



wwPDB X-ray Structure Validation Summary Report ⓘ

Mar 9, 2026 – 02:55 AM UTC

PDB ID : 5HNQ / pdb_00005hnq
Title : Base Pairing and Structure Insights into the 5-Formylcytosine in RNA Duplex
Authors : Luo, Z.; Sheng, J.
Deposited on : 2016-01-18
Resolution : 2.40 Å(reported)

This is a wwPDB X-ray Structure Validation Summary 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

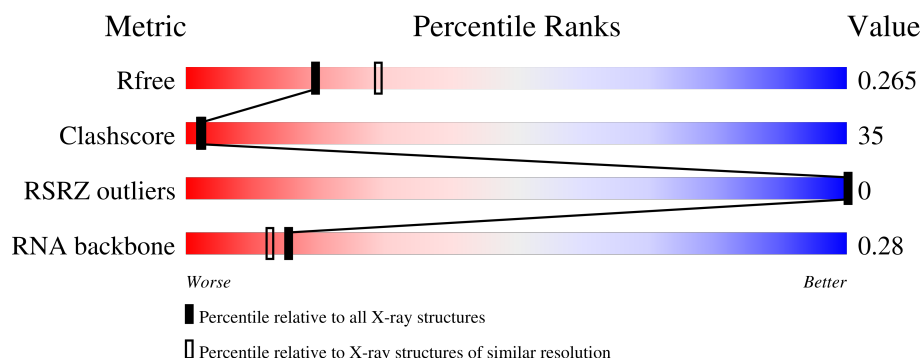
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.40 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.



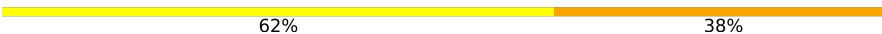
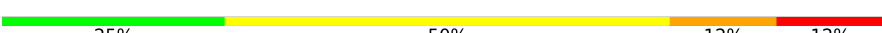
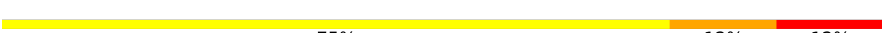
Metric	Whole archive (#Entries)	Similar resolution (#Entries, resolution range(Å))
R_{free}	180053	4912 (2.40-2.40)
Clashscore	190562	5391 (2.40-2.40)
RSRZ outliers	180081	4916 (2.40-2.40)
RNA backbone	3983	1155 (2.70-2.10)

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	8	
1	B	8	
1	C	8	
1	D	8	
1	E	8	
1	F	8	

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Mol	Chain	Length	Quality of chain
1	G	8	
1	H	8	
1	I	8	
1	J	8	
1	K	8	
1	L	8	
1	M	8	

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
1	RSQ	L	4	-	-	X	-

2 Entry composition

There are 2 unique types of molecules in this entry. The entry contains 2203 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 RNA chain called 5fC modified RNA.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	8	Total	C	N	O	P	0	0	0
			169	77	30	55	7			
1	B	8	Total	C	N	O	P	0	0	0
			169	77	30	55	7			
1	C	8	Total	C	N	O	P	0	0	0
			169	77	30	55	7			
1	D	8	Total	C	N	O	P	0	0	0
			169	77	30	55	7			
1	E	8	Total	C	N	O	P	0	0	0
			169	77	30	55	7			
1	F	8	Total	C	N	O	P	0	0	0
			169	77	30	55	7			
1	G	8	Total	C	N	O	P	0	0	0
			169	77	30	55	7			
1	H	8	Total	C	N	O	P	0	0	0
			169	77	30	55	7			
1	I	8	Total	C	N	O	P	0	0	0
			169	77	30	55	7			
1	J	8	Total	C	N	O	P	0	0	0
			169	77	30	55	7			
1	K	8	Total	C	N	O	P	0	0	0
			169	77	30	55	7			
1	L	8	Total	C	N	O	P	0	0	0
			169	77	30	55	7			
1	M	8	Total	C	N	O	P	0	0	0
			169	77	30	55	7			

