



# Full wwPDB X-ray Structure Validation Report ⓘ

Jan 1, 2026 – 02:06 PM EST

PDB ID : 9P0D / pdb\_00009p0d  
Title : Crystal structure of Sr<sup>2+</sup>-bound RTX domain block V of adenylate cyclase toxin from *Bordetella pertussis*  
Authors : Gudinas, A.P.; Fernandez, D.; Mai, D.J.  
Deposited on : 2025-06-06  
Resolution : 1.50 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](mailto: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	:	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

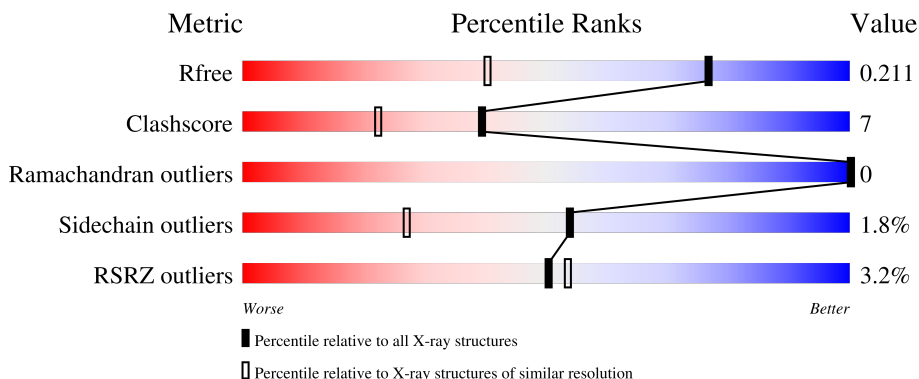
# 1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

*X-RAY DIFFRACTION*

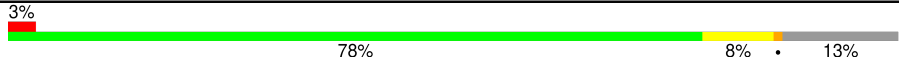
The reported resolution of this entry is 1.50 Å.

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))
$R_{free}$	164625	3717 (1.50-1.50)
Clashscore	180529	4048 (1.50-1.50)
Ramachandran outliers	177936	3970 (1.50-1.50)
Sidechain outliers	177891	3967 (1.50-1.50)
RSRZ outliers	164620	3718 (1.50-1.50)

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  $\geq 3$ , 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	179	

## 2 Entry composition

There are 8 unique types of molecules in this entry. The entry contains 1297 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 Hemolysin.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	156	Total	C	N	O	S	0	2	0
			1151	703	200	247	1			

There are 27 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	1510	MET	-	initiating methionine	UNP P0DKX7
A	1511	ARG	-	expression tag	UNP P0DKX7
A	1512	GLY	-	expression tag	UNP P0DKX7
A	1513	SER	-	expression tag	UNP P0DKX7
A	1514	HIS	-	expression tag	UNP P0DKX7
A	1515	HIS	-	expression tag	UNP P0DKX7
A	1516	HIS	-	expression tag	UNP P0DKX7
A	1517	HIS	-	expression tag	UNP P0DKX7
A	1518	HIS	-	expression tag	UNP P0DKX7
A	1519	HIS	-	expression tag	UNP P0DKX7
A	1520	GLY	-	cloning artifact	UNP P0DKX7
A	1521	SER	-	cloning artifact	UNP P0DKX7
A	1522	HIS	-	cloning artifact	UNP P0DKX7
A	1523	MET	-	cloning artifact	UNP P0DKX7
A	1524	GLU	-	cloning artifact	UNP P0DKX7
A	1525	LEU	-	cloning artifact	UNP P0DKX7
A	1526	GLY	-	cloning artifact	UNP P0DKX7
A	1527	ALA	-	cloning artifact	UNP P0DKX7
A	1528	SER	-	cloning artifact	UNP P0DKX7
A	1681	GLU	-	cloning artifact	UNP P0DKX7
A	1682	PHE	-	cloning artifact	UNP P0DKX7
A	1683	THR	-	cloning artifact	UNP P0DKX7
A	1684	SER	-	cloning artifact	UNP P0DKX7
A	1685	LEU	-	cloning artifact	UNP P0DKX7
A	1686	GLU	-	cloning artifact	UNP P0DKX7
A	1687	LYS	-	cloning artifact	UNP P0DKX7
A	1688	ASN	-	cloning artifact	UNP P0DKX7

- Molecule 2 is STRONTIUM ION (CCD ID: SR) (formula: Sr) (labeled as "Ligand of Interest" by depositor).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	A	8	Total	Sr	0	0
			8	8		

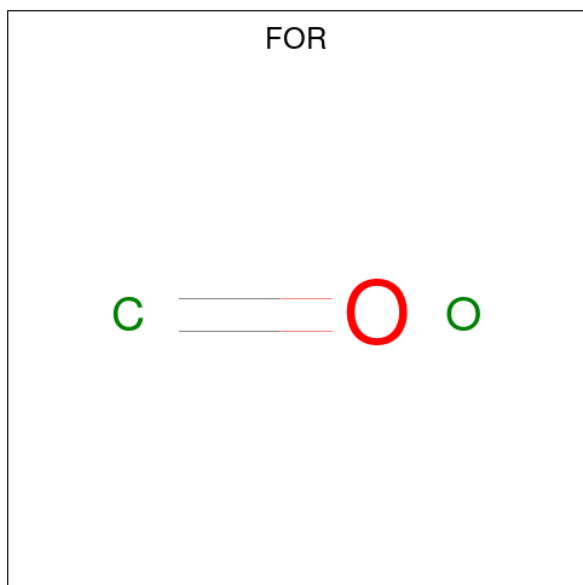
- Molecule 3 is CHLORIDE ION (CCD ID: CL) (formula: Cl).

