



# wwPDB X-ray Structure Validation Summary Report

Sep 20, 2023 – 06:48 AM EDT


PDB ID : 5HKO  
Title : Crystal structure of ABC transporter Solute Binding Protein MSMEG\_3598 from Mycobacterium smegmatis str. MC2 155, target EFI-510969, in complex with L-sorbitol  
Authors : Roth, Y.; Vetting, M.W.; Al Obaidi, N.F.; Toro, R.; Morisco, L.L.; Benach, J.; Koss, J.; Wasserman, S.R.; Gerlt, J.A.; Almo, S.C.; Enzyme Function Initiative (EFI)  
Deposited on : 2016-01-14  
Resolution : 1.20 Å(reported)

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We welcome your comments at [validation@mail.wwpdb.org](mailto:validation@mail.wwpdb.org)

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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>.

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

MolProbity : 4.02b-467  
Mogul : 1.8.5 (274361), CSD as541be (2020)  
Xtriage (Phenix) : 1.13  
EDS : 2.35.1  
Percentile statistics : 20191225.v01 (using entries in the PDB archive December 25th 2019)  
Refmac : 5.8.0158  
CCP4 : 7.0.044 (Gargrove)  
Ideal geometry (proteins) : Engh & Huber (2001)  
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)

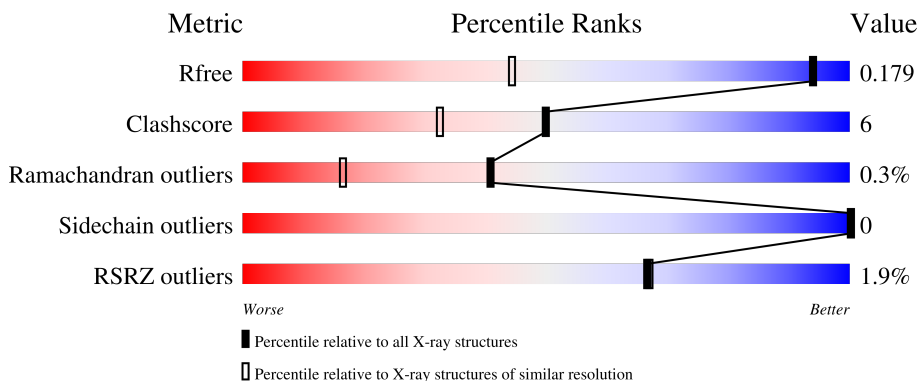
# 1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

*X-RAY DIFFRACTION*

The reported resolution of this entry is 1.20 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))
$R_{free}$	130704	1223 (1.22-1.18)
Clashscore	141614	1286 (1.22-1.18)
Ramachandran outliers	138981	1240 (1.22-1.18)
Sidechain outliers	138945	1239 (1.22-1.18)
RSRZ outliers	127900	1200 (1.22-1.18)

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	348	

The following table lists non-polymeric compounds, carbohydrate monomers and non-standard residues in protein, DNA, RNA chains that are outliers for geometric or electron-density-fit criteria:

Mol	Type	Chain	Res	Chirality	Geometry	Clashes	Electron density
2	ZN	A	412	-	-	X	-
3	CL	A	420	-	-	X	-
3	CL	A	424	-	-	X	-
6	ACT	A	432	-	-	X	-
6	ACT	A	433	-	X	-	-

## 2 Entry composition [i](#)

There are 7 unique types of molecules in this entry. The entry contains 2717 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 ABC transporter, carbohydrate uptake transporter-2 (CUT2) family, periplasmic sugar-binding protein.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	314	2357	1466	402	481	8	0	7	0