- Molecule 2 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	D	1	Total	O	0	0
			1	1		

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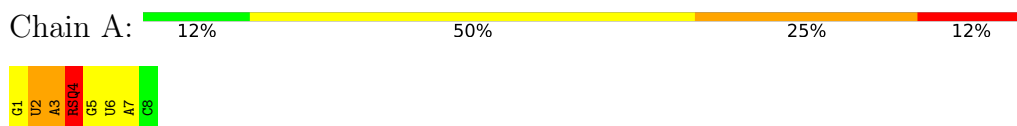
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Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	K	2	Total	O	0	0
			2	2		
2	L	3	Total	O	0	0
			3	3		

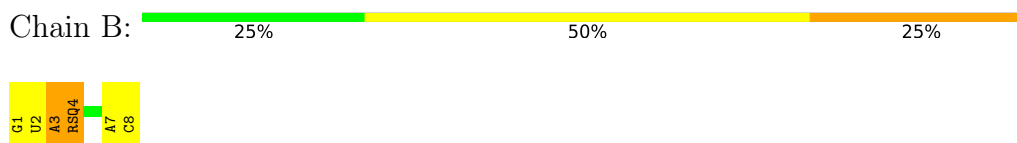
3 Residue-property plots [i](#)

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: 5fC modified RNA



- Molecule 1: 5fC modified RNA



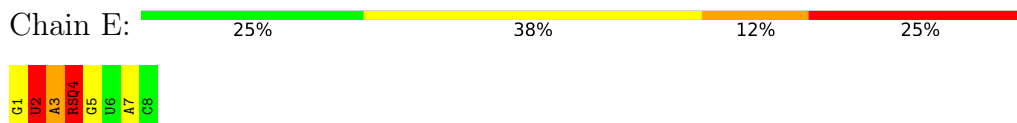
- Molecule 1: 5fC modified RNA



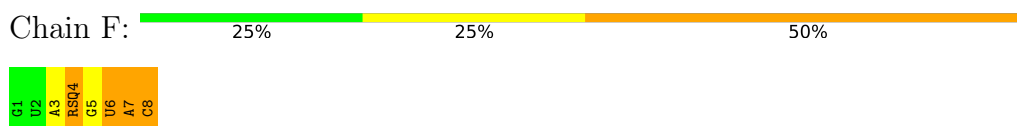
- Molecule 1: 5fC modified RNA



- Molecule 1: 5fC modified RNA



- Molecule 1: 5fC modified RNA



• Molecule 1: 5fC modified RNA

Chain G:  12% 25% 62%

• Molecule 1: 5fC modified RNA

Chain H:  62% 38%

• Molecule 1: 5fC modified RNA

Chain I:  38% 62%

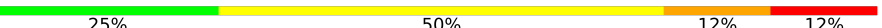
• Molecule 1: 5fC modified RNA

Chain J:  38% 62%

• Molecule 1: 5fC modified RNA

Chain K:  88% 12%

• Molecule 1: 5fC modified RNA

Chain L:  25% 50% 12% 12%

• Molecule 1: 5fC modified RNA

Chain M:  75% 12% 12%

4 Data and refinement statistics

Property	Value	Source
Space group	C 1 2 1	Depositor
Cell constants a, b, c, α , β , γ	138.90Å 44.32Å 50.59Å 90.00° 102.76° 90.00°	Depositor
Resolution (Å)	28.72 – 2.40 28.72 – 2.40	Depositor EDS
% Data completeness (in resolution range)	99.7 (28.72-2.40) 99.6 (28.72-2.40)	Depositor EDS
R_{merge}	0.05	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.14 (at 2.36Å)	Xtriage
Refinement program	REFMAC 5.8.0107	Depositor
R, R_{free}	0.221 , 0.261 0.226 , 0.265	Depositor DCC
R_{free} test set	644 reflections (5.18%)	wwPDB-VP
Wilson B-factor (Å ²)	58.4	Xtriage
Anisotropy	0.773	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.31 , 78.5	EDS
L-test for twinning ²	$\langle L \rangle = 0.51$, $\langle L^2 \rangle = 0.34$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.96	EDS
Total number of atoms	2203	wwPDB-VP
Average B, all atoms (Å ²)	104.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 17.83% 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 [i](#)