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

- Molecule 4 is SODIUM ION (CCD ID: NA) (formula: Na).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	1	Total	Na	0	0
			1	1		

- Molecule 5 is FORMYL GROUP (CCD ID: FOR) (formula: CH<sub>2</sub>O).



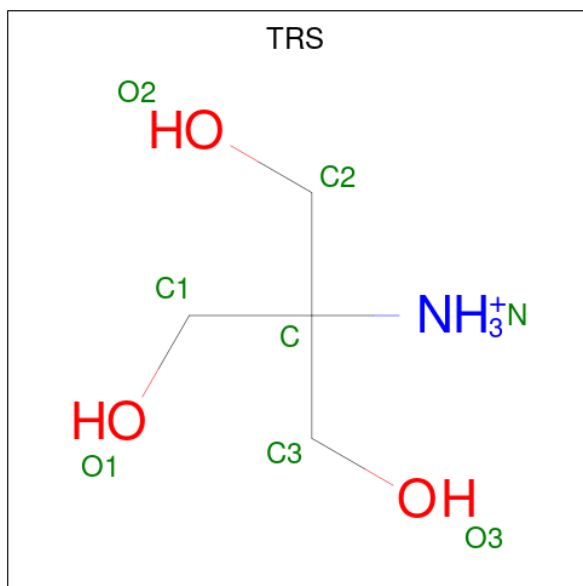
Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
5	A	1	Total	C	O	0	0
			2	1	1		
5	A	1	Total	C	O	0	0
			2	1	1		

- Molecule 6 is GLYCEROL (CCD ID: GOL) (formula: C<sub>3</sub>H<sub>8</sub>O<sub>3</sub>).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
6	A	1	Total	C	O	0	0
			6	3	3		

- Molecule 7 is 2-AMINO-2-HYDROXYMETHYL-PROPANE-1,3-DIOL (CCD ID: TRS) (formula:  $C_4H_{12}NO_3$ ).



Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
7	A	1	Total	C	N	O	0	0
			8	4	1	3		
7	A	1	Total	C	N	O	0	0
			8	4	1	3		

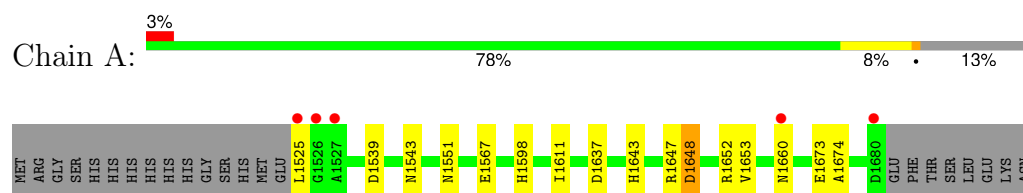
- Molecule 8 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
8	A	110	Total	O	0	0
			110	110		

### 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: Hemolysin



## 4 Data and refinement statistics

Property	Value	Source
Space group	I 2 2 2	Depositor
Cell constants a, b, c, $\alpha$ , $\beta$ , $\gamma$	62.54Å 73.09Å 73.84Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	30.95 – 1.50 30.95 – 1.50	Depositor EDS
% Data completeness (in resolution range)	98.1 (30.95-1.50) 98.1 (30.95-1.50)	Depositor EDS
$R_{merge}$	0.30	Depositor
$R_{sym}$	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ <sup>1</sup>	1.38 (at 1.50Å)	Xtriage
Refinement program	REFMAC 5.8.0415	Depositor
R, $R_{free}$	0.174 , 0.201 0.188 , 0.211	Depositor DCC
$R_{free}$ test set	1315 reflections (4.80%)	wwPDB-VP
Wilson B-factor (Å <sup>2</sup> )	12.3	Xtriage
Anisotropy	0.960	Xtriage
Bulk solvent $k_{sol}$ (e/Å <sup>3</sup> ), $B_{sol}$ (Å <sup>2</sup> )	0.42 , 48.4	EDS
L-test for twinning <sup>2</sup>	$\langle  L  \rangle = 0.50$ , $\langle L^2 \rangle = 0.33$	Xtriage
Estimated twinning fraction	0.000 for -h,-l,-k	Xtriage
$F_o, F_c$ correlation	0.97	EDS
Total number of atoms	1297	wwPDB-VP
Average B, all atoms (Å <sup>2</sup> )	21.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 13.71% of the height of the origin peak. No significant pseudotranslation is detected.*

<sup>1</sup>Intensities estimated from amplitudes.

<sup>2</sup>Theoretical 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: FOR, CL, TRS, GOL, SR, NA

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	0.65	0/1174	1.14	1/1593 (0.1%)

There are no bond length outliers.

All (1) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed( $^{\circ}$ )	Ideal( $^{\circ}$ )
1	A	1648	ASP	CA-CB-CG	5.66	118.26	112.60

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	1151	0	1054	12	1
2	A	8	0	0	0	0
3	A	1	0	0	0	0
4	A	1	0	0	0	0
5	A	4	0	0	0	0
6	A	6	0	8	1	0
7	A	16	0	24	6	0
8	A	110	0	0	5	0
All	All	1297	0	1086	15	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 7.

