



# Full wwPDB X-ray Structure Validation Report ⓘ

Feb 12, 2017 – 09:46 pm GMT

PDB ID : 3UTW  
Title : Crystal structure of bacteriorhodopsin mutant P50A/Y57F  
Authors : Cao, Z.; Bowie, J.U.  
Deposited on : 2011-11-27  
Resolution : 2.40 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

<http://wwpdb.org/validation/2016/XrayValidationReportHelp>

with specific help available everywhere you see the ⓘ symbol.

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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 : 1.7.2 (RC1), CSD as538be (2017)  
Xtriage (Phenix) : 1.9-1692  
EDS : trunk28620  
Percentile statistics : 20161228.v01 (using entries in the PDB archive December 28th 2016)  
Refmac : 5.8.0135  
CCP4 : 6.5.0  
Ideal geometry (proteins) : Engh & Huber (2001)  
Ideal geometry (DNA, RNA) : Parkinson et al. (1996)  
Validation Pipeline (wwPDB-VP) : recalc28949

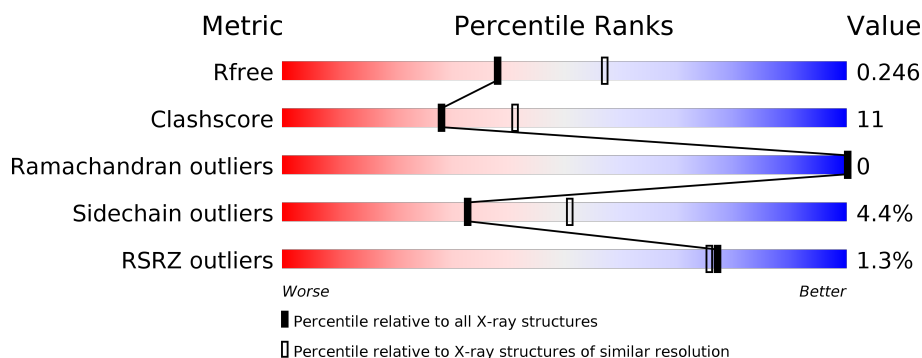
# 1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

## *X-RAY DIFFRACTION*

The reported resolution of this entry is 2.40 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))
$R_{free}$	100719	3166 (2.40-2.40)
Clashscore	112137	3674 (2.40-2.40)
Ramachandran outliers	110173	3616 (2.40-2.40)
Sidechain outliers	110143	3617 (2.40-2.40)
RSRZ outliers	101464	3195 (2.40-2.40)

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 on the lower bar indicate the fraction of residues that contain outliers for  $\geq 3$ , 2, 1 and 0 types of geometric quality criteria. 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	249	<div> <div></div> <div>71%</div> <div>17%</div> <div>9%</div> </div>

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
3	BOG	A	302	-	-	-	X
4	MC3	A	303	-	-	-	X

## 2 Entry composition [i](#)

There are 5 unique types of molecules in this entry. The entry contains 1848 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.

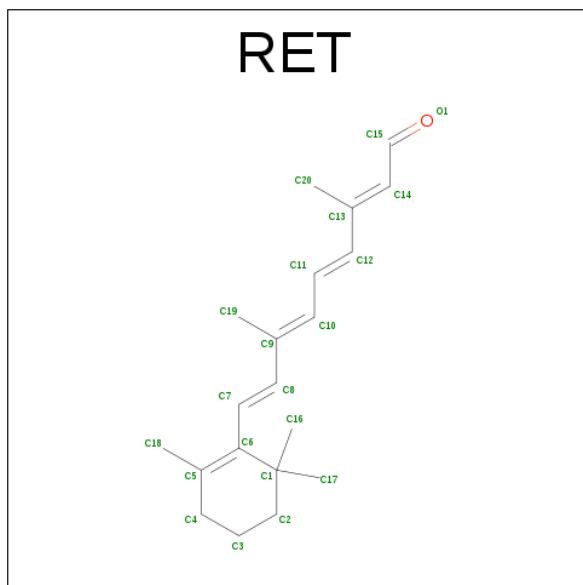
- Molecule 1 is a protein called Bacteriorhodopsin.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	227	Total	C	N	O	S	0	0	0
			1753	1178	268	298	9			

