



Full wwPDB X-ray Structure Validation Report ⓘ

Sep 14, 2023 – 07:57 AM EDT

PDB ID : 4RUL
Title : Crystal structure of full-length E.Coli topoisomerase I in complex with ssDNA
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Deposited on : 2014-11-20
Resolution : 2.90 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 : 4.02b-467
Mogul : 1.8.5 (274361), CSD as541be (2020)
Xtrriage (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)
Validation Pipeline (wwPDB-VP) : 2.35.1

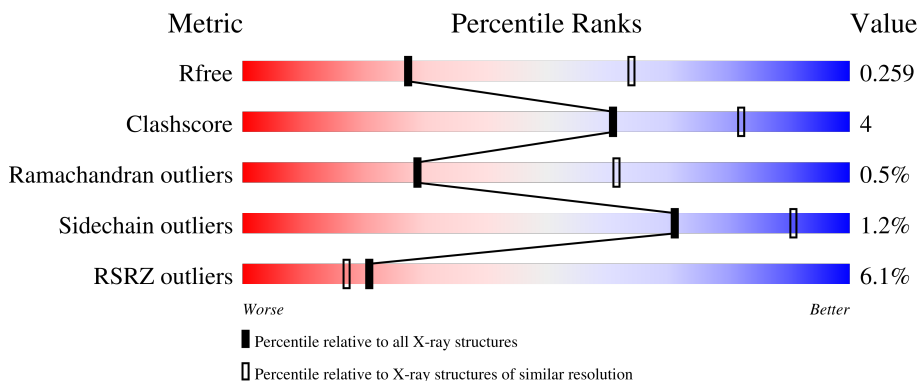
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.90 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	1957 (2.90-2.90)
Clashscore	141614	2172 (2.90-2.90)
Ramachandran outliers	138981	2115 (2.90-2.90)
Sidechain outliers	138945	2117 (2.90-2.90)
RSRZ outliers	127900	1906 (2.90-2.90)

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	867	
2	B	29	

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
4	SO4	A	1006	-	-	X	-

2 Entry composition

There are 6 unique types of molecules in this entry. The entry contains 6480 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 1.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	823	6159	3879	1089	1155	36	0	2	1

There are 3 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	-1	SER	-	expression tag	UNP C9QXS7
A	0	ASN	-	expression tag	UNP C9QXS7
A	1	ALA	-	expression tag	UNP C9QXS7

- Molecule 2 is a DNA chain called single strand DNA.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	P			
2	B	13	252	119	41	79	13	0	0	0

- Molecule 3 is ZINC ION (three-letter code: ZN) (formula: Zn).

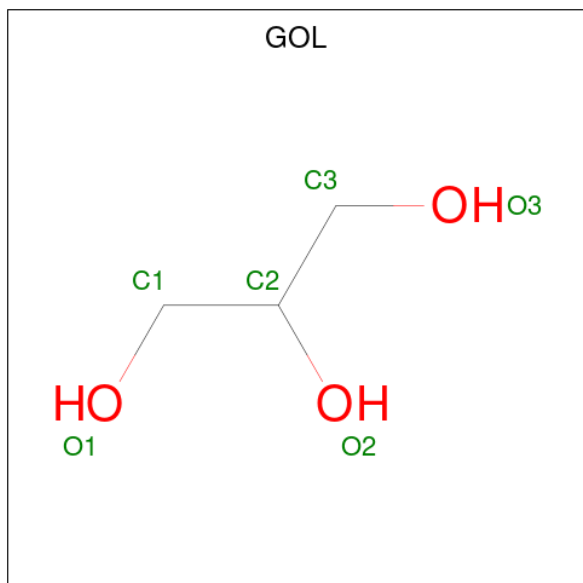
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	A	4	Total	Zn	0	1
			5	5		

- Molecule 4 is SULFATE ION (three-letter code: SO4) (formula: O₄S).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
4	A	1	Total	O	S	0	0
			5	4	1		
4	A	1	Total	O	S	0	0
			5	4	1		
4	A	1	Total	O	S	0	0
			5	4	1		
4	A	1	Total	O	S	0	0
			5	4	1		

- Molecule 5 is GLYCEROL (three-letter code: GOL) (formula: C₃H₈O₃).



