



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 5, 2026 – 08:10 AM UTC

PDB ID : 2GAJ / pdb_00002gaj
Title : Structure of Full Length Topoisomerase I from *Thermotoga maritima* in monoclinic crystal form
Authors : Hansen, G.
Deposited on : 2006-03-09
Resolution : 1.95 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

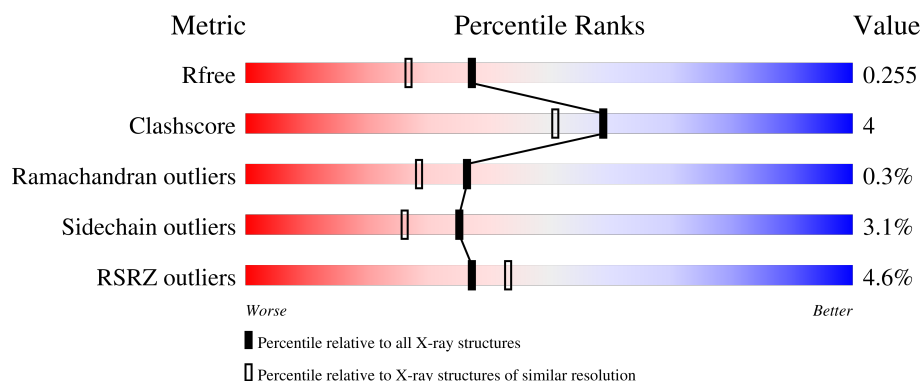
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 1.95 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	3494 (1.96-1.96)
Clashscore	190562	3612 (1.96-1.96)
Ramachandran outliers	187476	3587 (1.96-1.96)
Sidechain outliers	187428	3587 (1.96-1.96)
RSRZ outliers	180081	3495 (1.96-1.96)

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	633	4% 82% 9% 8%
1	B	633	5% 80% 11% 8%

2 Entry composition

There are 2 unique types of molecules in this entry. The entry contains 10305 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 DNA topoisomerase I.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	581	Total	C	N	O	S	0	0	0
			4714	3017	799	881	17			
1	B	581	Total	C	N	O	S	0	0	0
			4714	3017	799	881	17			

There are 4 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	1	MET	-	initiating methionine	UNP P46799
B	1	MET	-	initiating methionine	UNP P46799
A	2	ALA	-	cloning artifact	UNP P46799
B	2	ALA	-	cloning artifact	UNP P46799

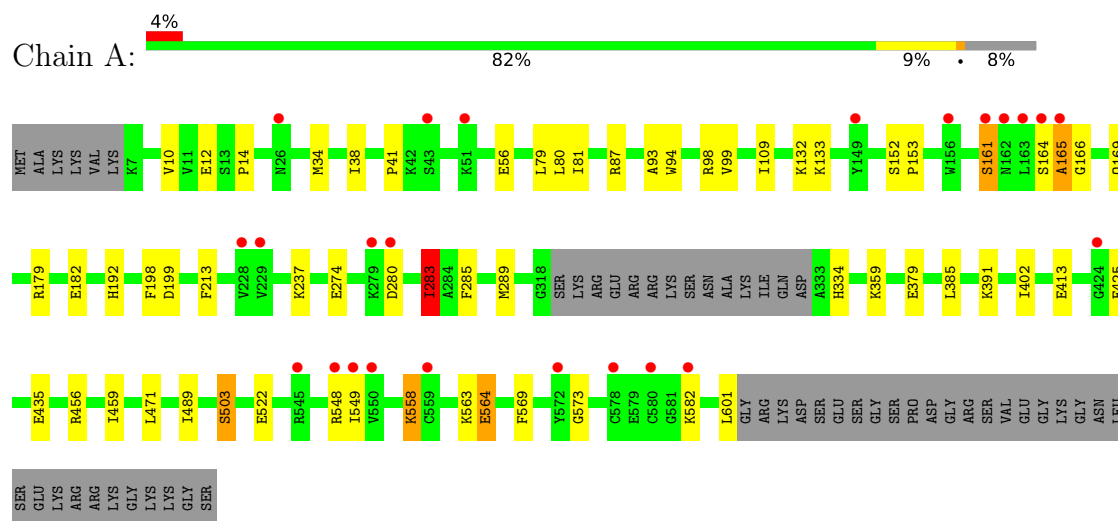
- Molecule 2 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	A	427	Total	O	0	0
			427	427		
2	B	450	Total	O	0	0
			450	450		