All (15) 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:1648:ASP:HB2	8:A:1877:HOH:O	1.87	0.73
7:A:1714:TRS:C2	8:A:1805:HOH:O	2.37	0.71
7:A:1714:TRS:H22	8:A:1805:HOH:O	1.91	0.71
1:A:1525:LEU:HB2	1:A:1543:ASN:HD22	1.57	0.69
1:A:1551:ASN:HB3	7:A:1714:TRS:H11	1.79	0.63
1:A:1643:HIS:HD2	8:A:1820:HOH:O	1.84	0.59
1:A:1652:ARG:NE	8:A:1801:HOH:O	2.36	0.59
1:A:1673:GLU:OE2	6:A:1713:GOL:H31	2.04	0.58
1:A:1525:LEU:HB2	1:A:1543:ASN:ND2	2.25	0.51
1:A:1673:GLU:HG3	7:A:1715:TRS:H31	1.93	0.50
1:A:1598:HIS:NE2	1:A:1637:ASP:O	2.47	0.46
1:A:1674:ALA:HA	7:A:1715:TRS:H32	1.97	0.46
1:A:1525:LEU:HD22	1:A:1539:ASP:OD2	2.16	0.46
1:A:1611:ILE:HG13	1:A:1653:VAL:HG11	2.01	0.41

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:1567:GLU:OE1	1:A:1567:GLU:OE1[4_555]	1.84	0.36

## 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	156/179 (87%)	151 (97%)	5 (3%)	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	114/133 (86%)	112 (98%)	2 (2%)	54 27

All (2) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	1647	ARG
1	A	1660	ASN

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

Mol	Chain	Res	Type
1	A	1643	HIS
1	A	1657	HIS
1	A	1665	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 15 ligands modelled in this entry, 10 are monoatomic - leaving 5 for Mogul analysis.

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
5	FOR	A	1712	-	0,1,1	-	-	-		
6	GOL	A	1713	-	5,5,5	0.22	0	5,5,5	0.58	0
7	TRS	A	1714	-	7,7,7	0.24	0	9,9,9	0.60	0
5	FOR	A	1711	-	0,1,1	-	-	-		
7	TRS	A	1715	-	7,7,7	0.42	0	9,9,9	1.05	1 (11%)

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
6	GOL	A	1713	-	-	4/4/4/4	-
7	TRS	A	1715	-	-	6/9/9/9	-
7	TRS	A	1714	-	-	6/9/9/9	-

There are no bond length outliers.

All (1) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
7	A	1715	TRS	O1-C1-C	2.19	116.99	110.88

There are no chirality outliers.

All (16) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
6	A	1713	GOL	O1-C1-C2-C3
6	A	1713	GOL	C1-C2-C3-O3
7	A	1714	TRS	C1-C-C2-O2
7	A	1714	TRS	C3-C-C2-O2
7	A	1714	TRS	N-C-C2-O2
7	A	1714	TRS	N-C-C3-O3

*Continued on next page...*

*Continued from previous page...*

Mol	Chain	Res	Type	Atoms
6	A	1713	GOL	O1-C1-C2-O2
7	A	1714	TRS	C1-C-C3-O3
7	A	1715	TRS	C3-C-C1-O1
6	A	1713	GOL	O2-C2-C3-O3
7	A	1715	TRS	N-C-C1-O1
7	A	1715	TRS	N-C-C3-O3
7	A	1715	TRS	C2-C-C1-O1
7	A	1715	TRS	C3-C-C2-O2
7	A	1715	TRS	C1-C-C3-O3
7	A	1714	TRS	C2-C-C3-O3

There are no ring outliers.

3 monomers are involved in 7 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
6	A	1713	GOL	1	0
7	A	1714	TRS	4	0
7	A	1715	TRS	2	0

## 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, 95<sup>th</sup> 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 <sup>2</sup> )	Q<0.9
1	A	156/179 (87%)	0.01	5 (3%) 50 53	9, 16, 36, 67	2 (1%)

All (5) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	1525	LEU	6.3
1	A	1526	GLY	3.7
1	A	1680	ASP	2.7
1	A	1527	ALA	2.5
1	A	1660	ASN	2.5

### 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, 95<sup>th</sup> 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 <sup>2</sup> )	Q<0.9
6	GOL	A	1713	6/6	0.75	0.18	44,51,53,55	0
7	TRS	A	1714	8/8	0.81	0.24	35,40,54,55	0

*Continued on next page...*

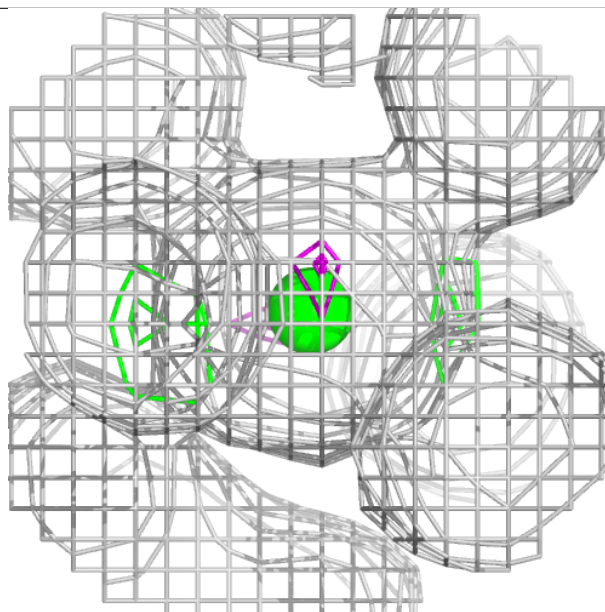
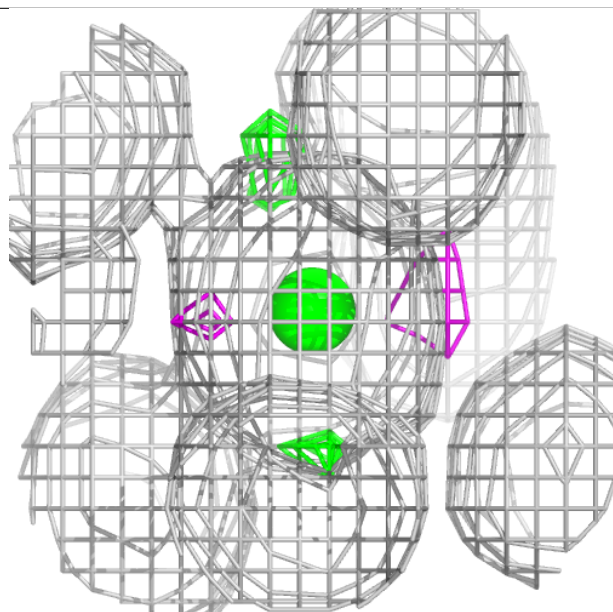
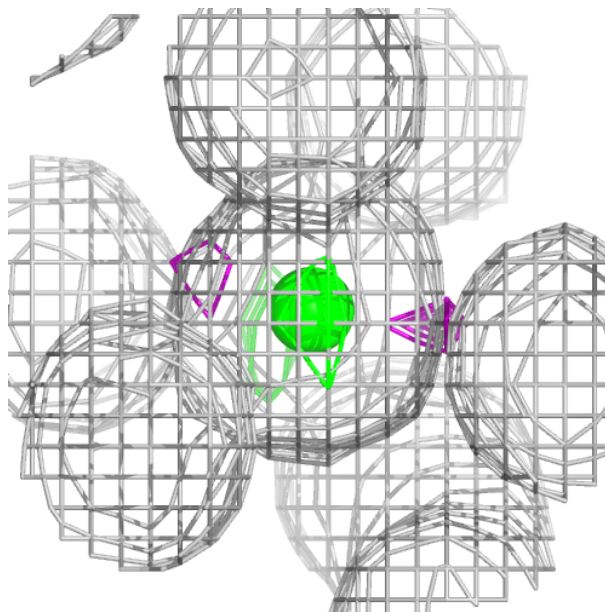
*Continued from previous page...*

Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors( $\text{\AA}^2$ )	Q<0.9
7	TRS	A	1715	8/8	0.81	0.20	40,41,49,55	0
4	NA	A	1710	1/1	0.87	0.22	41,41,41,41	1
5	FOR	A	1712	2/2	0.90	0.27	34,34,34,34	2
3	CL	A	1709	1/1	0.96	0.08	34,34,34,34	1
5	FOR	A	1711	2/2	0.98	0.05	12,12,12,12	2
2	SR	A	1702	1/1	0.99	0.02	11,11,11,11	1
2	SR	A	1703	1/1	0.99	0.03	13,13,13,13	1
2	SR	A	1701	1/1	0.99	0.02	13,13,13,13	1
2	SR	A	1706	1/1	1.00	0.02	10,10,10,10	1
2	SR	A	1707	1/1	1.00	0.01	11,11,11,11	0
2	SR	A	1708	1/1	1.00	0.01	12,12,12,12	1
2	SR	A	1704	1/1	1.00	0.01	12,12,12,12	1
2	SR	A	1705	1/1	1.00	0.01	9,9,9,9	1

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 SR A 1702:**

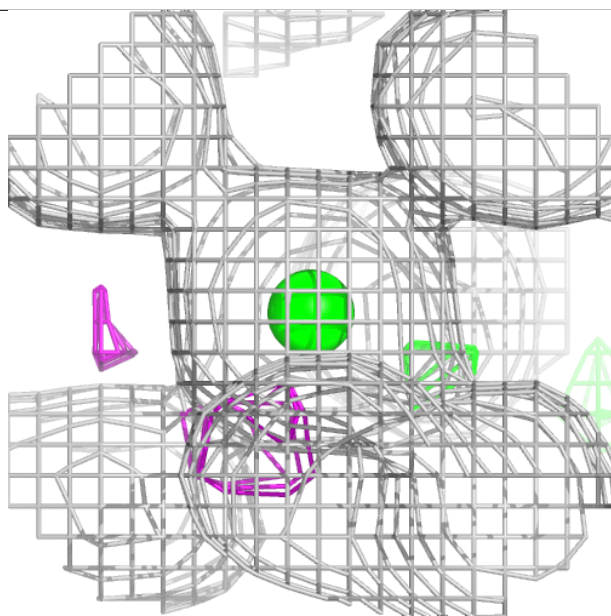
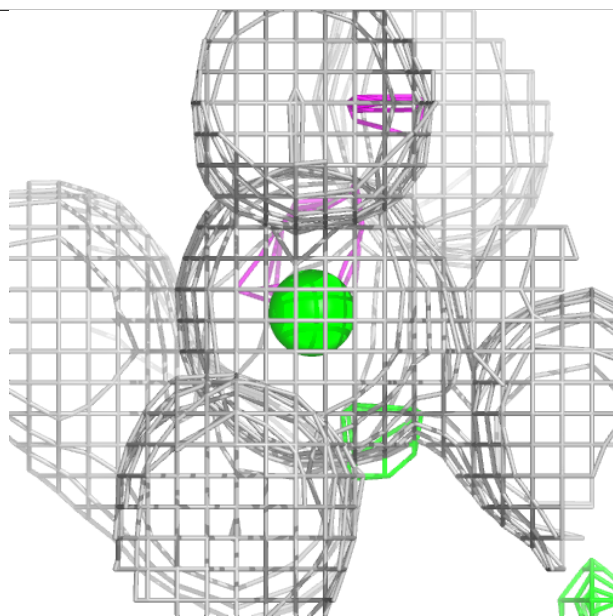
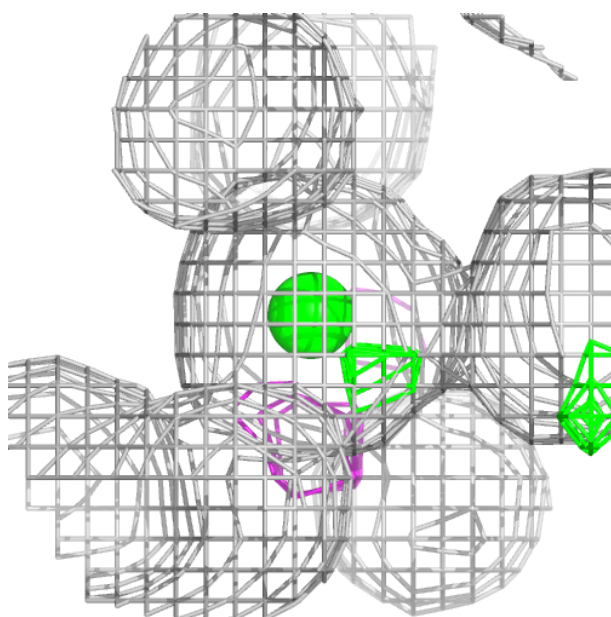
$2mF_o-DF_c$  (at 0.7 rmsd) in gray  
 $mF_o-DF_c$  (at 3 rmsd) in purple (negative)  
and green (positive)





