



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 8, 2026 – 04:39 PM UTC

PDB ID : 4XXW / pdb_00004xxw
Title : Crystal structure of mouse Cadherin-23 EC1-2 and Protocadherin-15 EC1-2 splice variant
Authors : Narui, Y.; Sotomayor, M.
Deposited on : 2015-01-31
Resolution : 2.26 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
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

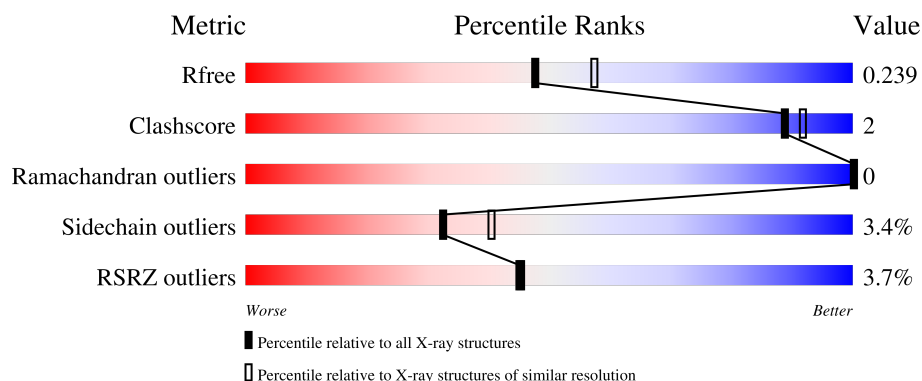
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

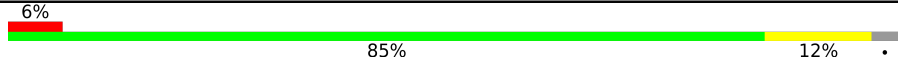
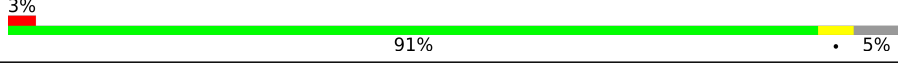
The reported resolution of this entry is 2.26 Å.

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	1898 (2.26-2.26)
Clashscore	190562	2005 (2.26-2.26)
Ramachandran outliers	187476	1965 (2.26-2.26)
Sidechain outliers	187428	1966 (2.26-2.26)
RSRZ outliers	180081	1898 (2.26-2.26)

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	237	
1	B	237	
2	C	214	
2	D	214	

2 Entry composition

There are 5 unique types of molecules in this entry. The entry contains 7306 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 Protocadherin-15.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	B	229	Total	C	N	O	S	0	0	0
			1802	1123	311	362	6			
1	A	229	Total	C	N	O	S	0	0	0
			1802	1123	311	362	6			

There are 18 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
B	5	MET	-	initiating methionine	UNP Q99PJ1
B	234	LEU	-	expression tag	UNP Q99PJ1
B	235	GLU	-	expression tag	UNP Q99PJ1
B	236	HIS	-	expression tag	UNP Q99PJ1
B	237	HIS	-	expression tag	UNP Q99PJ1
B	238	HIS	-	expression tag	UNP Q99PJ1
B	239	HIS	-	expression tag	UNP Q99PJ1
B	240	HIS	-	expression tag	UNP Q99PJ1
B	241	HIS	-	expression tag	UNP Q99PJ1
A	5	MET	-	initiating methionine	UNP Q99PJ1
A	234	LEU	-	expression tag	UNP Q99PJ1
A	235	GLU	-	expression tag	UNP Q99PJ1
A	236	HIS	-	expression tag	UNP Q99PJ1
A	237	HIS	-	expression tag	UNP Q99PJ1
A	238	HIS	-	expression tag	UNP Q99PJ1
A	239	HIS	-	expression tag	UNP Q99PJ1
A	240	HIS	-	expression tag	UNP Q99PJ1
A	241	HIS	-	expression tag	UNP Q99PJ1

- Molecule 2 is a protein called Cadherin-23.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	C	204	Total	C	N	O	S	0	3	0
			1617	1032	266	318	1			

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Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	D	204	Total	C	N	O	S	0	2	0
			1606	1022	265	318	1			