There are 2 discrepancies between the modelled and reference sequences:

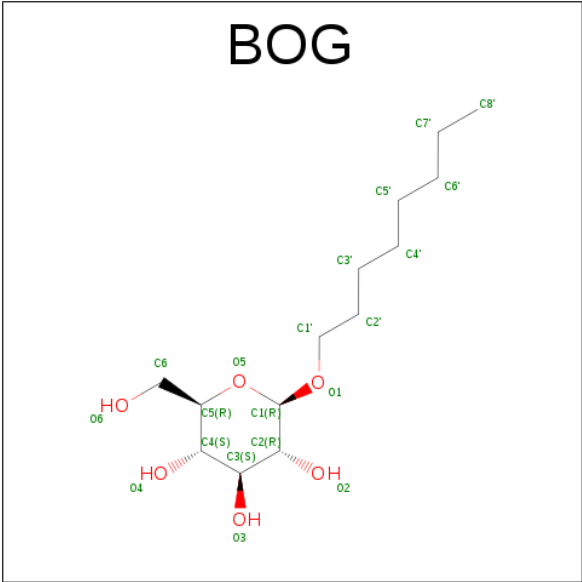
Chain	Residue	Modelled	Actual	Comment	Reference
A	50	ALA	PRO	ENGINEERED MUTATION	UNP P02945
A	57	PHE	TYR	ENGINEERED MUTATION	UNP P02945

- Molecule 2 is RETINAL (three-letter code: RET) (formula:  $C_{20}H_{28}O$ ).



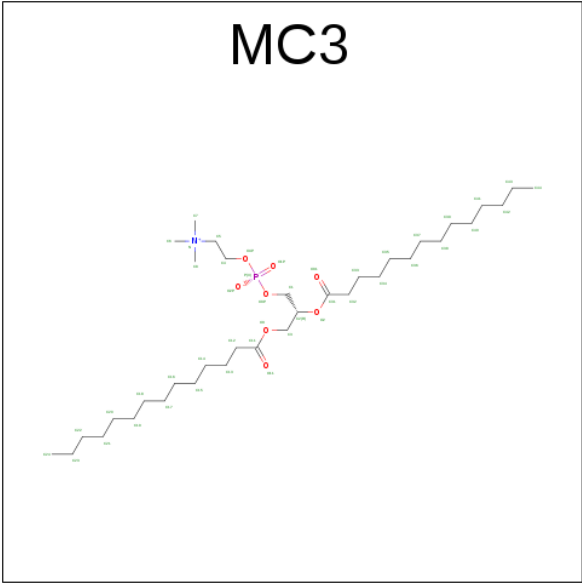
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	A	1	Total	C	0	0
			20	20		

- Molecule 3 is SUGAR (B-OCTYLGLUCOSIDE) (three-letter code: BOG) (formula:  $C_{14}H_{28}O_6$ ).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
3	A	1	Total	C	O	0	0
			20	14	6		

- Molecule 4 is 1,2-DIMYRISTOYL-RAC-GLYCERO-3-PHOSPHOCHOLINE (three-letter code: MC3) (formula: C<sub>36</sub>H<sub>72</sub>NO<sub>8</sub>P).



Mol	Chain	Residues	Atoms					ZeroOcc	AltConf
4	A	1	Total	C	N	O	P	0	0
			46	36	1	8	1		

