



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 5, 2026 – 07:42 PM UTC

PDB ID : 4OU9 / pdb_00004ou9
Title : Crystal structure of apocarotenoid oxygenase in the presence of Triton X-100
Authors : Sui, X.; Palczewski, K.; Kiser, P.D.
Deposited on : 2014-02-15
Resolution : 2.00 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

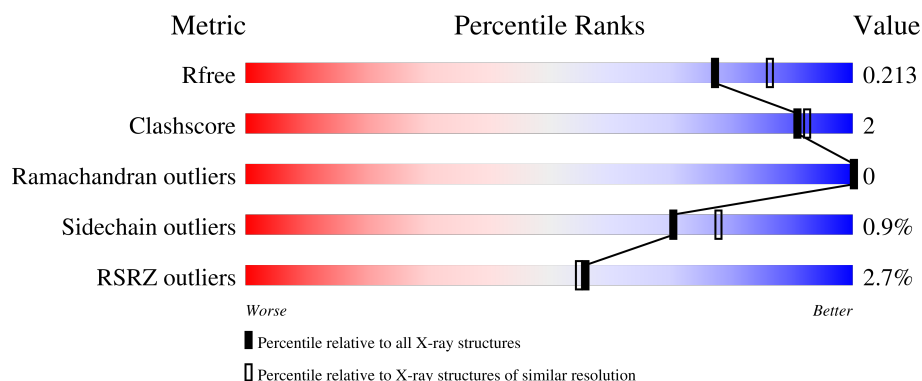
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

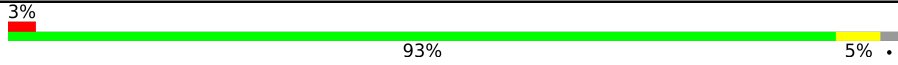
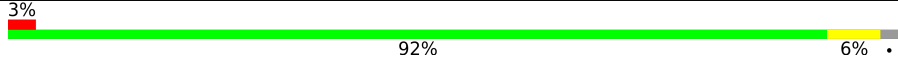
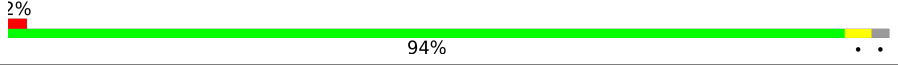
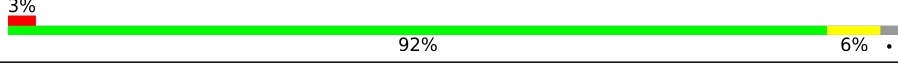
The reported resolution of this entry is 2.00 Å.

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	10052 (2.00-2.00)
Clashscore	190562	11152 (2.00-2.00)
Ramachandran outliers	187476	11031 (2.00-2.00)
Sidechain outliers	187428	11029 (2.00-2.00)
RSRZ outliers	180081	10067 (2.00-2.00)

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	490	
1	B	490	
1	C	490	
1	D	490	

2 Entry composition [i](#)

There are 4 unique types of molecules in this entry. The entry contains 16035 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 Apocarotenoid-15,15'-oxygenase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	481	Total	C	N	O	S	0	3	0
			3803	2439	656	698	10			
1	B	481	Total	C	N	O	S	0	3	0
			3802	2438	657	697	10			
1	C	479	Total	C	N	O	S	0	1	0
			3777	2423	652	692	10			
1	D	479	Total	C	N	O	S	0	1	0
			3772	2421	650	691	10			

- Molecule 2 is FE (II) ION (CCD ID: FE2) (formula: Fe).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	A	1	Total	Fe	0	0
			1	1		
2	B	1	Total	Fe	0	0
			1	1		
2	C	1	Total	Fe	0	0
			1	1		
2	D	1	Total	Fe	0	0
			1	1		

- Molecule 3 is CHLORIDE ION (CCD ID: CL) (formula: Cl).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	A	1	Total	Cl	0	0
			1	1		
3	B	1	Total	Cl	0	0
			1	1		