There are 18 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
C	0	MET	-	initiating methionine	UNP Q99PF4
C	206	LEU	-	expression tag	UNP Q99PF4
C	207	GLU	-	expression tag	UNP Q99PF4
C	208	HIS	-	expression tag	UNP Q99PF4
C	209	HIS	-	expression tag	UNP Q99PF4
C	210	HIS	-	expression tag	UNP Q99PF4
C	211	HIS	-	expression tag	UNP Q99PF4
C	212	HIS	-	expression tag	UNP Q99PF4
C	213	HIS	-	expression tag	UNP Q99PF4
D	0	MET	-	initiating methionine	UNP Q99PF4
D	206	LEU	-	expression tag	UNP Q99PF4
D	207	GLU	-	expression tag	UNP Q99PF4
D	208	HIS	-	expression tag	UNP Q99PF4
D	209	HIS	-	expression tag	UNP Q99PF4
D	210	HIS	-	expression tag	UNP Q99PF4
D	211	HIS	-	expression tag	UNP Q99PF4
D	212	HIS	-	expression tag	UNP Q99PF4
D	213	HIS	-	expression tag	UNP Q99PF4

- Molecule 3 is CALCIUM ION (CCD ID: CA) (formula: Ca).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	B	3	Total	Ca	0	0
			3	3		
3	A	3	Total	Ca	0	0
			3	3		
3	C	4	Total	Ca	0	0
			4	4		
3	D	4	Total	Ca	0	0
			4	4		

- Molecule 4 is CHLORIDE ION (CCD ID: CL) (formula: Cl).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	B	1	Total	Cl	0	0
			1	1		

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

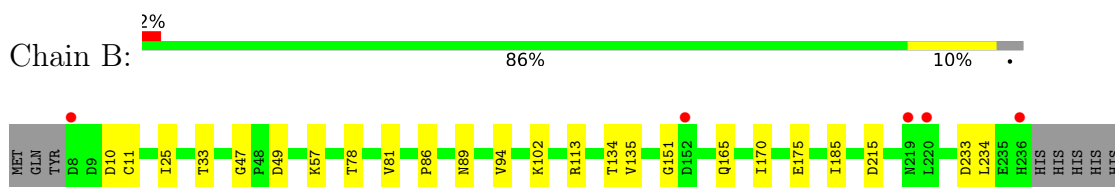
- Molecule 5 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
5	B	155	Total	O	0	0
			155	155		
5	A	83	Total	O	0	0
			83	83		
5	C	124	Total	O	0	0
			124	124		
5	D	101	Total	O	0	0
			101	101		

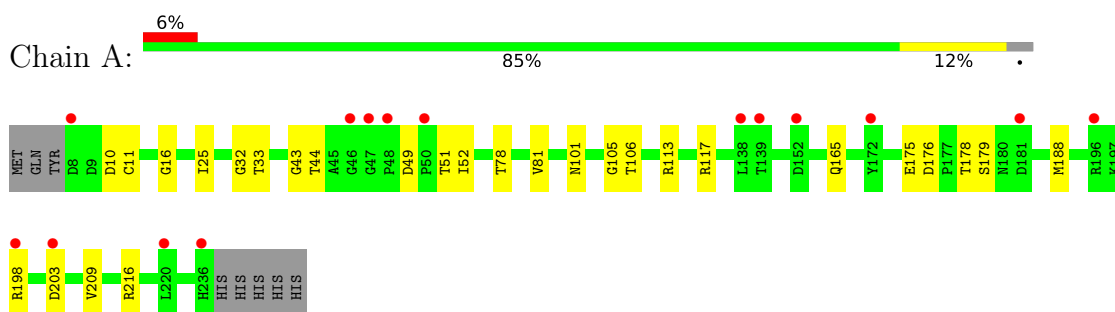
3 Residue-property plots

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.