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

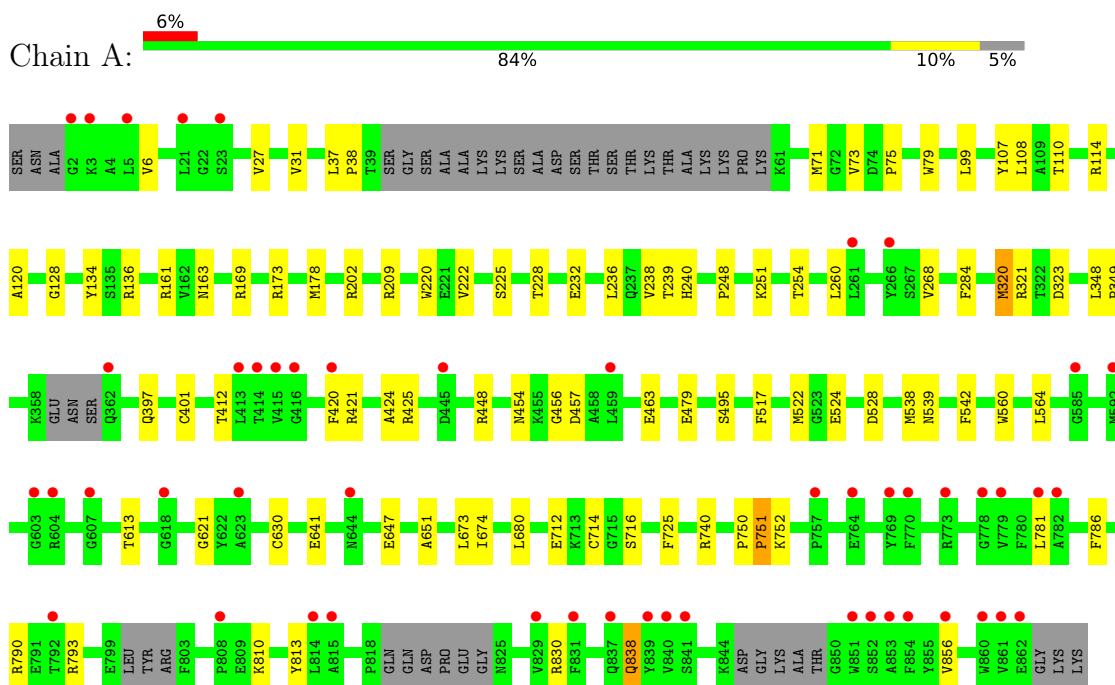
- Molecule 6 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
6	A	37	Total	O	0	0
			37	37		
6	B	1	Total	O	0	0
			1	1		

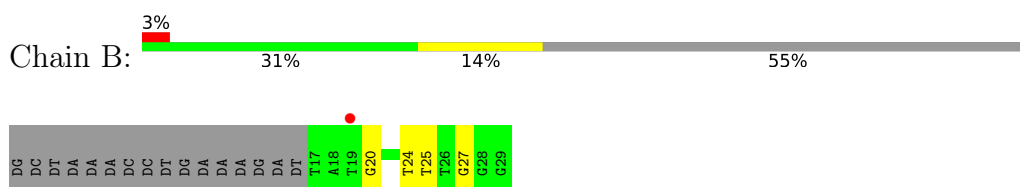
3 Residue-property plots [i](#)

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 1



- Molecule 2: single strand DNA



4 Data and refinement statistics

Property	Value	Source
Space group	P 1 21 1	Depositor
Cell constants a, b, c, α , β , γ	85.61Å 80.30Å 97.47Å 90.00° 91.26° 90.00°	Depositor
Resolution (Å)	37.73 – 2.90 49.86 – 2.90	Depositor EDS
% Data completeness (in resolution range)	99.5 (37.73-2.90) 99.6 (49.86-2.90)	Depositor EDS
R_{merge}	0.06	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.16 (at 2.91Å)	Xtrriage
Refinement program	PHENIX (phenix.refine: 1.8.2_1309)	Depositor
R, R_{free}	0.209 , 0.259 0.209 , 0.259	Depositor DCC
R_{free} test set	1492 reflections (5.05%)	wwPDB-VP
Wilson B-factor (Å ²)	77.5	Xtrriage
Anisotropy	0.188	Xtrriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.29 , 58.7	EDS
L-test for twinning ²	$\langle L \rangle = 0.50$, $\langle L^2 \rangle = 0.34$	Xtrriage
Estimated twinning fraction	0.021 for h,-k,-l	Xtrriage
F_o, F_c correlation	0.92	EDS
Total number of atoms	6480	wwPDB-VP
Average B, all atoms (Å ²)	94.0	wwPDB-VP

Xtrriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 4.10% 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: GOL, SO4, ZN

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	0.22	0/6286	0.38	0/8535
2	B	0.46	0/281	1.10	0/432
All	All	0.24	0/6567	0.44	0/8967

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

There are no planarity outliers.

