



wwPDB X-ray Structure Validation Summary Report ⓘ

Mar 6, 2026 – 10:00 AM UTC

PDB ID : 1VL6 / pdb_00001vl6
Title : Crystal structure of NAD-dependent malic enzyme (TM0542) from *Thermotoga maritima* at 2.61 Å resolution
Authors : Joint Center for Structural Genomics (JCSG)
Deposited on : 2004-07-13
Resolution : 2.61 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

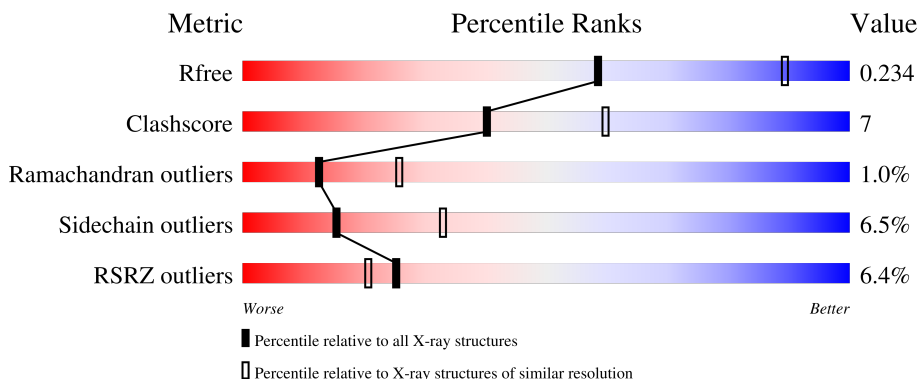
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.61 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	4951 (2.64-2.60)
Clashscore	190562	5303 (2.64-2.60)
Ramachandran outliers	187476	5217 (2.64-2.60)
Sidechain outliers	187428	5217 (2.64-2.60)
RSRZ outliers	180081	4950 (2.64-2.60)

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	388	% 79% 17% ..
1	B	388	10% 68% 20% 9%
1	C	388	7% 81% 14% ..
1	D	388	7% 84% 11% ..

2 Entry composition

There are 2 unique types of molecules in this entry. The entry contains 11180 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 malate oxidoreductase.

Mol	Chain	Residues	Atoms						ZeroOcc	AltConf	Trace
1	A	377	Total	C	N	O	S	Se	0	2	0
			2879	1846	481	541	5	6			
1	B	355	Total	C	N	O	S	Se	0	1	0
			2600	1664	434	492	5	5			
1	C	377	Total	C	N	O	S	Se	0	0	0
			2813	1796	468	538	5	6			
1	D	377	Total	C	N	O	S	Se	0	1	0
			2844	1824	470	539	5	6			

There are 80 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	-11	MSE	-	expression tag	UNP Q9WZ12
A	-10	GLY	-	expression tag	UNP Q9WZ12
A	-9	SER	-	expression tag	UNP Q9WZ12
A	-8	ASP	-	expression tag	UNP Q9WZ12
A	-7	LYS	-	expression tag	UNP Q9WZ12
A	-6	ILE	-	expression tag	UNP Q9WZ12
A	-5	HIS	-	expression tag	UNP Q9WZ12
A	-4	HIS	-	expression tag	UNP Q9WZ12
A	-3	HIS	-	expression tag	UNP Q9WZ12
A	-2	HIS	-	expression tag	UNP Q9WZ12
A	-1	HIS	-	expression tag	UNP Q9WZ12
A	0	HIS	-	expression tag	UNP Q9WZ12
A	1	VAL	MET	SEE REMARK 999	UNP Q9WZ12
A	6	VAL	ILE	SEE REMARK 999	UNP Q9WZ12
A	84	MSE	MET	modified residue	UNP Q9WZ12
A	147	MSE	MET	modified residue	UNP Q9WZ12
A	272	MSE	MET	modified residue	UNP Q9WZ12
A	322	MSE	MET	modified residue	UNP Q9WZ12
A	336	MSE	MET	modified residue	UNP Q9WZ12
A	362	MSE	MET	modified residue	UNP Q9WZ12
B	-11	MSE	-	expression tag	UNP Q9WZ12