There are 23 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	2	MET	-	initiating methionine	UNP A0QYB3
A	3	HIS	-	expression tag	UNP A0QYB3
A	4	HIS	-	expression tag	UNP A0QYB3
A	5	HIS	-	expression tag	UNP A0QYB3
A	6	HIS	-	expression tag	UNP A0QYB3
A	7	HIS	-	expression tag	UNP A0QYB3
A	8	HIS	-	expression tag	UNP A0QYB3
A	9	SER	-	expression tag	UNP A0QYB3
A	10	SER	-	expression tag	UNP A0QYB3
A	11	GLY	-	expression tag	UNP A0QYB3
A	12	VAL	-	expression tag	UNP A0QYB3
A	13	ASP	-	expression tag	UNP A0QYB3
A	14	LEU	-	expression tag	UNP A0QYB3
A	15	GLY	-	expression tag	UNP A0QYB3
A	16	THR	-	expression tag	UNP A0QYB3
A	17	GLU	-	expression tag	UNP A0QYB3
A	18	ASN	-	expression tag	UNP A0QYB3
A	19	LEU	-	expression tag	UNP A0QYB3
A	20	TYR	-	expression tag	UNP A0QYB3
A	21	PHE	-	expression tag	UNP A0QYB3
A	22	GLN	-	expression tag	UNP A0QYB3
A	23	SER	-	expression tag	UNP A0QYB3
A	24	MET	-	expression tag	UNP A0QYB3

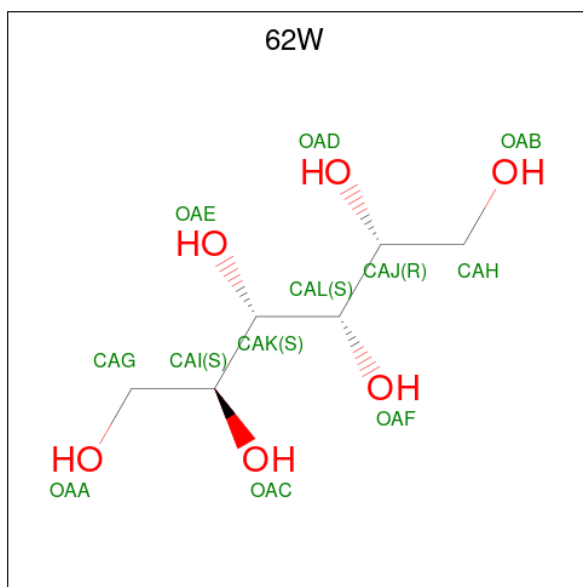
- Molecule 2 is ZINC ION (three-letter code: ZN) (formula: Zn).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	A	15	Total	Zn	0	0
			15	15		

- Molecule 3 is CHLORIDE ION (three-letter code: CL) (formula: Cl).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	A	9	Total	Cl	0	0
			9	9		

- Molecule 4 is L-glucitol (three-letter code: 62W) (formula: C<sub>6</sub>H<sub>14</sub>O<sub>6</sub>).



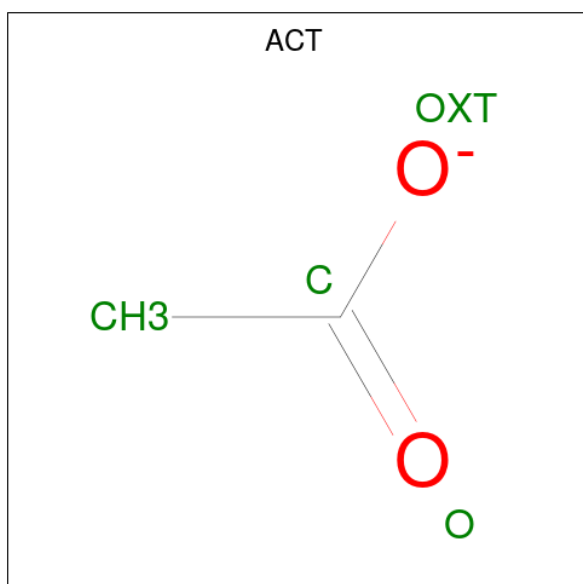
Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
4	A	1	Total	C	O	0	0
			12	6	6		

- Molecule 5 is IMIDAZOLE (three-letter code: IMD) (formula: C<sub>3</sub>H<sub>5</sub>N<sub>2</sub>).



Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
5	A	1	Total C N 5 3 2	0	0
5	A	1	Total C N 5 3 2	0	0
5	A	1	Total C N 5 3 2	0	0
5	A	1	Total C N 5 3 2	0	0
5	A	1	Total C N 5 3 2	0	0

- Molecule 6 is ACETATE ION (three-letter code: ACT) (formula:  $C_2H_3O_2$ ).



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

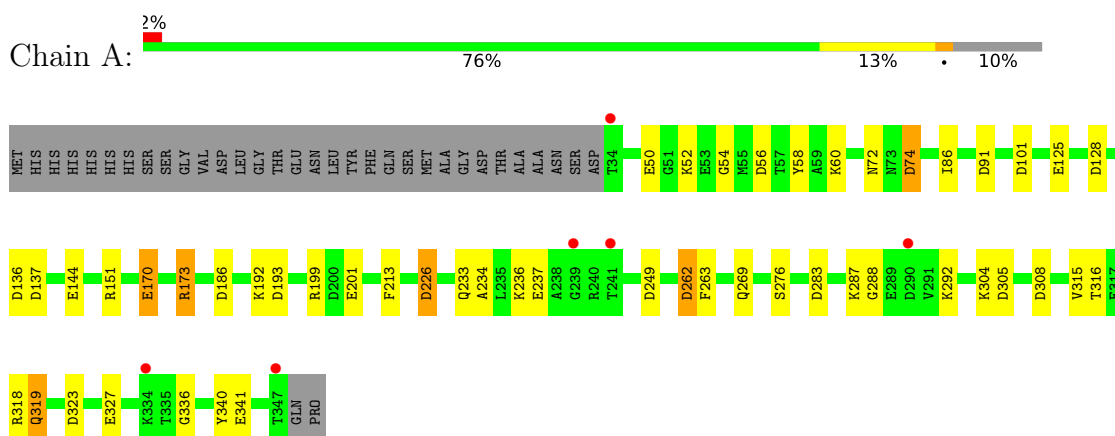
- Molecule 7 is water.

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
7	A	287	Total O 287 287	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: ABC transporter, carbohydrate uptake transporter-2 (CUT2) family, periplasmic sugar-binding protein





## 4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, $\alpha$ , $\beta$ , $\gamma$	62.95Å 62.94Å 73.15Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	47.71 – 1.20 28.26 – 1.20	Depositor EDS
% Data completeness (in resolution range)	100.0 (47.71-1.20) 100.0 (28.26-1.20)	Depositor EDS
$R_{merge}$	0.09	Depositor
$R_{sym}$	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ <sup>1</sup>	2.62 (at 1.20Å)	Xtrriage
Refinement program	REFMAC 5.8.0123	Depositor
R, $R_{free}$	0.156 , 0.178 0.156 , 0.179	Depositor DCC
$R_{free}$ test set	4465 reflections (4.88%)	wwPDB-VP
Wilson B-factor (Å <sup>2</sup> )	10.3	Xtrriage
Anisotropy	0.225	Xtrriage
Bulk solvent $k_{sol}$ (e/Å <sup>3</sup> ), $B_{sol}$ (Å <sup>2</sup> )	0.41 , 46.1	EDS
L-test for twinning <sup>2</sup>	$\langle  L  \rangle = 0.49$ , $\langle L^2 \rangle = 0.32$	Xtrriage
Estimated twinning fraction	0.020 for k,h,-l	Xtrriage
$F_o, F_c$ correlation	0.97	EDS
Total number of atoms	2717	wwPDB-VP
Average B, all atoms (Å <sup>2</sup> )	14.0	wwPDB-VP

Xtrriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 5.42% 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: ZN, CL, ACT, 62W, IMD

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	1.71	29/2393 (1.2%)	1.50	35/3246 (1.1%)

Chiral center outliers are detected by calculating the chiral volume of a chiral center and verifying if the center is modelled as a planar moiety or with the opposite hand. A planarity outlier is detected by checking planarity of atoms in a peptide group, atoms in a mainchain group or atoms of a sidechain that are expected to be planar.