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	6159	0	5743	54	0
2	B	252	0	138	4	0
3	A	5	0	0	0	0
4	A	20	0	0	3	0
5	A	6	0	8	0	0
6	A	37	0	0	0	0
6	B	1	0	0	0	0
All	All	6480	0	5889	55	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 (55) 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:38:PRO:O	1:A:173:ARG:NH2	2.24	0.70
1:A:161:ARG:NH1	4:A:1006:SO4:O3	2.25	0.69
1:A:110:THR:OG1	1:A:136:ARG:NH1	2.26	0.68
1:A:830:ARG:NH1	2:B:20:DG:OP2	2.26	0.68
1:A:714:CYS:SG	1:A:716:SER:OG	2.52	0.66
1:A:220:TRP:HB2	1:A:248:PRO:HG2	1.80	0.64
1:A:169:ARG:NH1	4:A:1005:SO4:O1	2.31	0.63
1:A:228:THR:HG1	1:A:232:GLU:H	1.44	0.63
1:A:412:THR:HG22	1:A:425:ARG:HG3	1.80	0.62
1:A:712:GLU:HG2	1:A:751:PRO:HB3	1.85	0.58
1:A:284:PHE:CZ	1:A:397:GLN:HG3	2.43	0.54
1:A:228:THR:OG1	1:A:232:GLU:N	2.28	0.53
1:A:674:ILE:HD11	1:A:680:LEU:HB2	1.90	0.53
1:A:240:HIS:HB2	1:A:421:ARG:HB3	1.92	0.52
1:A:454:ASN:N	1:A:457:ASP:OD2	2.35	0.51
1:A:128:GLY:O	1:A:134:TYR:OH	2.21	0.51
1:A:239:THR:OG1	1:A:240:HIS:ND1	2.43	0.49
1:A:613:THR:HG21	2:B:27:DG:H22	1.78	0.48
1:A:79:TRP:CE2	1:A:564:LEU:HB3	2.48	0.48
1:A:222:VAL:HG13	1:A:238:VAL:HG21	1.96	0.48
1:A:202:ARG:NH1	1:A:538:MET:O	2.46	0.48
1:A:268:VAL:HG23	1:A:456:GLY:H	1.78	0.48
1:A:114:ARG:NE	4:A:1006:SO4:O4	2.37	0.48
1:A:236:LEU:HD13	1:A:424:ALA:HB2	1.95	0.48
1:A:260:LEU:HD22	1:A:420:PHE:HE2	1.78	0.47
1:A:750:PRO:O	1:A:752:LYS:N	2.41	0.47
1:A:786:PHE:CE1	1:A:790:ARG:HG3	2.50	0.47
1:A:539:ASN:HB3	1:A:542:PHE:HB2	1.96	0.47
1:A:320:MET:SD	1:A:320:MET:N	2.76	0.46
1:A:37:LEU:HD12	1:A:37:LEU:H	1.81	0.46
1:A:786:PHE:HE1	1:A:790:ARG:HG3	1.81	0.46
1:A:209:ARG:NH2	1:A:528:ASP:OD2	2.44	0.45
1:A:781:LEU:HB3	1:A:793:ARG:O	2.17	0.44
1:A:209:ARG:HH21	1:A:524:GLU:HB3	1.82	0.44
1:A:108:LEU:HD13	1:A:120:ALA:HB1	2.00	0.44
1:A:79:TRP:CZ2	1:A:564:LEU:HB3	2.53	0.44
1:A:810:LYS:O	1:A:813:TYR:HD1	2.01	0.43
1:A:321:ARG:HD3	1:A:495:SER:HA	2.00	0.43
1:A:71:MET:HE3	1:A:178:MET:HG3	2.01	0.43
1:A:725:PHE:HB2	2:B:25:DT:C2	2.54	0.43

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
2:B:24:DT:H2''	2:B:25:DT:O5'	2.18	0.42
1:A:251:LYS:O	1:A:254:THR:OG1	2.30	0.42
1:A:37:LEU:HD22	1:A:173:ARG:HD2	2.01	0.42
1:A:621:GLY:O	1:A:630:CYS:N	2.31	0.42
1:A:323:ASP:N	1:A:323:ASP:OD1	2.52	0.42
1:A:163:ASN:HB3	1:A:560:TRP:CG	2.55	0.42
1:A:348:LEU:HA	1:A:349:PRO:HD2	1.92	0.42
1:A:813:TYR:OH	1:A:838:GLN:NE2	2.50	0.42
1:A:6:VAL:HG22	1:A:107:TYR:HB2	2.01	0.41
1:A:647:GLU:HG2	1:A:651:ALA:HA	2.02	0.41
1:A:673:LEU:HD23	1:A:673:LEU:HA	1.93	0.41
1:A:6:VAL:HB	1:A:27:VAL:HG12	2.03	0.41
1:A:225:SER:OG	1:A:463:GLU:HB3	2.21	0.41
1:A:73:VAL:O	1:A:75:PRO:HD3	2.21	0.40
1:A:479:GLU:HA	1:A:517:PHE:HE2	1.85	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	813/867 (94%)	763 (94%)	46 (6%)	4 (0%)	29 61

