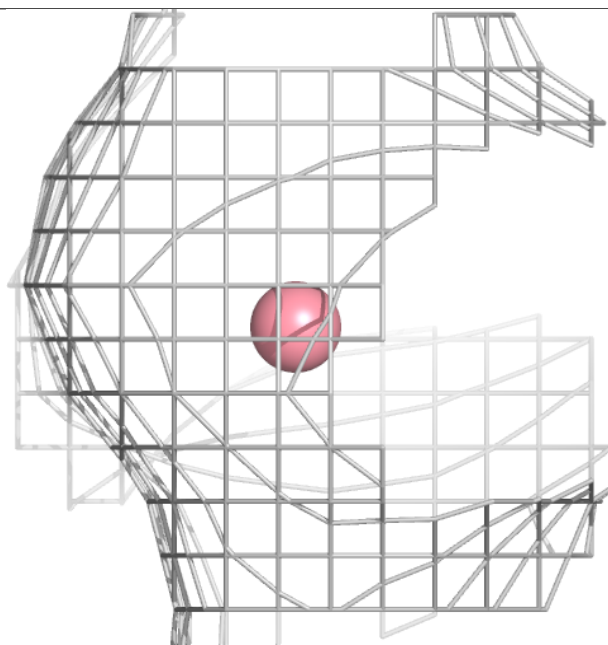
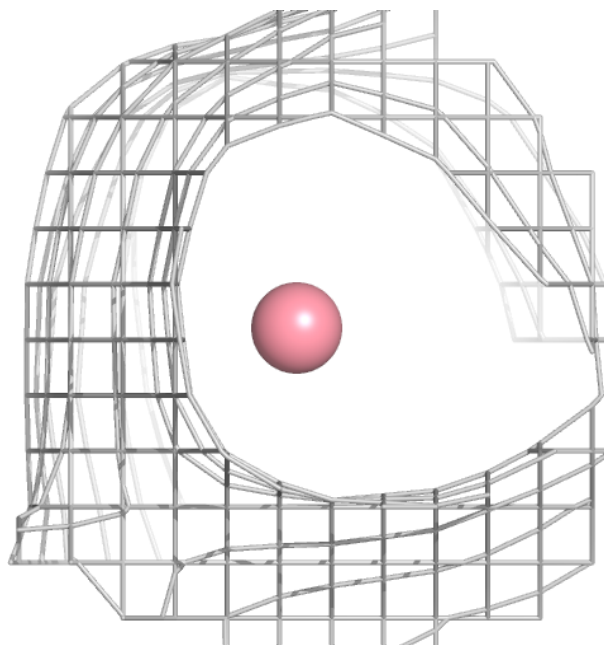
Electron density around CO B 301:

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



Electron density around CO A 301:

$2mF_o-DF_c$ (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.