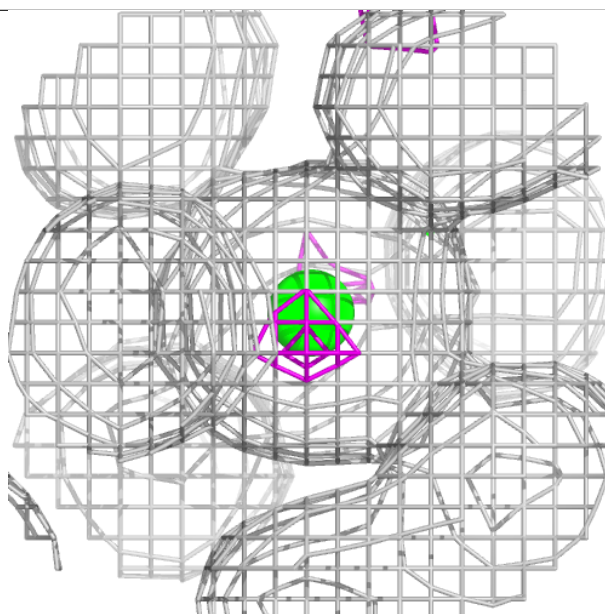
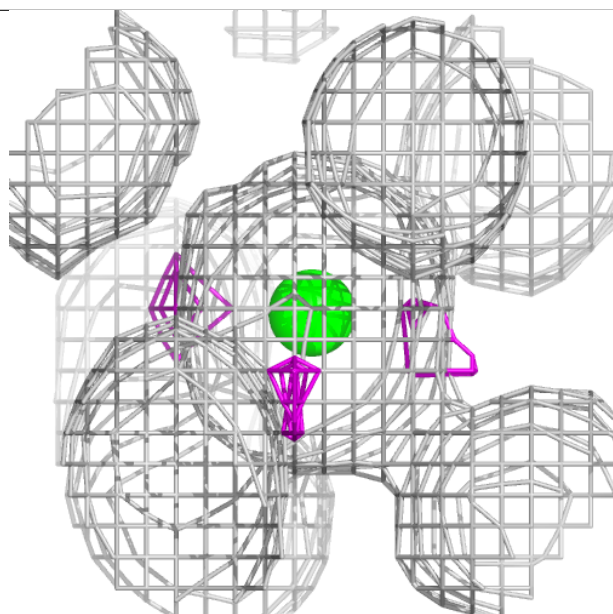
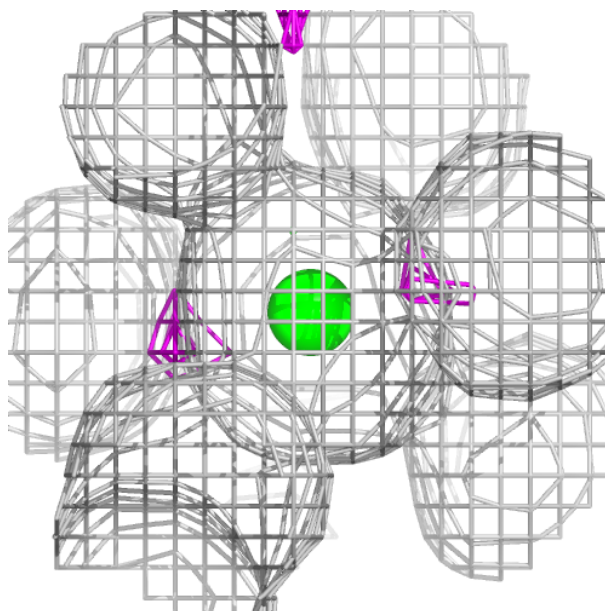
**Electron density around SR A 1703:**