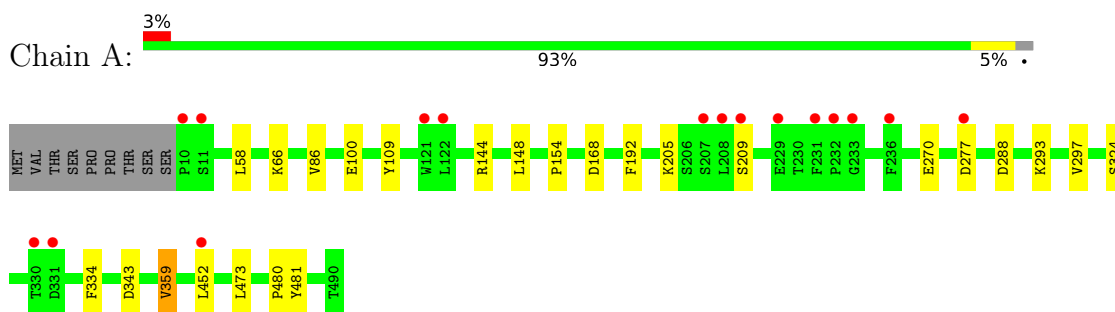
- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	248	Total 248	O 248	0	0
4	B	224	Total 224	O 224	0	0
4	C	209	Total 209	O 209	0	0
4	D	194	Total 194	O 194	0	0

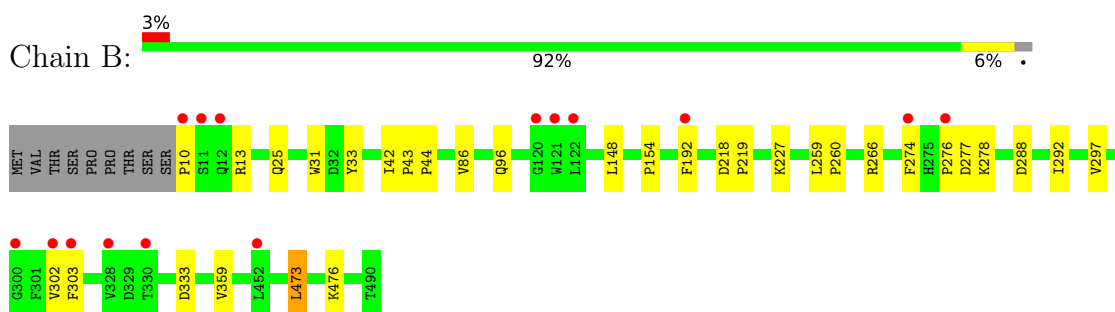
3 Residue-property plots [i](#)

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.

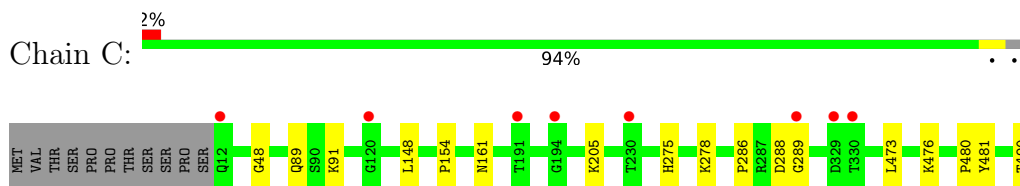
- Molecule 1: Apocarotenoid-15,15'-oxygenase



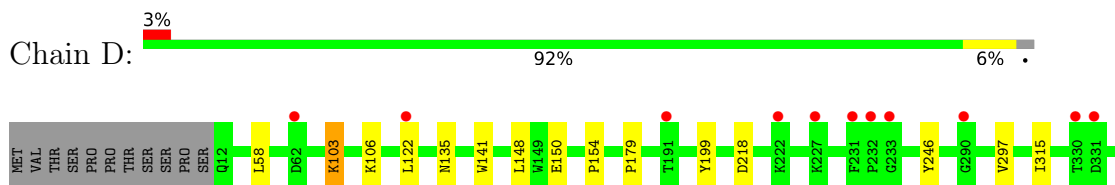
- Molecule 1: Apocarotenoid-15,15'-oxygenase