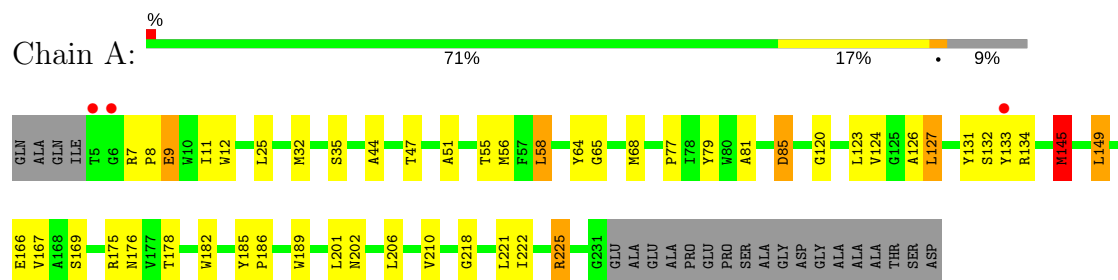
- Molecule 5 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
5	A	9	Total	O	0	0
			9	9		

### 3 Residue-property plots [i](#)

These plots are drawn for all protein, RNA and DNA 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: Bacteriorhodopsin



## 4 Data and refinement statistics

Property	Value	Source
Space group	C 2 2 21	Depositor
Cell constants a, b, c, $\alpha$ , $\beta$ , $\gamma$	45.28Å 103.06Å 128.88Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	47.85 – 2.40 47.85 – 2.40	Depositor EDS
% Data completeness (in resolution range)	95.7 (47.85-2.40) 95.7 (47.85-2.40)	Depositor EDS
$R_{merge}$	(Not available)	Depositor
$R_{sym}$	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ <sup>1</sup>	3.63 (at 2.39Å)	Xtriage
Refinement program	REFMAC 5.6.0117	Depositor
R, $R_{free}$	0.203 , 0.246 0.201 , 0.246	Depositor DCC
$R_{free}$ test set	929 reflections (8.68%)	DCC
Wilson B-factor (Å <sup>2</sup> )	27.2	Xtriage
Anisotropy	0.446	Xtriage
Bulk solvent $k_{sol}$ (e/Å <sup>3</sup> ), $B_{sol}$ (Å <sup>2</sup> )	0.38 , 71.8	EDS
L-test for twinning <sup>2</sup>	$\langle  L  \rangle = 0.51$ , $\langle L^2 \rangle = 0.35$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
$F_o, F_c$ correlation	0.93	EDS
Total number of atoms	1848	wwPDB-VP
Average B, all atoms (Å <sup>2</sup> )	37.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 6.64% 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

### 5.1 Standard geometry

Bond lengths and bond angles in the following residue types are not validated in this section: MC3, RET, BOG

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	1.16	4/1800 (0.2%)	1.10	11/2457 (0.4%)

All (4) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	9	GLU	CD-OE1	7.77	1.34	1.25
1	A	169	SER	CB-OG	-6.78	1.33	1.42
1	A	12	TRP	CD2-CE2	6.17	1.48	1.41
1	A	79	TYR	CG-CD1	5.18	1.45	1.39

All (11) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	145	MET	CG-SD-CE	-8.38	86.80	100.20
1	A	25	LEU	CA-CB-CG	6.64	130.58	115.30
1	A	167	VAL	CG1-CB-CG2	6.49	121.29	110.90
1	A	127	LEU	CB-CG-CD1	-6.33	100.23	111.00
1	A	85	ASP	CB-CG-OD1	6.02	123.72	118.30
1	A	134	ARG	NE-CZ-NH1	5.46	123.03	120.30
1	A	133	TYR	CB-CG-CD1	5.33	124.20	121.00
1	A	7	ARG	NE-CZ-NH1	5.26	122.93	120.30
1	A	133	TYR	CB-CG-CD2	-5.24	117.86	121.00
1	A	32	MET	CA-CB-CG	-5.23	104.41	113.30
1	A	85	ASP	CB-CG-OD2	-5.09	113.72	118.30

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	1753	0	1811	37	0
2	A	20	0	27	6	0
3	A	20	0	28	2	0
4	A	46	0	72	1	0
5	A	9	0	0	0	0
All	All	1848	0	1938	42	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 11.