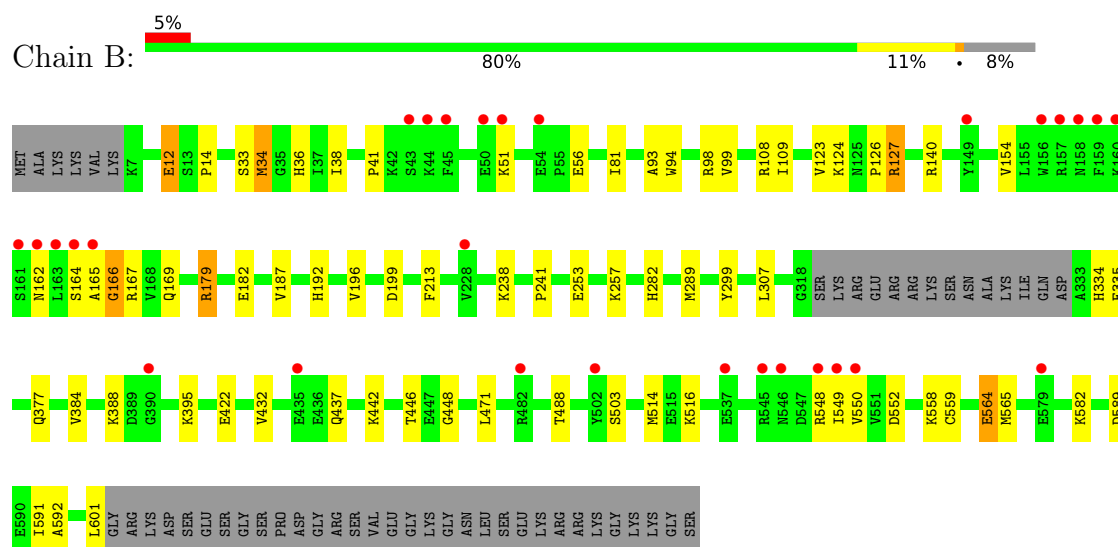
3 Residue-property plots [i](#)

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: DNA topoisomerase I



• Molecule 1: DNA topoisomerase I



4 Data and refinement statistics

Property	Value	Source
Space group	P 1 21 1	Depositor
Cell constants a, b, c, α , β , γ	45.05Å 142.71Å 127.64Å 90.00° 90.84° 90.00°	Depositor
Resolution (Å)	15.00 – 1.95 15.00 – 1.95	Depositor EDS
% Data completeness (in resolution range)	99.6 (15.00-1.95) 99.6 (15.00-1.95)	Depositor EDS
R_{merge}	0.12	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.10 (at 1.95Å)	Xtriage
Refinement program	REFMAC 5.2.0005	Depositor
R, R_{free}	0.195 , 0.246 0.204 , 0.255	Depositor DCC
R_{free} test set	5837 reflections (5.00%)	wwPDB-VP
Wilson B-factor (Å ²)	20.5	Xtriage
Anisotropy	0.062	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.38 , 40.3	EDS
L-test for twinning ²	$\langle L \rangle = 0.47$, $\langle L^2 \rangle = 0.30$	Xtriage
Estimated twinning fraction	0.000 for h,-k,-l	Xtriage
F_o, F_c correlation	0.94	EDS
Total number of atoms	10305	wwPDB-VP
Average B, all atoms (Å ²)	11.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The analyses of the Patterson function reveals a significant off-origin peak that is 45.74 % of the origin peak, indicating pseudo-translational symmetry. The chance of finding a peak of this or larger height randomly in a structure without pseudo-translational symmetry is equal to 1.2655e-04. The detected translational NCS is most likely also responsible for the elevated intensity ratio.*

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

5.1 Standard geometry

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	0.79	0/4799	1.21	8/6441 (0.1%)
1	B	0.80	0/4799	1.24	12/6441 (0.2%)
All	All	0.79	0/9598	1.22	20/12882 (0.2%)

There are no bond length outliers.