All (4) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	31	VAL
1	A	751	PRO
1	A	641	GLU
1	A	856	VAL

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	589/734 (80%)	582 (99%)	7 (1%)	71 91

All (7) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	99	LEU
1	A	320	MET
1	A	401	CYS
1	A	448	ARG
1	A	522	MET
1	A	740	ARG
1	A	838	GLN

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 10 ligands modelled in this entry, 5 are monoatomic - leaving 5 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	SO4	A	1007	-	4,4,4	0.14	0	6,6,6	0.06	0
4	SO4	A	1005	-	4,4,4	0.15	0	6,6,6	0.06	0
5	GOL	A	1009	-	5,5,5	0.36	0	5,5,5	0.30	0
4	SO4	A	1008	-	4,4,4	0.14	0	6,6,6	0.07	0
4	SO4	A	1006	-	4,4,4	0.15	0	6,6,6	0.07	0

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
5	GOL	A	1009	-	-	2/4/4/4	-

There are no bond length outliers.

There are no bond angle outliers.

There are no chirality outliers.

All (2) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
5	A	1009	GOL	O1-C1-C2-C3
5	A	1009	GOL	O1-C1-C2-O2

There are no ring outliers.

2 monomers are involved in 3 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
4	A	1005	SO4	1	0
4	A	1006	SO4	2	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

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	823/867 (94%)	0.37	50 (6%) 21 17	41, 88, 157, 205	0
2	B	13/29 (44%)	0.15	1 (7%) 13 10	96, 122, 196, 202	0
All	All	836/896 (93%)	0.37	51 (6%) 21 17	41, 90, 159, 205	0

All (51) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	2	GLY	6.6
1	A	853	ALA	6.2
1	A	854	PHE	6.1
1	A	415	VAL	4.9
1	A	839	TYR	4.9
1	A	814	LEU	4.6
1	A	603	GLY	4.4
1	A	861	VAL	4.3
1	A	778	GLY	4.1
1	A	851	TRP	3.9
1	A	773	ARG	3.8
1	A	770	PHE	3.8
1	A	592	MET	3.7
1	A	840	VAL	3.7
1	A	21	LEU	3.5
1	A	644	ASN	3.3
1	A	781	LEU	3.1
1	A	445	ASP	3.1
1	A	829	VAL	3.0
1	A	618	GLY	3.0
1	A	757	PRO	3.0
1	A	413	LEU	2.9
1	A	856	VAL	2.9
1	A	769	TYR	2.8

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Mol	Chain	Res	Type	RSRZ
1	A	852	SER	2.8
1	A	266	TYR	2.8
1	A	860	TRP	2.7
1	A	362	GLN	2.7
1	A	261	LEU	2.7
1	A	459	LEU	2.6
1	A	837	GLN	2.6
1	A	604	ARG	2.5
1	A	414	THR	2.5
1	A	815	ALA	2.5
1	A	607	GLY	2.5
1	A	779	VAL	2.5
1	A	416	GLY	2.5
1	A	5	LEU	2.3
1	A	862	GLU	2.3
1	A	623	ALA	2.3
1	A	831	PHE	2.3
1	A	3	LYS	2.3
1	A	792	THR	2.2
1	A	841	SER	2.2
1	A	23	SER	2.2
1	A	782	ALA	2.1
1	A	808	PRO	2.1
1	A	420	PHE	2.1
2	B	19	DT	2.1
1	A	585	GLY	2.0
1	A	764	GLU	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 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, 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
4	SO4	A	1008	5/5	0.80	0.23	129,133,136,136	5
5	GOL	A	1009	6/6	0.85	0.27	86,88,92,93	0
4	SO4	A	1006	5/5	0.87	0.24	132,135,137,139	0
3	ZN	A	1003	1/1	0.93	0.19	98,98,98,98	0
4	SO4	A	1007	5/5	0.93	0.17	70,76,80,84	5
3	ZN	A	1004[A]	1/1	0.93	0.36	120,120,120,120	1
3	ZN	A	1004[B]	1/1	0.93	0.36	119,119,119,119	1
3	ZN	A	1002	1/1	0.94	0.22	83,83,83,83	0
4	SO4	A	1005	5/5	0.95	0.19	86,91,92,96	5
3	ZN	A	1001	1/1	0.96	0.12	105,105,105,105	0

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

There are no such residues in this entry.