All (42) 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:127:LEU:HD12	1:A:127:LEU:N	1.63	1.08
1:A:123:LEU:O	1:A:127:LEU:HD13	1.63	0.99
1:A:126:ALA:C	1:A:127:LEU:HD12	1.85	0.97
1:A:127:LEU:N	1:A:127:LEU:CD1	2.27	0.97
1:A:145:MET:CE	1:A:182:TRP:O	2.22	0.87
1:A:145:MET:HE1	1:A:182:TRP:O	1.79	0.82
1:A:145:MET:HE1	1:A:182:TRP:C	1.99	0.82
2:A:301:RET:H161	2:A:301:RET:H8	1.71	0.72
1:A:9:GLU:HG2	1:A:201:LEU:HG	1.73	0.70
1:A:68:MET:HE1	1:A:77:PRO:HB3	1.74	0.70
1:A:145:MET:HE3	1:A:182:TRP:O	1.91	0.68
1:A:9:GLU:OE1	1:A:201:LEU:HD23	2.01	0.61
1:A:51:ALA:O	1:A:55:THR:HG23	2.02	0.60
1:A:65:GLY:HA3	1:A:81:ALA:HB2	1.87	0.57
1:A:175:ARG:HH21	1:A:176:ASN:HD21	1.52	0.57
1:A:225:ARG:HG2	1:A:225:ARG:HH21	1.70	0.56
1:A:206:LEU:O	1:A:210:VAL:HG23	2.05	0.55
1:A:9:GLU:CG	1:A:201:LEU:HG	2.37	0.55
1:A:221:LEU:O	1:A:225:ARG:HD2	2.08	0.54
1:A:44:ALA:HB1	3:A:302:BOG:H4	1.90	0.54
2:A:301:RET:H8	2:A:301:RET:H171	1.92	0.52
1:A:68:MET:CE	1:A:77:PRO:HB3	2.40	0.51

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:47:THR:HG22	3:A:302:BOG:H3'1	1.93	0.51
1:A:185:TYR:N	1:A:186:PRO:HD2	2.26	0.51
1:A:127:LEU:N	1:A:127:LEU:HD13	2.26	0.48
2:A:301:RET:H181	2:A:301:RET:H7	1.69	0.48
1:A:64:TYR:CD2	4:A:303:MC3:H72	2.49	0.48
2:A:301:RET:C8	2:A:301:RET:H171	2.43	0.48
1:A:120:GLY:O	1:A:124:VAL:HG23	2.14	0.47
1:A:8:PRO:O	1:A:11:ILE:HD12	2.14	0.47
1:A:9:GLU:HG3	1:A:202:ASN:HA	1.97	0.46
1:A:58:LEU:O	1:A:58:LEU:HD22	2.15	0.46
1:A:123:LEU:O	1:A:127:LEU:CD1	2.51	0.45
2:A:301:RET:H161	2:A:301:RET:C8	2.43	0.45
1:A:178:THR:HG23	1:A:182:TRP:CE2	2.51	0.44
1:A:178:THR:HG23	1:A:182:TRP:NE1	2.32	0.44
1:A:56:MET:HG3	1:A:85:ASP:HB2	1.98	0.44
1:A:189:TRP:CD1	2:A:301:RET:H22	2.53	0.44
1:A:68:MET:HE2	1:A:77:PRO:HA	2.00	0.42
1:A:218:GLY:O	1:A:222:ILE:HG13	2.21	0.41
1:A:149:LEU:HD12	1:A:149:LEU:HA	1.93	0.40
1:A:225:ARG:HH21	1:A:225:ARG:CG	2.33	0.40

There are no symmetry-related clashes.

## 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	225/249 (90%)	223 (99%)	2 (1%)	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	181/194 (93%)	173 (96%)	8 (4%)	33 51

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

Mol	Chain	Res	Type
1	A	35	SER
1	A	58	LEU
1	A	131	TYR
1	A	132	SER
1	A	145	MET
1	A	149	LEU
1	A	166	GLU
1	A	225	ARG

Some sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (1) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	176	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 carbohydrates in this entry.

## 5.6 Ligand geometry

3 ligands are modelled in this entry.