5.1 Standard geometry [i](#)

Bond lengths and bond angles in the following residue types are not validated in this section: RSQ

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	0.90	0/163	1.59	6/250 (2.4%)
1	B	0.87	0/163	1.45	3/250 (1.2%)
1	C	0.79	0/163	1.37	4/250 (1.6%)
1	D	0.85	0/163	1.77	8/250 (3.2%)
1	E	0.67	1/163 (0.6%)	1.07	1/250 (0.4%)
1	F	0.55	0/163	1.08	1/250 (0.4%)
1	G	0.77	1/163 (0.6%)	1.16	2/250 (0.8%)
1	H	0.51	0/163	1.04	0/250
1	I	0.69	0/163	1.37	6/250 (2.4%)
1	J	0.52	0/163	1.10	2/250 (0.8%)
1	K	0.75	0/163	1.77	10/250 (4.0%)
1	L	0.78	0/163	1.63	5/250 (2.0%)
1	M	0.48	0/163	1.02	2/250 (0.8%)
All	All	0.72	2/2119 (0.1%)	1.37	50/3250 (1.5%)

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	G	7	A	O3'-P	-5.53	1.52	1.61
1	E	7	A	O3'-P	-5.19	1.53	1.61

The worst 5 of 50 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	L	8	C	C2'-C3'-O3'	-10.06	98.60	113.70
1	K	6	U	C3'-C2'-O2'	9.60	125.10	110.70
1	D	2	U	C1'-C2'-O2'	-9.09	94.77	108.40
1	A	1	G	C1'-C2'-O2'	-8.12	96.22	108.40
1	A	7	A	C4'-C3'-O3'	-7.69	101.46	113.00

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	169	0	88	6	0
1	B	169	0	87	6	0
1	C	169	0	87	2	0
1	D	169	0	87	6	0
1	E	169	0	88	12	0
1	F	169	0	88	11	0
1	G	169	0	88	9	0
1	H	169	0	88	16	0
1	I	169	0	88	8	0
1	J	169	0	88	18	0
1	K	169	0	88	7	0
1	L	169	0	88	10	0
1	M	169	0	88	16	1
2	D	1	0	0	0	0
2	K	2	0	0	0	0
2	L	3	0	0	0	0
All	All	2203	0	1141	117	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 35.

The worst 5 of 117 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:J:1:G:H2'	1:J:2:U:H6	1.19	1.03
1:J:1:G:H2'	1:J:2:U:C6	1.95	1.01
1:H:8:C:C6	1:J:1:G:H5'	1.97	0.98
1:K:1:G:H5''	1:K:1:G:H8	1.30	0.94
1:K:1:G:H5''	1:K:1:G:C8	2.04	0.93

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:M:1:G:N2	1:M:8:C:O2[2_658]	2.03	0.17

5.3 Torsion angles [i](#)

5.3.1 Protein backbone [i](#)

There are no protein molecules in this entry.

5.3.2 Protein sidechains [i](#)

There are no protein molecules in this entry.

5.3.3 RNA [i](#)

Mol	Chain	Analysed	Backbone Outliers	Pucker Outliers
1	A	7/8 (87%)	2 (28%)	0
1	B	7/8 (87%)	0	0
1	C	7/8 (87%)	1 (14%)	0
1	D	7/8 (87%)	2 (28%)	0
1	E	7/8 (87%)	4 (57%)	1 (14%)
1	F	7/8 (87%)	3 (42%)	0
1	G	7/8 (87%)	2 (28%)	0
1	H	7/8 (87%)	3 (42%)	0
1	I	7/8 (87%)	2 (28%)	0
1	J	7/8 (87%)	2 (28%)	0
1	K	8/8 (100%)	1 (12%)	1 (12%)
1	L	7/8 (87%)	2 (28%)	0
1	M	7/8 (87%)	1 (14%)	0
All	All	92/104 (88%)	25 (27%)	2 (2%)