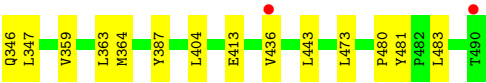


- Molecule 1: Apocarotenoid-15,15'-oxygenase



- Molecule 1: Apocarotenoid-15,15'-oxygenase





4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α , β , γ	118.47Å 125.39Å 202.54Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	48.61 – 2.00 48.61 – 2.00	Depositor EDS
% Data completeness (in resolution range)	98.7 (48.61-2.00) 98.7 (48.61-2.00)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.59 (at 2.00Å)	Xtriage
Refinement program	REFMAC	Depositor
R, R_{free}	0.177 , 0.205 0.186 , 0.213	Depositor DCC
R_{free} test set	9860 reflections (4.92%)	wwPDB-VP
Wilson B-factor (Å ²)	39.7	Xtriage
Anisotropy	0.226	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.34 , 45.3	EDS
L-test for twinning ²	$\langle L \rangle = 0.48$, $\langle L^2 \rangle = 0.31$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.96	EDS
Total number of atoms	16035	wwPDB-VP
Average B, all atoms (Å ²)	46.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 2.81% 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: CL, FE2

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	0.80	0/3920	0.82	0/5340
1	B	0.82	0/3919	0.85	6/5337 (0.1%)
1	C	0.74	0/3890	0.79	0/5296
1	D	0.75	1/3888 (0.0%)	0.81	2/5295 (0.0%)
All	All	0.78	1/15617 (0.0%)	0.82	8/21268 (0.0%)

Chiral center outliers are detected by calculating the chiral volume of a chiral center and verifying if the center is modelled as a planar moiety or with the opposite hand. A planarity outlier is detected by checking planarity of atoms in a peptide group, atoms in a mainchain group or atoms of a sidechain that are expected to be planar.

Mol	Chain	#Chirality outliers	#Planarity outliers
1	B	0	1

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	D	483	LEU	N-CA	-5.38	1.42	1.46

All (8) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	B	278	LYS	N-CA-C	-5.77	102.63	110.36
1	D	106	LYS	N-CA-C	5.54	117.48	109.07
1	B	302	VAL	N-CA-C	5.31	115.49	107.80
1	D	135	ASN	N-CA-C	5.23	120.31	113.30
1	B	42	ILE	CA-C-N	-5.12	115.11	120.38
1	B	42	ILE	C-N-CA	-5.12	115.11	120.38
1	B	266	ARG	CA-C-N	5.11	124.95	120.10
1	B	266	ARG	C-N-CA	5.11	124.95	120.10

There are no chirality outliers.

All (1) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	B	277	ASP	Peptide

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	3803	0	3696	15	0
1	B	3802	0	3698	19	0
1	C	3777	0	3671	9	0
1	D	3772	0	3668	13	0
2	A	1	0	0	0	0
2	B	1	0	0	0	0
2	C	1	0	0	0	0
2	D	1	0	0	0	0
3	A	1	0	0	0	0
3	B	1	0	0	0	0
4	A	248	0	0	1	0
4	B	224	0	0	1	0
4	C	209	0	0	1	0
4	D	194	0	0	0	0
All	All	16035	0	14733	52	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 (52) 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:86:VAL:HG11	1:A:473:LEU:HD13	1.60	0.83
1:B:86:VAL:HG11	1:B:473:LEU:HD13	1.60	0.82
1:A:58:LEU:HD11	1:A:334:PHE:CZ	2.32	0.64
1:A:277:ASP:HB3	1:B:31:TRP:HZ3	1.65	0.61
1:B:274:PHE:CZ	1:B:276:PRO:HA	2.38	0.58
1:A:277:ASP:HB3	1:B:31:TRP:CZ3	2.39	0.58