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$
2	RET	A	301	1	19,20,21	1.00	0	27,27,28	2.33	10 (37%)
3	BOG	A	302	-	20,20,20	1.44	2 (10%)	25,25,25	3.30	12 (48%)
4	MC3	A	303	-	45,45,45	1.57	4 (8%)	50,53,53	1.86	7 (14%)

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
2	RET	A	301	1	-	0/13/30/31	0/1/1/1
3	BOG	A	302	-	-	0/11/31/31	0/1/1/1
4	MC3	A	303	-	-	0/49/49/49	0/0/0/0

All (6) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
4	A	303	MC3	P-O3P	2.23	1.68	1.59
3	A	302	BOG	O4-C4	3.69	1.51	1.43
4	A	303	MC3	C3-C2	3.78	1.61	1.50
3	A	302	BOG	O1-C1	3.83	1.46	1.40
4	A	303	MC3	O2-C31	5.25	1.49	1.34
4	A	303	MC3	O3-C11	5.77	1.50	1.33

All (29) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	A	302	BOG	C3-C4-C5	-6.22	99.25	110.22
2	A	301	RET	C17-C1-C6	-4.17	103.54	110.31
3	A	302	BOG	O5-C5-C4	-4.17	101.98	109.66

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
3	A	302	BOG	O5-C1-C2	-4.05	102.48	110.30
3	A	302	BOG	O2-C2-C1	-3.70	102.30	110.03
2	A	301	RET	C17-C1-C16	-3.60	97.47	108.50
2	A	301	RET	C10-C11-C12	-2.64	115.12	123.23
2	A	301	RET	C18-C5-C6	-2.54	121.66	124.51
4	A	303	MC3	O3-C11-O11	-2.44	117.49	123.55
2	A	301	RET	C12-C13-C14	-2.00	112.38	118.83
2	A	301	RET	C1-C6-C7	2.09	121.59	115.73
3	A	302	BOG	O4-C4-C5	2.56	115.74	109.28
4	A	303	MC3	O2P-P-O3P	2.80	121.39	108.14
3	A	302	BOG	C4-C3-C2	3.23	116.54	110.84
4	A	303	MC3	O2-C2-C3	3.35	120.63	108.44
2	A	301	RET	C2-C3-C4	3.65	120.05	111.34
2	A	301	RET	C20-C13-C12	3.72	124.03	118.10
3	A	302	BOG	O3-C3-C4	3.82	118.68	110.36
3	A	302	BOG	O3-C3-C2	4.29	119.69	110.36
3	A	302	BOG	C1'-O1-C1	4.37	121.38	113.87
4	A	303	MC3	O2-C31-C32	4.53	120.95	111.55
2	A	301	RET	C16-C1-C6	4.71	117.95	110.31
2	A	301	RET	C2-C1-C6	4.72	117.86	110.48
4	A	303	MC3	O3-C11-C12	4.73	125.67	111.90
4	A	303	MC3	C3-O3-C11	4.92	131.94	117.13
3	A	302	BOG	O4-C4-C3	5.46	122.23	110.36
3	A	302	BOG	O1-C1-C2	6.08	118.15	108.23
3	A	302	BOG	C1-C2-C3	6.44	121.95	109.98
4	A	303	MC3	O3-C3-C2	6.82	125.79	108.66

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

3 monomers are involved in 9 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	A	301	RET	6	0
3	A	302	BOG	2	0
4	A	303	MC3	1	0

## 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 [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	227/249 (91%)	-0.24	3 (1%) 77 75	23, 33, 52, 91	0

All (3) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	5	THR	9.8
1	A	6	GLY	4.4
1	A	133	TYR	2.1

### 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 carbohydrates 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. LLDF column lists the quality of electron density of the group with respect to its neighbouring residues in protein, DNA or RNA chains. 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	LLDF	B-factors(Å <sup>2</sup> )	Q<0.9
3	BOG	A	302	20/20	0.59	0.37	9.97	40,80,94,97	0
4	MC3	A	303	46/46	0.66	0.30	5.60	50,72,94,110	0
2	RET	A	301	20/21	0.93	0.11	-0.01	2,21,25,28	0

## 6.5 Other polymers [i](#)

There are no such residues in this entry.