5 of 25 RNA backbone outliers are listed below:

Mol	Chain	Res	Type
1	A	4	RSQ
1	A	5	G
1	C	4	RSQ
1	D	5	G
1	D	7	A

All (2) RNA pucker outliers are listed below:

Mol	Chain	Res	Type
1	E	2	U
1	K	1	G

5.4 Non-standard residues in protein, DNA, RNA chains [i](#)

13 non-standard protein/DNA/RNA residues 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
1	RSQ	H	4	1	19,23,24	1.33	2 (10%)	25,33,36	2.13	8 (32%)
1	RSQ	A	4	1	19,23,24	1.84	5 (26%)	25,33,36	2.22	12 (48%)
1	RSQ	E	4	1	19,23,24	1.50	3 (15%)	25,33,36	1.90	7 (28%)
1	RSQ	B	4	1	19,23,24	1.51	4 (21%)	25,33,36	2.29	8 (32%)
1	RSQ	K	4	1	19,23,24	1.46	5 (26%)	25,33,36	1.95	7 (28%)
1	RSQ	I	4	1	19,23,24	1.69	4 (21%)	25,33,36	1.89	5 (20%)
1	RSQ	L	4	1	19,23,24	1.50	3 (15%)	25,33,36	2.21	5 (20%)
1	RSQ	C	4	1	19,23,24	1.95	5 (26%)	25,33,36	1.73	5 (20%)
1	RSQ	G	4	1	19,23,24	1.37	4 (21%)	25,33,36	1.49	3 (12%)
1	RSQ	D	4	1	19,23,24	1.92	6 (31%)	25,33,36	2.47	8 (32%)
1	RSQ	J	4	1	19,23,24	1.52	4 (21%)	25,33,36	1.36	4 (16%)
1	RSQ	M	4	1	19,23,24	1.63	4 (21%)	25,33,36	1.23	3 (12%)
1	RSQ	F	4	1	19,23,24	1.83	6 (31%)	25,33,36	1.20	2 (8%)

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
1	RSQ	H	4	1	-	2/9/27/28	0/2/2/2
1	RSQ	A	4	1	-	2/9/27/28	0/2/2/2
1	RSQ	E	4	1	-	4/9/27/28	0/2/2/2

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Mol	Type	Chain	Res	Link	Chirals	Torsions	Rings
1	RSQ	B	4	1	-	0/9/27/28	0/2/2/2
1	RSQ	K	4	1	-	1/9/27/28	0/2/2/2
1	RSQ	I	4	1	-	1/9/27/28	0/2/2/2
1	RSQ	L	4	1	-	2/9/27/28	0/2/2/2
1	RSQ	C	4	1	-	1/9/27/28	0/2/2/2
1	RSQ	G	4	1	-	2/9/27/28	0/2/2/2
1	RSQ	D	4	1	-	0/9/27/28	0/2/2/2
1	RSQ	J	4	1	-	0/9/27/28	0/2/2/2
1	RSQ	M	4	1	-	0/9/27/28	0/2/2/2
1	RSQ	F	4	1	-	0/9/27/28	0/2/2/2

The worst 5 of 55 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	C	4	RSQ	O4'-C1'	4.59	1.52	1.42
1	A	4	RSQ	O3'-C3'	-4.56	1.31	1.43
1	M	4	RSQ	C4-N3	4.33	1.41	1.34
1	C	4	RSQ	O2'-C2'	-3.92	1.33	1.43
1	J	4	RSQ	C4-N3	3.89	1.40	1.34

The worst 5 of 77 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	K	4	RSQ	O2-C2-N3	-6.63	111.88	122.33
1	D	4	RSQ	C5-C4-N4	-5.95	114.65	121.90
1	D	4	RSQ	O2-C2-N3	-5.78	113.22	122.33
1	L	4	RSQ	O2-C2-N3	-5.52	113.63	122.33
1	B	4	RSQ	O2-C2-N3	-5.43	113.78	122.33

There are no chirality outliers.