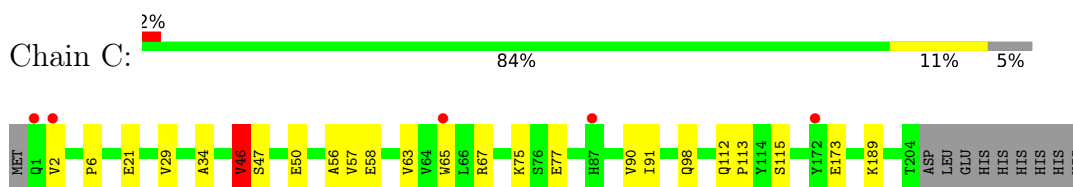
• Molecule 1: Protocadherin-15



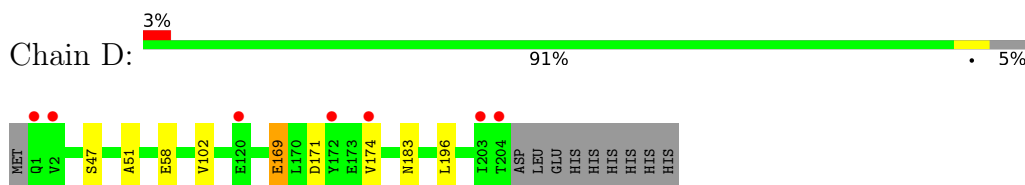
• Molecule 1: Protocadherin-15



• Molecule 2: Cadherin-23



• Molecule 2: Cadherin-23



4 Data and refinement statistics

Property	Value	Source
Space group	C 1 2 1	Depositor
Cell constants a, b, c, α , β , γ	157.75Å 57.79Å 155.26Å 90.00° 99.17° 90.00°	Depositor
Resolution (Å)	50.00 – 2.26 50.00 – 2.26	Depositor EDS
% Data completeness (in resolution range)	96.5 (50.00-2.26) 96.6 (50.00-2.26)	Depositor EDS
R_{merge}	0.08	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.36 (at 2.27Å)	Xtriage
Refinement program	REFMAC 5.8.0107	Depositor
R, R_{free}	0.187 , 0.233 (Not available) , 0.239	Depositor DCC
R_{free} test set	3126 reflections (4.80%)	wwPDB-VP
Wilson B-factor (Å ²)	38.8	Xtriage
Anisotropy	0.244	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.33 , 41.8	EDS
L-test for twinning ²	$\langle L \rangle = 0.48$, $\langle L^2 \rangle = 0.32$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.95	EDS
Total number of atoms	7306	wwPDB-VP
Average B, all atoms (Å ²)	53.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 4.40% 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: CA, CL

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	1.08	1/1834 (0.1%)	1.08	5/2502 (0.2%)
1	B	1.22	2/1834 (0.1%)	1.10	4/2502 (0.2%)
2	C	1.27	5/1667 (0.3%)	1.10	2/2285 (0.1%)
2	D	1.16	1/1651 (0.1%)	0.99	0/2262
All	All	1.18	9/6986 (0.1%)	1.07	11/9551 (0.1%)

All (9) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	B	86	PRO	CA-C	7.26	1.55	1.51
2	C	63	VAL	C-O	-6.36	1.17	1.24
2	C	34	ALA	C-O	-6.25	1.16	1.23
2	C	29	VAL	C-O	-6.12	1.18	1.24
2	C	189	LYS	C-O	-5.54	1.17	1.24
1	B	102	LYS	C-O	-5.29	1.17	1.24
1	A	203	ASP	CA-C	5.27	1.58	1.52
2	C	21	GLU	C-O	-5.20	1.17	1.24
2	D	51	ALA	CA-C	5.02	1.59	1.52

All (11) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	176	ASP	CA-C-N	9.05	131.16	119.84
1	A	176	ASP	C-N-CA	9.05	131.16	119.84
2	C	46	VAL	CB-CA-C	-8.33	97.99	110.82
2	C	2	VAL	N-CA-C	-7.90	101.28	110.21
1	A	43	GLY	N-CA-C	-6.03	104.69	111.63
1	B	89	ASN	N-CA-C	5.60	118.92	111.30
1	A	16	GLY	N-CA-C	-5.43	104.83	112.60
1	B	47	GLY	CA-C-N	5.28	124.73	119.24

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	B	47	GLY	C-N-CA	5.28	124.73	119.24
1	B	151	GLY	N-CA-C	-5.28	103.03	112.22
1	A	52	ILE	N-CA-C	5.07	117.03	108.81