All (20) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	B	179	ARG	NE-CZ-NH2	-13.12	107.40	119.20
1	A	283	ILE	N-CA-C	8.30	120.43	108.48
1	B	179	ARG	NE-CZ-NH1	8.14	129.64	121.50
1	B	179	ARG	CG-CD-NE	-7.82	94.79	112.00
1	B	179	ARG	CD-NE-CZ	7.43	134.80	124.40
1	B	12	GLU	CB-CG-CD	7.30	125.00	112.60
1	A	199	ASP	N-CA-C	7.21	121.35	111.54
1	B	241	PRO	CA-C-N	7.07	127.06	119.78
1	B	241	PRO	C-N-CA	7.07	127.06	119.78
1	A	280	ASP	N-CA-C	-7.06	102.94	112.26
1	B	448	GLY	N-CA-C	6.05	119.99	112.73
1	B	166	GLY	N-CA-C	6.05	122.19	111.73
1	B	199	ASP	N-CA-C	5.97	119.66	111.54
1	B	12	GLU	CA-CB-CG	5.83	125.76	114.10
1	A	274	GLU	N-CA-C	5.51	118.22	111.82
1	A	12	GLU	CB-CG-CD	5.16	121.37	112.60
1	B	446	THR	N-CA-C	-5.15	102.53	109.95
1	A	161	SER	N-CA-C	5.13	114.92	108.45
1	A	359	LYS	N-CA-C	5.12	117.26	111.11
1	A	456	ARG	NE-CZ-NH2	-5.12	114.59	119.20

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	4714	0	4821	35	0
1	B	4714	0	4821	48	0
2	A	427	0	0	7	0
2	B	450	0	0	14	0
All	All	10305	0	9642	83	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 4.

All (83) 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:B:14:PRO:HG3	1:B:34:MET:HE1	1.50	0.92
1:A:489:ILE:HD11	1:A:601:LEU:HD21	1.56	0.86
1:A:80:LEU:HD13	1:A:109:ILE:HD11	1.58	0.84
1:A:413:GLU:O	2:A:892:HOH:O	1.96	0.82
1:A:334:HIS:HD2	2:A:729:HOH:O	1.65	0.80
1:B:192:HIS:HD2	1:B:213:PHE:H	1.31	0.77
1:A:334:HIS:CD2	2:A:729:HOH:O	2.37	0.77
1:B:253:GLU:OE1	1:B:257:LYS:HE2	1.88	0.73
1:B:94:TRP:CE2	1:B:98:ARG:HD2	2.25	0.71
1:A:80:LEU:HB3	1:A:109:ILE:HD12	1.73	0.70
1:B:187:VAL:O	2:B:1009:HOH:O	2.10	0.69
1:B:282:HIS:HE1	2:B:802:HOH:O	1.78	0.66
1:A:41:PRO:HD3	1:A:56:GLU:O	1.98	0.62
1:A:169:GLN:NE2	1:A:471:LEU:HD21	2.14	0.62
1:B:94:TRP:CZ2	1:B:98:ARG:HD2	2.37	0.60
1:B:592:ALA:HB2	1:B:601:LEU:HD23	1.84	0.60
1:A:379:GLU:HG3	1:A:402:ILE:HD11	1.84	0.59
1:A:10:VAL:CG2	1:A:79:LEU:HD11	2.32	0.59
1:A:192:HIS:HD2	1:A:213:PHE:H	1.50	0.58
1:A:334:HIS:CD2	2:A:1024:HOH:O	2.57	0.55
1:B:41:PRO:HD3	1:B:56:GLU:O	2.07	0.55
1:B:14:PRO:CG	1:B:34:MET:HE1	2.28	0.55
1:B:38:ILE:HD11	1:B:99:VAL:HG11	1.89	0.55