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



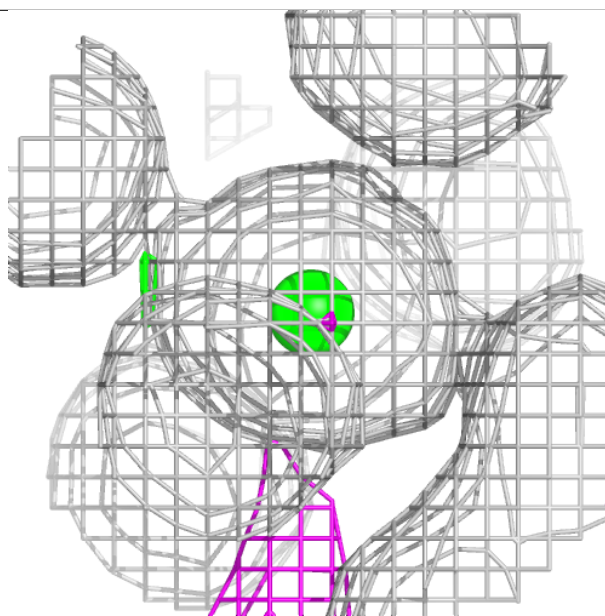
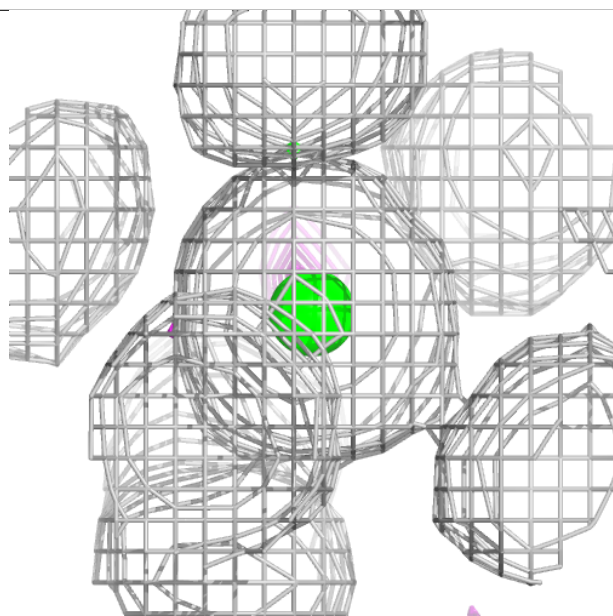
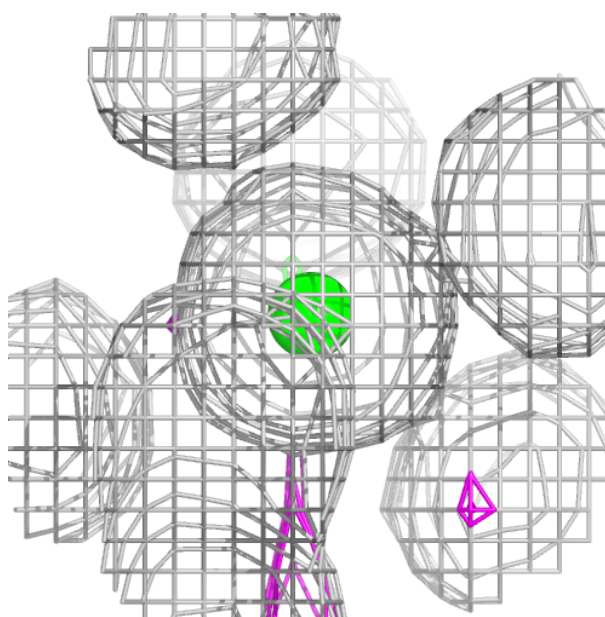
**Electron density around SR A 1701:**

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



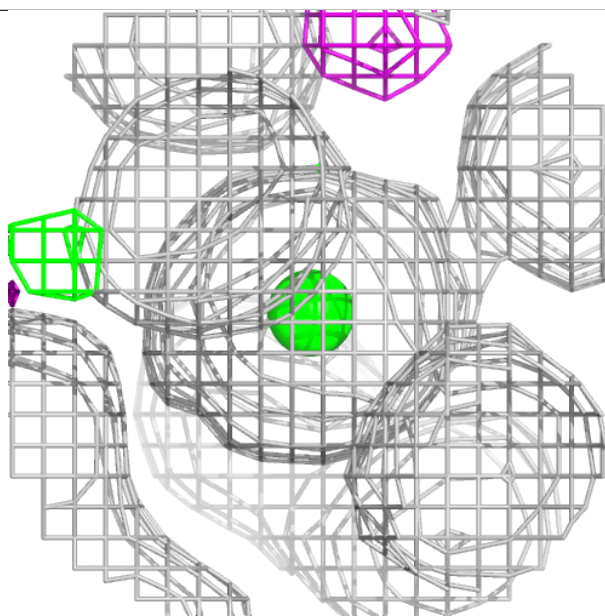
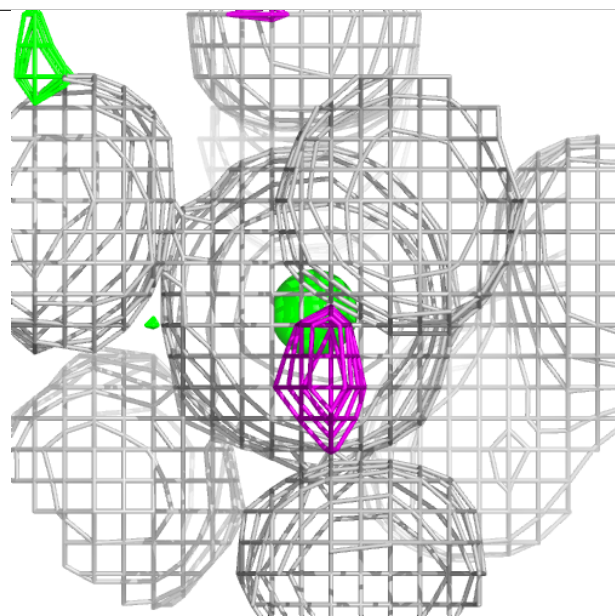
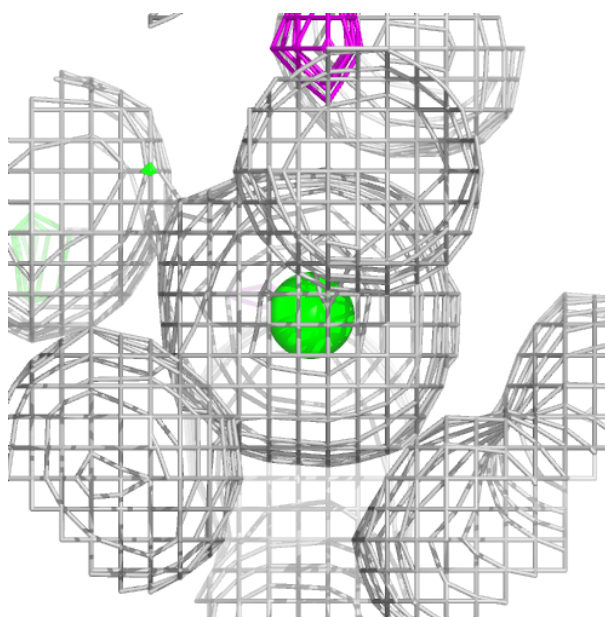
**Electron density around SR A 1706:**