Mol	Chain	#Chirality outliers	#Planarity outliers
1	A	0	1

The worst 5 of 29 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	58	TYR	CZ-OH	12.52	1.59	1.37
1	A	125	GLU	CG-CD	-10.70	1.35	1.51
1	A	128	ASP	CG-OD2	-9.56	1.03	1.25
1	A	58	TYR	CE2-CZ	-8.97	1.26	1.38
1	A	128	ASP	CB-CG	8.54	1.69	1.51

The worst 5 of 35 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	58	TYR	CG-CD1-CE1	-11.03	112.47	121.30
1	A	308	ASP	CB-CG-OD1	11.03	128.23	118.30
1	A	323	ASP	CB-CG-OD1	10.79	128.01	118.30
1	A	128	ASP	CB-CG-OD2	-9.80	109.48	118.30
1	A	58	TYR	CZ-CE2-CD2	-9.28	111.45	119.80

There are no chirality outliers.

All (1) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	A	173	ARG	Sidechain

## 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	2357	0	2365	19	0
2	A	15	0	0	3	0
3	A	9	0	0	10	1
4	A	12	0	14	0	0
5	A	25	0	21	4	0
6	A	12	0	9	4	0
7	A	287	0	0	14	6
All	All	2717	0	2409	28	6

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 6.

The worst 5 of 28 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:A:424:CL:CL	5:A:428:IMD:C5	2.17	1.29
3:A:423:CL:CL	3:A:424:CL:CL	2.28	1.24
3:A:424:CL:CL	5:A:428:IMD:N1	2.12	1.19
3:A:424:CL:CL	5:A:428:IMD:H5	1.78	1.19
1:A:170:GLU:OE2	3:A:420:CL:CL	2.07	1.08

The worst 5 of 6 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)
7:A:516:HOH:O	7:A:681:HOH:O[4_545]	1.91	0.29
3:A:424:CL:CL	7:A:535:HOH:O[4_545]	2.07	0.13
7:A:729:HOH:O	7:A:738:HOH:O[4_545]	2.07	0.13
7:A:675:HOH:O	7:A:692:HOH:O[4_445]	2.10	0.10
7:A:518:HOH:O	7:A:732:HOH:O[3_555]	2.11	0.09

## 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	319/348 (92%)	312 (98%)	6 (2%)	1 (0%)	41 16

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	249	ASP

### 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	254/275 (92%)	254 (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. There are no such sidechains identified.

### 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 monosaccharides in this entry.

## 5.6 Ligand geometry [i](#)

Of 33 ligands modelled in this entry, 24 are monoatomic - leaving 9 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
4	62W	A	425	-	11,11,11	0.87	1 (9%)	14,14,14	0.75	0
6	ACT	A	432	2	3,3,3	4.71	2 (66%)	3,3,3	0.94	0
5	IMD	A	429	2	3,5,5	0.79	0	4,5,5	0.84	0
5	IMD	A	430	2	3,5,5	0.51	0	4,5,5	0.48	0
5	IMD	A	428	2	3,5,5	1.44	1 (33%)	4,5,5	0.37	0
6	ACT	A	433	2	3,3,3	1.51	1 (33%)	3,3,3	2.33	2 (66%)
5	IMD	A	427	2	3,5,5	0.30	0	4,5,5	0.79	0
5	IMD	A	426	2	3,5,5	1.10	0	4,5,5	0.70	0
6	ACT	A	431	2	3,3,3	1.51	0	3,3,3	1.53	1 (33%)

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
4	62W	A	425	-	-	1/16/16/16	-
5	IMD	A	429	2	-	-	0/1/1/1
5	IMD	A	430	2	-	-	0/1/1/1
5	IMD	A	428	2	-	-	0/1/1/1
5	IMD	A	427	2	-	-	0/1/1/1
5	IMD	A	426	2	-	-	0/1/1/1