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:58:LEU:HD11	1:A:334:PHE:HZ	1.70	0.54
1:A:58:LEU:HB2	4:A:837:HOH:O	2.09	0.53
1:C:148:LEU:HD23	1:C:154:PRO:HB3	1.91	0.53
1:A:324:SER:OG	1:A:343:ASP:OD2	2.26	0.52
1:D:148:LEU:HD23	1:D:154:PRO:HB3	1.92	0.52
1:D:347:LEU:O	1:D:363:LEU:HD12	2.10	0.52
1:B:25:GLN:NE2	1:D:103:LYS:HB2	2.27	0.49
1:C:286:PRO:HB2	1:C:289:GLY:O	2.13	0.48
1:C:48:GLY:HA2	1:C:490:THR:HG23	1.94	0.48
1:D:297:VAL:HB	1:D:359:VAL:HG11	1.96	0.47
1:B:227:LYS:HE3	1:B:292:ILE:HD11	1.96	0.47
1:C:288:ASP:OD1	1:C:289:GLY:O	2.34	0.46
1:B:303:PHE:HB2	4:B:743:HOH:O	2.15	0.46
1:D:218:ASP:C	1:D:218:ASP:OD1	2.59	0.46
1:A:297:VAL:HB	1:A:359:VAL:HG11	1.97	0.46
1:A:192:PHE:CE1	1:A:288:ASP:HB3	2.51	0.46
1:A:480:PRO:O	1:A:481:TYR:C	2.60	0.45
1:C:91[B]:LYS:NZ	1:C:161:ASN:O	2.43	0.45
1:A:148:LEU:HD23	1:A:154:PRO:HB3	1.99	0.44
1:D:246:TYR:CE2	1:D:315:ILE:HD11	2.53	0.44
1:B:297:VAL:HB	1:B:359:VAL:HG11	2.00	0.43
1:B:218:ASP:HB2	1:B:219:PRO:CD	2.49	0.43
1:A:100:GLU:OE1	1:A:109:TYR:OH	2.27	0.43
1:B:473:LEU:N	1:B:473:LEU:HD23	2.33	0.42
1:B:96:GLN:NE2	1:B:96:GLN:HA	2.34	0.42
1:D:346:GLN:HB3	1:D:363:LEU:HD11	2.02	0.42
1:A:66:LYS:NZ	1:A:270:GLU:OE2	2.48	0.42
1:C:275:HIS:HB3	1:C:278:LYS:HG3	2.02	0.42
1:B:43:PRO:HA	1:B:44:PRO:HD3	1.93	0.42
1:D:404:LEU:HD11	1:D:413:GLU:HB3	2.01	0.42
1:A:144:ARG:NH2	1:A:168:ASP:OD1	2.52	0.42
1:B:25:GLN:HE22	1:D:103:LYS:HB2	1.84	0.42
1:C:480:PRO:O	1:C:481:TYR:C	2.61	0.41
1:D:150:GLU:O	1:D:179:PRO:HB3	2.20	0.41
1:B:259:LEU:HB2	1:B:260:PRO:HD3	2.02	0.41
1:C:476:LYS:NZ	4:C:725:HOH:O	2.52	0.41
1:D:387:TYR:CD2	1:D:443:LEU:HD11	2.55	0.41
1:B:10:PRO:HA	1:B:13:ARG:HG3	2.02	0.41
1:A:58:LEU:HG	1:A:58:LEU:O	2.21	0.41
1:C:89:GLN:OE1	1:C:161:ASN:HA	2.21	0.41
1:D:480:PRO:O	1:D:481:TYR:C	2.63	0.41

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:B:33:TYR:CD1	1:B:476:LYS:HE2	2.55	0.41
1:B:148:LEU:HD23	1:B:154:PRO:HB3	2.03	0.41
1:B:192:PHE:CE1	1:B:288:ASP:HB3	2.57	0.40
1:B:333:ASP:OD1	1:B:333:ASP:C	2.64	0.40
1:D:141:TRP:CE2	1:D:199:TYR:HB2	2.57	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	482/490 (98%)	473 (98%)	9 (2%)	0	100	100
1	B	482/490 (98%)	471 (98%)	11 (2%)	0	100	100
1	C	478/490 (98%)	469 (98%)	9 (2%)	0	100	100
1	D	478/490 (98%)	468 (98%)	10 (2%)	0	100	100
All	All	1920/1960 (98%)	1881 (98%)	39 (2%)	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	404/410 (98%)	399 (99%)	5 (1%)	63	70