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



**Electron density around SR A 1707:**

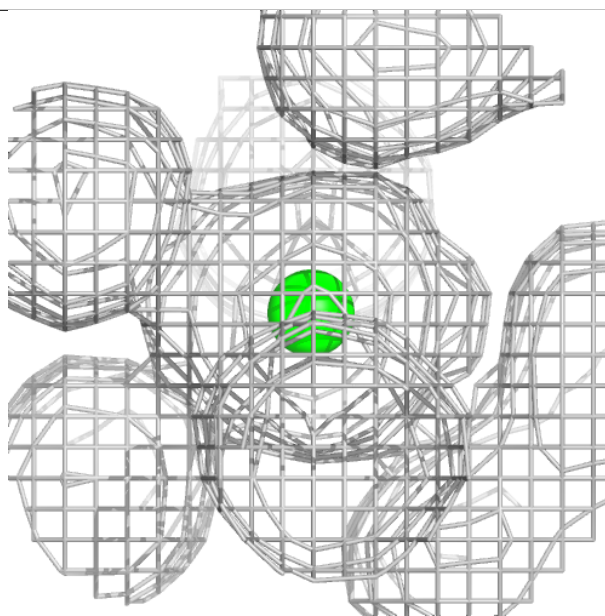
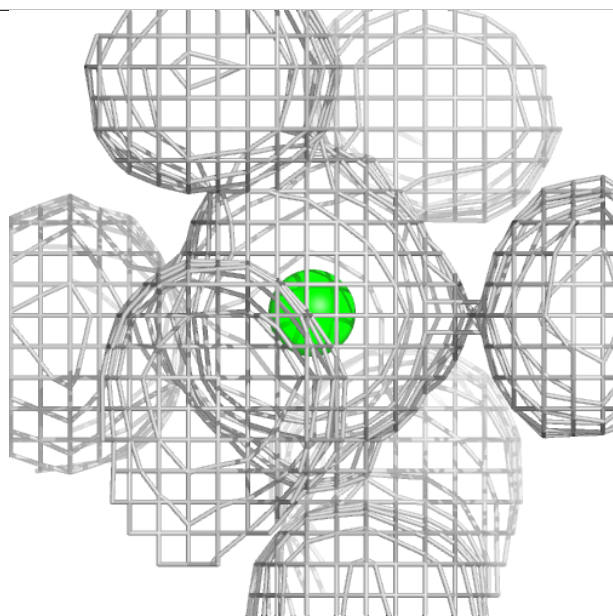
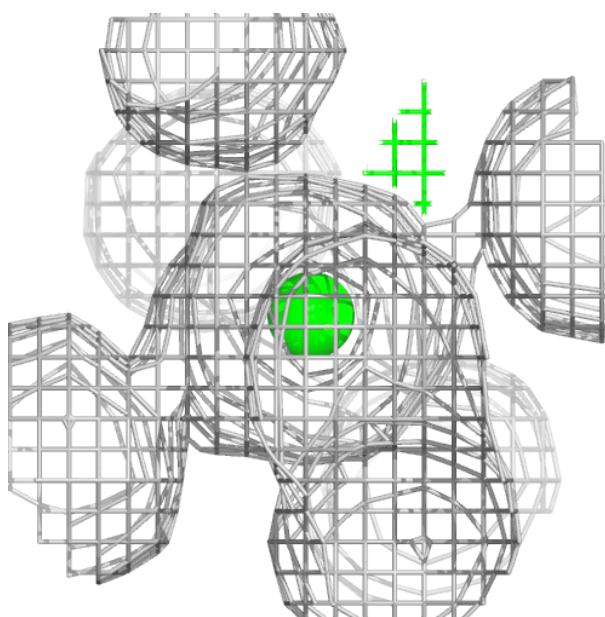
$2mF_o-DF_c$  (at 0.7 rmsd) in gray  
 $mF_o-DF_c$  (at 3 rmsd) in purple (negative)  
and green (positive)