All (5) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
6	A	432	ACT	O-C	-7.24	0.89	1.22
6	A	432	ACT	CH3-C	-3.50	1.34	1.49
6	A	433	ACT	OXT-C	-2.06	1.20	1.30
4	A	425	62W	CAI-CAK	2.03	1.57	1.53
5	A	428	IMD	C5-N1	-2.02	1.27	1.37

All (3) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
6	A	433	ACT	O-C-CH3	3.08	134.32	122.33
6	A	433	ACT	OXT-C-CH3	-2.60	104.45	115.18
6	A	431	ACT	OXT-C-CH3	2.09	123.83	115.18

There are no chirality outliers.

All (1) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
4	A	425	62W	CAH-CAJ-CAL-CAK

There are no ring outliers.

3 monomers are involved in 8 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
6	A	432	ACT	4	0
5	A	428	IMD	3	0
5	A	426	IMD	1	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	314/348 (90%)	-0.26	6 (1%) 66 67	6, 12, 25, 40	0

The worst 5 of 6 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	290	ASP	3.8
1	A	241	THR	2.8
1	A	347	THR	2.6
1	A	334	LYS	2.4
1	A	239	GLY	2.3

### 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 monosaccharides 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	ACT	A	433	4/4	0.69	0.15	25,27,33,34	0
5	IMD	A	430	5/5	0.79	0.22	26,27,34,36	0

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Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors( $\text{\AA}^2$ )	Q<0.9
5	IMD	A	428	5/5	0.84	0.11	15,16,17,18	0
2	ZN	A	410	1/1	0.87	0.10	38,38,38,38	0
5	IMD	A	429	5/5	0.87	0.15	25,32,32,35	0
2	ZN	A	406	1/1	0.91	0.10	25,25,25,25	0
3	CL	A	419	1/1	0.93	0.07	16,16,16,16	0
5	IMD	A	427	5/5	0.93	0.07	16,18,20,22	0
3	CL	A	424	1/1	0.94	0.13	15,15,15,15	0
2	ZN	A	409	1/1	0.94	0.19	24,24,24,24	1
2	ZN	A	412	1/1	0.95	0.14	22,22,22,22	1
3	CL	A	423	1/1	0.95	0.07	16,16,16,16	0
5	IMD	A	426	5/5	0.96	0.07	8,8,10,12	0
2	ZN	A	405	1/1	0.96	0.12	20,20,20,20	0
2	ZN	A	411	1/1	0.96	0.22	33,33,33,33	1
2	ZN	A	407	1/1	0.97	0.20	27,27,27,27	1
3	CL	A	417	1/1	0.97	0.04	13,13,13,13	0
2	ZN	A	404	1/1	0.97	0.13	20,20,20,20	1
6	ACT	A	432	4/4	0.97	0.12	13,13,14,16	0
3	CL	A	420	1/1	0.97	0.12	16,16,16,16	0
2	ZN	A	415	1/1	0.98	0.24	34,34,34,34	0
6	ACT	A	431	4/4	0.98	0.05	10,10,11,12	0
2	ZN	A	401	1/1	0.98	0.03	12,12,12,12	0
3	CL	A	422	1/1	0.98	0.04	11,11,11,11	0
3	CL	A	418	1/1	0.99	0.03	13,13,13,13	0
2	ZN	A	402	1/1	0.99	0.02	10,10,10,10	0
2	ZN	A	413	1/1	0.99	0.03	9,9,9,9	0
3	CL	A	421	1/1	0.99	0.03	11,11,11,11	0
2	ZN	A	414	1/1	0.99	0.20	19,19,19,19	0
2	ZN	A	403	1/1	0.99	0.07	17,17,17,17	0
2	ZN	A	408	1/1	0.99	0.03	11,11,11,11	0
4	62W	A	425	12/12	0.99	0.09	5,6,6,7	0
3	CL	A	416	1/1	1.00	0.02	12,12,12,12	0

## 6.5 Other polymers [\(i\)](#)

There are no such residues in this entry.