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:140:ARG:HD2	2:B:761:HOH:O	2.06	0.54
1:B:167:ARG:HD3	2:B:635:HOH:O	2.08	0.54
1:A:165:ALA:HB2	1:A:471:LEU:HD13	1.90	0.54
1:B:127:ARG:HH11	1:B:127:ARG:HG3	1.73	0.53
1:A:425:GLU:OE2	2:A:847:HOH:O	2.19	0.51
1:B:81:ILE:HG21	1:B:93:ALA:HA	1.92	0.50
1:B:516:LYS:HG2	2:B:907:HOH:O	2.11	0.50
1:B:552:ASP:OD2	2:B:945:HOH:O	2.19	0.50
1:B:182:GLU:OE2	1:B:442:LYS:NZ	2.40	0.50
1:B:282:HIS:CE1	2:B:802:HOH:O	2.59	0.49
1:A:94:TRP:CE2	1:A:98:ARG:HD2	2.49	0.48
1:B:33:SER:C	1:B:34:MET:HG2	2.39	0.48
1:B:169:GLN:NE2	1:B:471:LEU:CD2	2.77	0.48
1:B:334:HIS:HD2	2:B:661:HOH:O	1.97	0.47
1:B:14:PRO:HD3	1:B:34:MET:CE	2.44	0.47
1:B:388:LYS:NZ	2:B:972:HOH:O	2.25	0.47
1:A:14:PRO:HG3	1:A:34:MET:SD	2.55	0.47
1:A:80:LEU:HD13	1:A:109:ILE:CD1	2.38	0.47
1:A:94:TRP:CZ2	1:A:98:ARG:HD2	2.50	0.47
1:B:238:LYS:HG2	1:B:377:GLN:HG2	1.96	0.47
1:A:165:ALA:CB	1:A:471:LEU:HD13	2.43	0.47
1:A:198:PHE:CZ	1:A:385:LEU:HD11	2.49	0.47
1:A:38:ILE:HD11	1:A:99:VAL:CG1	2.46	0.46
1:A:164:SER:C	1:A:166:GLY:H	2.22	0.46
1:A:152:SER:N	1:A:153:PRO:CD	2.80	0.45
1:B:488:THR:HB	1:B:589:ASP:HA	1.98	0.45
1:B:34:MET:CE	1:B:34:MET:HA	2.47	0.45
1:B:514:MET:HE2	2:B:939:HOH:O	2.16	0.45
1:B:384:VAL:HG22	1:B:395:LYS:HG2	1.97	0.45
1:A:237:LYS:NZ	2:A:943:HOH:O	2.49	0.44
1:B:165:ALA:HB3	1:B:471:LEU:HD13	1.99	0.44
1:A:179:ARG:NH1	1:A:182:GLU:OE1	2.51	0.43
1:B:558:LYS:HE3	1:B:564:GLU:HB3	2.01	0.43
1:A:132:LYS:HE2	2:A:866:HOH:O	2.18	0.43
1:A:569:PHE:CE1	1:A:573:GLY:HA2	2.53	0.43
1:B:471:LEU:C	1:B:471:LEU:HD23	2.43	0.43
1:A:38:ILE:HD11	1:A:99:VAL:HG11	2.01	0.43
1:A:558:LYS:NZ	1:A:564:GLU:HB2	2.33	0.43
1:B:307:LEU:C	1:B:307:LEU:HD23	2.44	0.42
1:B:559:CYS:SG	1:B:565:MET:HE3	2.59	0.42
1:B:34:MET:HA	1:B:34:MET:HE2	2.00	0.42

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:108:ARG:HD2	1:B:127:ARG:NH1	2.35	0.42
1:B:109:ILE:CD1	1:B:126:PRO:HB3	2.50	0.42
1:B:196:VAL:HG12	1:B:432:VAL:HG22	2.00	0.42
1:B:282:HIS:HD2	2:B:678:HOH:O	2.03	0.42
1:B:38:ILE:HD11	1:B:99:VAL:CG1	2.48	0.42
1:B:282:HIS:CD2	2:B:678:HOH:O	2.73	0.42
1:B:34:MET:CE	1:B:34:MET:CA	2.98	0.41
1:A:81:ILE:HG21	1:A:93:ALA:HA	2.02	0.41
1:B:169:GLN:NE2	1:B:471:LEU:HD21	2.35	0.41
1:A:283:ILE:HD11	1:A:285:PHE:CZ	2.54	0.41
1:A:80:LEU:HB3	1:A:109:ILE:CD1	2.47	0.41
1:B:36:HIS:CD2	2:B:942:HOH:O	2.74	0.41
1:B:14:PRO:HG3	1:B:34:MET:CE	2.35	0.41
1:A:459:ILE:HD13	1:A:459:ILE:HA	1.78	0.41
1:B:299:TYR:CD2	1:B:299:TYR:C	2.99	0.40
1:B:516:LYS:HG3	2:B:932:HOH:O	2.21	0.40
1:A:10:VAL:HG22	1:A:79:LEU:HD11	2.04	0.40
1:A:87:ARG:NE	1:A:522:GLU:OE1	2.45	0.40
1:B:164:SER:C	1:B:166:GLY:H	2.30	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	577/633 (91%)	561 (97%)	14 (2%)	2 (0%)	36	28
1	B	577/633 (91%)	562 (97%)	14 (2%)	1 (0%)	43	36
All	All	1154/1266 (91%)	1123 (97%)	28 (2%)	3 (0%)	36	28