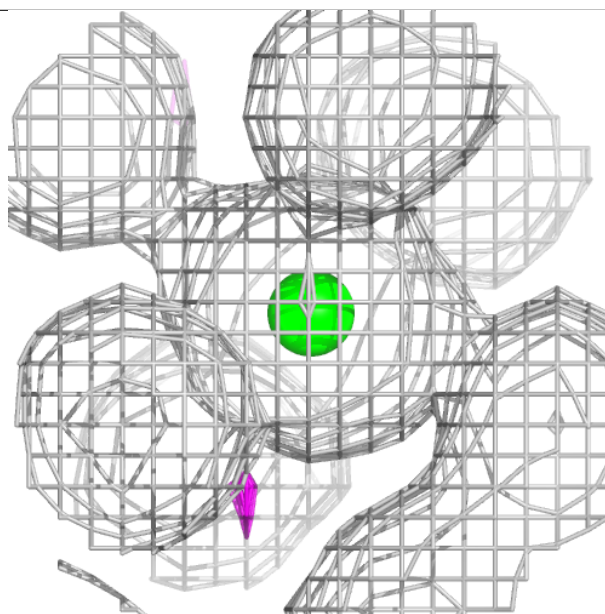
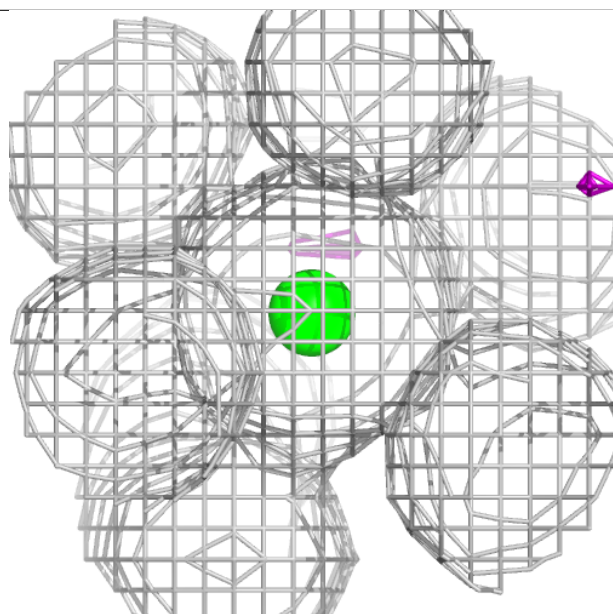
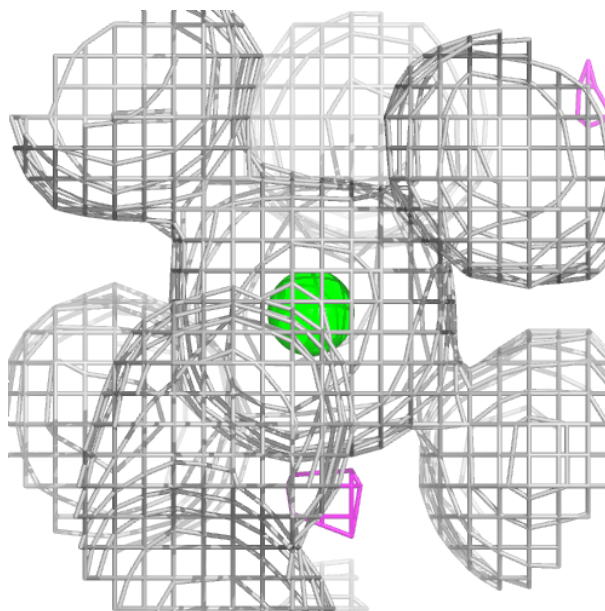
**Electron density around SR A 1708:**

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



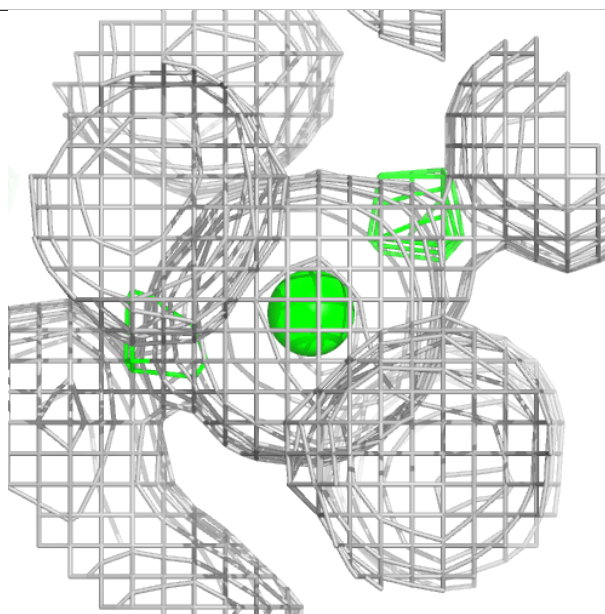
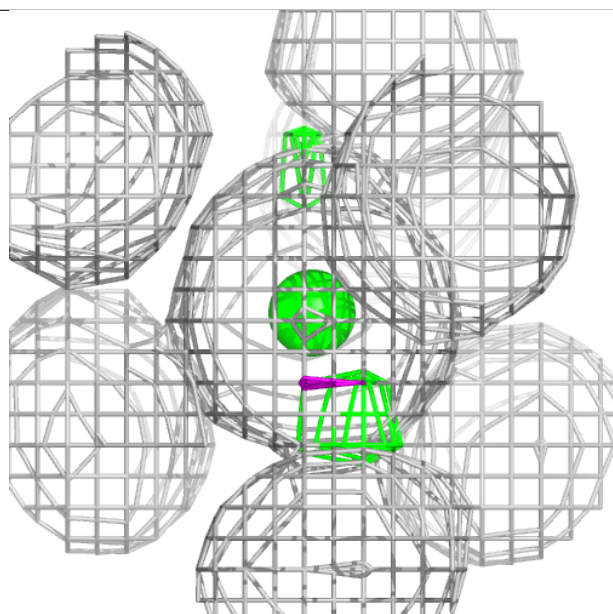
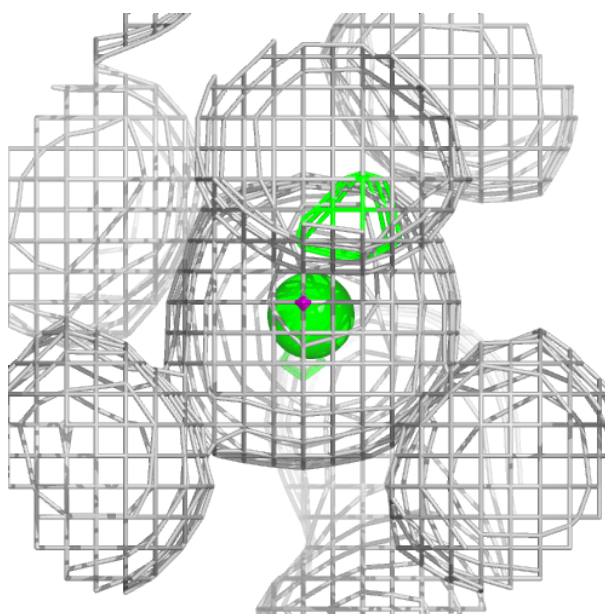
**Electron density around SR A 1704:**

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



**Electron density around SR A 1705:**

$2mF_o-DF_c$  (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.