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Mol	Chain	Analysed	Rotameric	Outliers	Percentiles	
1	B	404/410 (98%)	403 (100%)	1 (0%)	87	92
1	C	400/410 (98%)	398 (100%)	2 (0%)	81	87
1	D	400/410 (98%)	394 (98%)	6 (2%)	57	64
All	All	1608/1640 (98%)	1594 (99%)	14 (1%)	70	78

All (14) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	205	LYS
1	A	209	SER
1	A	293	LYS
1	A	359	VAL
1	A	452	LEU
1	B	473	LEU
1	C	205	LYS
1	C	473	LEU
1	D	58	LEU
1	D	103	LYS
1	D	122	LEU
1	D	364	MET
1	D	436	VAL
1	D	473	LEU

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

Mol	Chain	Res	Type
1	A	25	GLN
1	A	29	GLN
1	A	253	ASN
1	B	25	GLN
1	C	102	GLN
1	C	298	GLN
1	C	346	GLN
1	D	25	GLN
1	D	196	GLN
1	D	362	GLN
1	D	393	HIS

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 oligosaccharides in this entry.

5.6 Ligand geometry [i](#)

Of 6 ligands modelled in this entry, 6 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 [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	481/490 (98%)	0.05	16 (3%)	49	48	14, 44, 68, 98	3 (0%)
1	B	481/490 (98%)	0.07	15 (3%)	51	50	20, 43, 65, 104	3 (0%)
1	C	479/490 (97%)	0.06	8 (1%)	69	68	18, 45, 71, 85	1 (0%)
1	D	479/490 (97%)	0.20	13 (2%)	56	55	23, 47, 73, 85	1 (0%)
All	All	1920/1960 (97%)	0.10	52 (2%)	56	55	14, 44, 71, 104	8 (0%)

All (52) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	208	LEU	5.1
1	B	10	PRO	4.5
1	B	11	SER	4.3
1	A	207	SER	4.3
1	C	289	GLY	3.9
1	B	302	VAL	3.8
1	D	231	PHE	3.6
1	B	303	PHE	3.4
1	D	330	THR	3.4
1	A	122	LEU	3.4
1	D	436	VAL	3.1
1	B	276	PRO	3.0
1	A	236	PHE	2.9
1	A	330	THR	2.8
1	C	120	GLY	2.7
1	D	227	LYS	2.6
1	A	277	ASP	2.6
1	A	231	PHE	2.5
1	A	232	PRO	2.5
1	C	12	GLN	2.5
1	D	222	LYS	2.5

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Mol	Chain	Res	Type	RSRZ
1	D	122	LEU	2.4
1	B	300	GLY	2.4
1	D	290	GLY	2.4
1	C	191	THR	2.4
1	A	11	SER	2.4
1	B	121	TRP	2.3
1	C	194	GLY	2.3
1	B	274	PHE	2.2
1	A	10	PRO	2.2
1	B	330	THR	2.2
1	D	490	THR	2.2
1	B	122	LEU	2.2
1	A	121	TRP	2.2
1	C	330	THR	2.2
1	D	232	PRO	2.2
1	C	329	ASP	2.2
1	A	331	ASP	2.2
1	A	229	GLU	2.1
1	A	452	LEU	2.1
1	A	209	SER	2.1
1	D	331	ASP	2.1
1	C	230	THR	2.1
1	D	62	ASP	2.1
1	B	12	GLN	2.1
1	D	233	GLY	2.1
1	D	191	THR	2.0
1	A	233	GLY	2.0
1	B	120	GLY	2.0
1	B	192	PHE	2.0
1	B	328	VAL	2.0
1	B	452	LEU	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 [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
3	CL	B	502	1/1	0.98	0.05	49,49,49,49	0
3	CL	A	502	1/1	0.99	0.08	45,45,45,45	0
2	FE2	B	501	1/1	0.99	0.03	32,32,32,32	0
2	FE2	D	501	1/1	1.00	0.03	36,36,36,36	0
2	FE2	A	501	1/1	1.00	0.02	32,32,32,32	0
2	FE2	C	501	1/1	1.00	0.02	34,34,34,34	0

6.5 Other polymers [i](#)

There are no such residues in this entry.