5 of 15 torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
1	G	4	RSQ	O30-C10-C5-C4
1	G	4	RSQ	O30-C10-C5-C6
1	H	4	RSQ	O30-C10-C5-C4
1	H	4	RSQ	O30-C10-C5-C6
1	A	4	RSQ	C3'-C4'-C5'-O5'

There are no ring outliers.

10 monomers are involved in 36 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
1	H	4	RSQ	3	0
1	A	4	RSQ	4	0
1	E	4	RSQ	3	0
1	B	4	RSQ	2	0
1	K	4	RSQ	1	0
1	I	4	RSQ	3	0
1	L	4	RSQ	10	0
1	G	4	RSQ	3	0
1	J	4	RSQ	6	0
1	F	4	RSQ	1	0

5.5 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

5.6 Ligand geometry [i](#)

There are no ligands in this entry.

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, 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	7/8 (87%)	-0.68	0 100 100	63, 66, 70, 72	0
1	B	7/8 (87%)	-0.38	0 100 100	62, 65, 72, 76	0
1	C	7/8 (87%)	-0.51	0 100 100	64, 66, 82, 85	0
1	D	7/8 (87%)	-0.35	0 100 100	62, 66, 74, 80	0
1	E	7/8 (87%)	-0.00	0 100 100	98, 118, 121, 128	0
1	F	7/8 (87%)	0.19	0 100 100	84, 95, 122, 131	0
1	G	7/8 (87%)	0.63	0 100 100	131, 152, 162, 162	0
1	H	7/8 (87%)	0.70	0 100 100	120, 137, 157, 159	0
1	I	7/8 (87%)	0.32	0 100 100	70, 87, 154, 157	0
1	J	7/8 (87%)	0.68	0 100 100	96, 130, 161, 166	0
1	K	7/8 (87%)	0.45	0 100 100	63, 72, 80, 82	0
1	L	7/8 (87%)	-0.06	0 100 100	64, 72, 86, 87	0
1	M	7/8 (87%)	0.47	0 100 100	130, 142, 174, 176	0
All	All	91/104 (87%)	0.11	0 100 100	62, 86, 162, 176	0

There are no RSRZ outliers to report.

6.2 Non-standard residues in protein, DNA, RNA chains [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(Å ²)	Q<0.9
1	RSQ	M	4	22/23	0.71	0.12	119,158,172,194	0

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Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors($\text{\AA}^2$)	Q<0.9
1	RSQ	G	4	22/23	0.84	0.09	125,150,163,177	0
1	RSQ	J	4	22/23	0.85	0.11	126,165,179,207	0
1	RSQ	I	4	22/23	0.88	0.09	80,97,121,129	0
1	RSQ	E	4	22/23	0.89	0.10	89,111,130,145	0
1	RSQ	H	4	22/23	0.90	0.09	108,129,141,176	0
1	RSQ	L	4	22/23	0.91	0.12	68,88,105,106	0
1	RSQ	A	4	22/23	0.94	0.08	61,70,82,98	0
1	RSQ	F	4	22/23	0.94	0.09	86,97,104,110	0
1	RSQ	C	4	22/23	0.96	0.09	57,65,81,84	0
1	RSQ	D	4	22/23	0.96	0.07	51,59,71,73	0
1	RSQ	B	4	22/23	0.97	0.08	54,64,73,74	0
1	RSQ	K	4	22/23	0.97	0.07	49,61,66,86	0

6.3 Carbohydrates [i](#)

There are no oligosaccharides in this entry.

6.4 Ligands [i](#)

There are no ligands in this entry.

6.5 Other polymers [i](#)

There are no such residues in this entry.