All (3) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	B	550	VAL
1	A	503	SER
1	A	165	ALA

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	519/562 (92%)	506 (98%)	13 (2%)	42	34
1	B	519/562 (92%)	500 (96%)	19 (4%)	30	20
All	All	1038/1124 (92%)	1006 (97%)	32 (3%)	35	26

All (32) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	133	LYS
1	A	161	SER
1	A	283	ILE
1	A	289	MET
1	A	391	LYS
1	A	435	GLU
1	A	503	SER
1	A	548	ARG
1	A	549	ILE
1	A	558	LYS
1	A	563	LYS
1	A	564	GLU
1	A	582	LYS
1	B	12	GLU
1	B	34	MET
1	B	51	LYS
1	B	123	VAL
1	B	124	LYS
1	B	127	ARG
1	B	154	VAL
1	B	162	ASN

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Mol	Chain	Res	Type
1	B	179	ARG
1	B	289	MET
1	B	335	GLU
1	B	422	GLU
1	B	437	GLN
1	B	503	SER
1	B	548	ARG
1	B	549	ILE
1	B	564	GLU
1	B	582	LYS
1	B	591	ILE

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (17) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	26	ASN
1	A	125	ASN
1	A	158	ASN
1	A	192	HIS
1	A	222	GLN
1	A	334	HIS
1	A	372	GLN
1	A	377	GLN
1	A	557	GLN
1	B	26	ASN
1	B	158	ASN
1	B	169	GLN
1	B	192	HIS
1	B	270	GLN
1	B	282	HIS
1	B	523	GLN
1	B	557	GLN

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 [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

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	581/633 (91%)	0.10	24 (4%)	41 48	2, 10, 24, 34	0
1	B	581/633 (91%)	0.21	29 (4%)	34 40	2, 9, 24, 36	0
All	All	1162/1266 (91%)	0.16	53 (4%)	37 43	2, 9, 24, 36	0

All (53) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	165	ALA	6.0
1	A	165	ALA	5.8
1	B	549	ILE	5.7
1	B	163	LEU	5.1
1	B	164	SER	5.0
1	A	164	SER	4.7
1	A	163	LEU	4.5
1	B	162	ASN	4.4
1	A	43	SER	4.4
1	B	43	SER	4.1
1	A	280	ASP	3.9
1	A	572	TYR	3.8
1	B	156	TRP	3.5
1	A	549	ILE	3.4
1	B	548	ARG	3.4
1	A	149	TYR	3.3
1	B	158	ASN	3.1
1	A	559	CYS	3.1
1	A	162	ASN	3.0
1	A	156	TRP	2.9
1	B	50	GLU	2.9
1	A	228	VAL	2.8
1	B	550	VAL	2.8
1	B	149	TYR	2.7

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Mol	Chain	Res	Type	RSRZ
1	A	545	ARG	2.7
1	B	545	ARG	2.7
1	B	157	ARG	2.7
1	B	228	VAL	2.7
1	B	51	LYS	2.6
1	B	502	TYR	2.6
1	B	546	ASN	2.6
1	B	160	LYS	2.6
1	A	51	LYS	2.5
1	A	580	CYS	2.4
1	B	54	GLU	2.4
1	A	548	ARG	2.3
1	A	279	LYS	2.3
1	B	44	LYS	2.3
1	B	159	PHE	2.2
1	B	579	GLU	2.2
1	B	390	GLY	2.2
1	A	26	ASN	2.1
1	B	537	GLU	2.1
1	A	582	LYS	2.1
1	A	229	VAL	2.1
1	A	424	GLY	2.1
1	A	550	VAL	2.1
1	A	578	CYS	2.1
1	A	161	SER	2.1
1	B	482	ARG	2.1
1	B	435	GLU	2.0
1	B	161	SER	2.0
1	B	45	PHE	2.0

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

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

6.3 Carbohydrates ⓘ

There are no oligosaccharides in this entry.

6.4 Ligands ⓘ

There are no ligands in this entry.

6.5 Other polymers [i](#)

There are no such residues in this entry.