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	1802	0	1766	6	0
1	B	1802	0	1766	7	0
2	C	1617	0	1566	10	0
2	D	1606	0	1556	3	0
3	A	3	0	0	0	0
3	B	3	0	0	0	0
3	C	4	0	0	0	0
3	D	4	0	0	0	0
4	A	1	0	0	0	0
4	B	1	0	0	0	0
5	A	83	0	0	1	0
5	B	155	0	0	0	0
5	C	124	0	0	0	0
5	D	101	0	0	0	0
All	All	7306	0	6654	26	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 2.

All (26) 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)
2:C:56:ALA:HB3	2:C:65[B]:TRP:CE2	2.29	0.67
2:D:171:ASP:OD2	2:D:174:VAL:HG23	1.93	0.67
1:B:94:VAL:HG22	1:B:113:ARG:HG2	1.78	0.66

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
2:C:46:VAL:HG22	2:C:57:VAL:HG23	1.79	0.65
1:B:170:ILE:HG13	1:B:185:ILE:HD12	1.91	0.53
1:A:101:ASN:O	1:A:105:GLY:N	2.38	0.53
1:B:10:ASP:O	1:B:11:CYS:HB2	2.09	0.52
2:C:50:GLU:OE2	2:C:75:LYS:HE2	2.09	0.51
1:A:179:SER:HB2	1:A:209:VAL:HG22	1.96	0.47
1:A:10:ASP:O	1:A:11:CYS:HB2	2.15	0.46
1:B:165:GLN:O	1:B:215:ASP:HA	2.16	0.46
2:D:183:ASN:HD22	2:D:196:LEU:HD21	1.80	0.46
1:A:113:ARG:NH2	5:A:1101:HOH:O	2.33	0.45
2:C:46:VAL:CG2	2:C:57:VAL:HG23	2.45	0.44
2:C:58:GLU:HB2	2:C:65[A]:TRP:CZ3	2.53	0.43
2:C:77[B]:GLU:HG2	2:C:98:GLN:NE2	2.34	0.43
2:D:169:GLU:H	2:D:169:GLU:CD	2.28	0.42
1:B:25:ILE:HD11	1:B:33:THR:HG21	2.02	0.42
1:B:134:THR:HA	1:B:233:ASP:O	2.20	0.41
2:C:56:ALA:HB2	2:C:67:ARG:HD2	2.02	0.41
2:C:77[B]:GLU:HG2	2:C:98:GLN:HE22	1.85	0.41
1:A:165:GLN:O	1:A:216:ARG:HG3	2.20	0.41
2:C:6:PRO:O	2:C:91:ILE:HG13	2.20	0.41
2:C:112:GLN:HB3	2:C:113:PRO:HA	2.03	0.41
1:B:135:VAL:O	1:B:234:LEU:HA	2.21	0.40
1:A:32:GLY:O	1:A:33:THR:C	2.64	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	227/237 (96%)	220 (97%)	7 (3%)	0	100	100
1	B	227/237 (96%)	220 (97%)	7 (3%)	0	100	100

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Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles	
2	C	205/214 (96%)	201 (98%)	4 (2%)	0	100	100
2	D	204/214 (95%)	202 (99%)	2 (1%)	0	100	100
All	All	863/902 (96%)	843 (98%)	20 (2%)	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	206/214 (96%)	194 (94%)	12 (6%)	18	19
1	B	206/214 (96%)	201 (98%)	5 (2%)	43	54
2	C	184/191 (96%)	179 (97%)	5 (3%)	39	49
2	D	183/191 (96%)	179 (98%)	4 (2%)	45	56
All	All	779/810 (96%)	753 (97%)	26 (3%)	32	42

All (26) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	B	49	ASP
1	B	57	LYS
1	B	78	THR
1	B	81	VAL
1	B	175	GLU
1	A	25	ILE
1	A	44	THR
1	A	49	ASP
1	A	51	THR
1	A	78	THR
1	A	81	VAL
1	A	106	THR
1	A	117	ARG
1	A	175	GLU

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Mol	Chain	Res	Type
1	A	178	THR
1	A	188	MET
1	A	198	ARG
2	C	46	VAL
2	C	47	SER
2	C	90	VAL
2	C	115	SER
2	C	173	GLU
2	D	47	SER
2	D	58	GLU
2	D	102	VAL
2	D	169	GLU

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (11) such sidechains are listed below:

Mol	Chain	Res	Type
1	B	98	GLN
1	B	219	ASN
1	A	128	HIS
1	A	153	ASN
1	A	163	ASN
1	A	165	GLN
2	C	88	GLN
2	C	105	ASN
2	C	168	GLN
2	D	168	GLN
2	D	183	ASN

5.3.3 RNA ⓘ

There are no RNA molecules in this entry.

5.4 Non-standard residues in protein, DNA, RNA chains ⓘ

There are no non-standard protein/DNA/RNA residues in this entry.

5.5 Carbohydrates ⓘ

There are no oligosaccharides in this entry.

5.6 Ligand geometry

Of 16 ligands modelled in this entry, 16 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	229/237 (96%)	0.66	15 (6%) 24 23	42, 66, 105, 142	0
1	B	229/237 (96%)	-0.14	5 (2%) 62 63	28, 43, 70, 100	0
2	C	204/214 (95%)	-0.22	5 (2%) 58 59	23, 41, 71, 89	3 (1%)
2	D	204/214 (95%)	-0.03	7 (3%) 48 48	25, 46, 91, 129	2 (0%)
All	All	866/902 (96%)	0.08	32 (3%) 45 45	23, 49, 92, 142	5 (0%)

All (32) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
2	D	204	THR	4.8
1	A	236	HIS	4.4
1	B	220	LEU	3.9
2	C	1	GLN	3.9
1	A	47	GLY	3.8
1	A	138	LEU	3.7
2	D	1	GLN	3.5
1	A	203	ASP	3.2
1	A	46	GLY	3.1
2	D	203	ILE	3.0
1	B	236	HIS	3.0
1	A	139	THR	3.0
1	A	48	PRO	2.9
2	C	65[A]	TRP	2.8
1	A	172	TYR	2.7
1	A	196	ARG	2.6
1	A	50	PRO	2.5
1	A	198	ARG	2.5
1	A	8	ASP	2.5
1	B	8	ASP	2.5
2	D	2	VAL	2.4

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Mol	Chain	Res	Type	RSRZ
2	D	174	VAL	2.4
1	A	181	ASP	2.3
1	A	152	ASP	2.3
2	C	2	VAL	2.3
2	C	172	TYR	2.2
1	B	152	ASP	2.2
2	D	172	TYR	2.2
1	B	219	ASN	2.2
2	D	120	GLU	2.1
2	C	87	HIS	2.0
1	A	220	LEU	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
4	CL	A	1004	1/1	0.98	0.08	45,45,45,45	0
3	CA	A	1002	1/1	0.99	0.04	56,56,56,56	0
3	CA	C	1002	1/1	0.99	0.04	38,38,38,38	0
3	CA	D	1001	1/1	0.99	0.03	46,46,46,46	0
3	CA	D	1002	1/1	0.99	0.03	37,37,37,37	0
4	CL	B	1004	1/1	0.99	0.05	34,34,34,34	0
3	CA	B	1001	1/1	0.99	0.03	40,40,40,40	0
3	CA	B	1003	1/1	1.00	0.01	30,30,30,30	0
3	CA	C	1003	1/1	1.00	0.02	32,32,32,32	0
3	CA	C	1004	1/1	1.00	0.03	25,25,25,25	0
3	CA	A	1001	1/1	1.00	0.02	54,54,54,54	0
3	CA	B	1002	1/1	1.00	0.01	34,34,34,34	0

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Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors($\text{\AA}^2$)	Q<0.9
3	CA	D	1003	1/1	1.00	0.02	31,31,31,31	0
3	CA	D	1004	1/1	1.00	0.01	33,33,33,33	0
3	CA	A	1003	1/1	1.00	0.02	50,50,50,50	0
3	CA	C	1001	1/1	1.00	0.02	33,33,33,33	0

6.5 Other polymers [i](#)

There are no such residues in this entry.