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Chain	Residue	Modelled	Actual	Comment	Reference
B	-10	GLY	-	expression tag	UNP Q9WZ12
B	-9	SER	-	expression tag	UNP Q9WZ12
B	-8	ASP	-	expression tag	UNP Q9WZ12
B	-7	LYS	-	expression tag	UNP Q9WZ12
B	-6	ILE	-	expression tag	UNP Q9WZ12
B	-5	HIS	-	expression tag	UNP Q9WZ12
B	-4	HIS	-	expression tag	UNP Q9WZ12
B	-3	HIS	-	expression tag	UNP Q9WZ12
B	-2	HIS	-	expression tag	UNP Q9WZ12
B	-1	HIS	-	expression tag	UNP Q9WZ12
B	0	HIS	-	expression tag	UNP Q9WZ12
B	1	VAL	MET	SEE REMARK 999	UNP Q9WZ12
B	6	VAL	ILE	SEE REMARK 999	UNP Q9WZ12
B	84	MSE	MET	modified residue	UNP Q9WZ12
B	147	MSE	MET	modified residue	UNP Q9WZ12
B	272	MSE	MET	modified residue	UNP Q9WZ12
B	322	MSE	MET	modified residue	UNP Q9WZ12
B	336	MSE	MET	modified residue	UNP Q9WZ12
B	362	MSE	MET	modified residue	UNP Q9WZ12
C	-11	MSE	-	expression tag	UNP Q9WZ12
C	-10	GLY	-	expression tag	UNP Q9WZ12
C	-9	SER	-	expression tag	UNP Q9WZ12
C	-8	ASP	-	expression tag	UNP Q9WZ12
C	-7	LYS	-	expression tag	UNP Q9WZ12
C	-6	ILE	-	expression tag	UNP Q9WZ12
C	-5	HIS	-	expression tag	UNP Q9WZ12
C	-4	HIS	-	expression tag	UNP Q9WZ12
C	-3	HIS	-	expression tag	UNP Q9WZ12
C	-2	HIS	-	expression tag	UNP Q9WZ12
C	-1	HIS	-	expression tag	UNP Q9WZ12
C	0	HIS	-	expression tag	UNP Q9WZ12
C	1	VAL	MET	SEE REMARK 999	UNP Q9WZ12
C	6	VAL	ILE	SEE REMARK 999	UNP Q9WZ12
C	84	MSE	MET	modified residue	UNP Q9WZ12
C	147	MSE	MET	modified residue	UNP Q9WZ12
C	272	MSE	MET	modified residue	UNP Q9WZ12
C	322	MSE	MET	modified residue	UNP Q9WZ12
C	336	MSE	MET	modified residue	UNP Q9WZ12
C	362	MSE	MET	modified residue	UNP Q9WZ12
D	-11	MSE	-	expression tag	UNP Q9WZ12
D	-10	GLY	-	expression tag	UNP Q9WZ12
D	-9	SER	-	expression tag	UNP Q9WZ12

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Chain	Residue	Modelled	Actual	Comment	Reference
D	-8	ASP	-	expression tag	UNP Q9WZ12
D	-7	LYS	-	expression tag	UNP Q9WZ12
D	-6	ILE	-	expression tag	UNP Q9WZ12
D	-5	HIS	-	expression tag	UNP Q9WZ12
D	-4	HIS	-	expression tag	UNP Q9WZ12
D	-3	HIS	-	expression tag	UNP Q9WZ12
D	-2	HIS	-	expression tag	UNP Q9WZ12
D	-1	HIS	-	expression tag	UNP Q9WZ12
D	0	HIS	-	expression tag	UNP Q9WZ12
D	1	VAL	MET	SEE REMARK 999	UNP Q9WZ12
D	6	VAL	ILE	SEE REMARK 999	UNP Q9WZ12
D	84	MSE	MET	modified residue	UNP Q9WZ12
D	147	MSE	MET	modified residue	UNP Q9WZ12
D	272	MSE	MET	modified residue	UNP Q9WZ12
D	322	MSE	MET	modified residue	UNP Q9WZ12
D	336	MSE	MET	modified residue	UNP Q9WZ12
D	362	MSE	MET	modified residue	UNP Q9WZ12

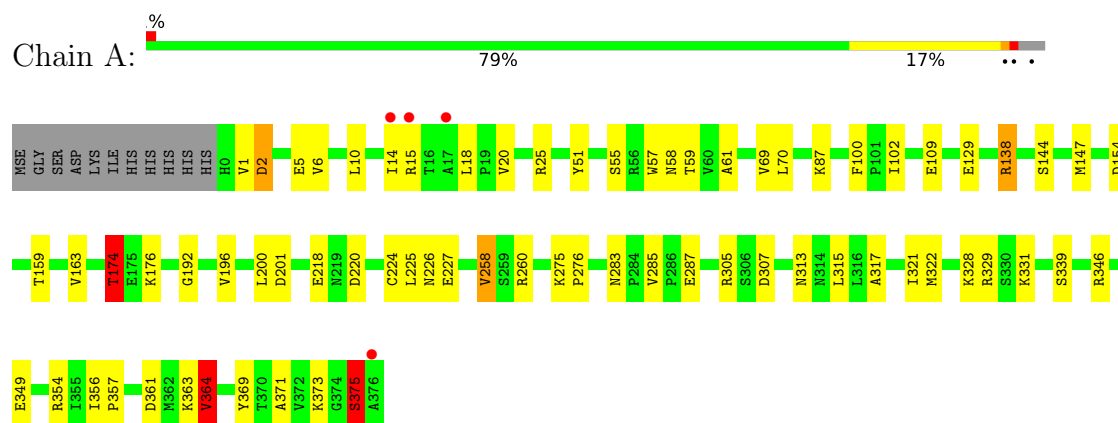
- Molecule 2 is water.

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
2	A	29	Total O 29 29	0	0
2	B	1	Total O 1 1	0	0
2	C	2	Total O 2 2	0	0
2	D	12	Total O 12 12	0	0

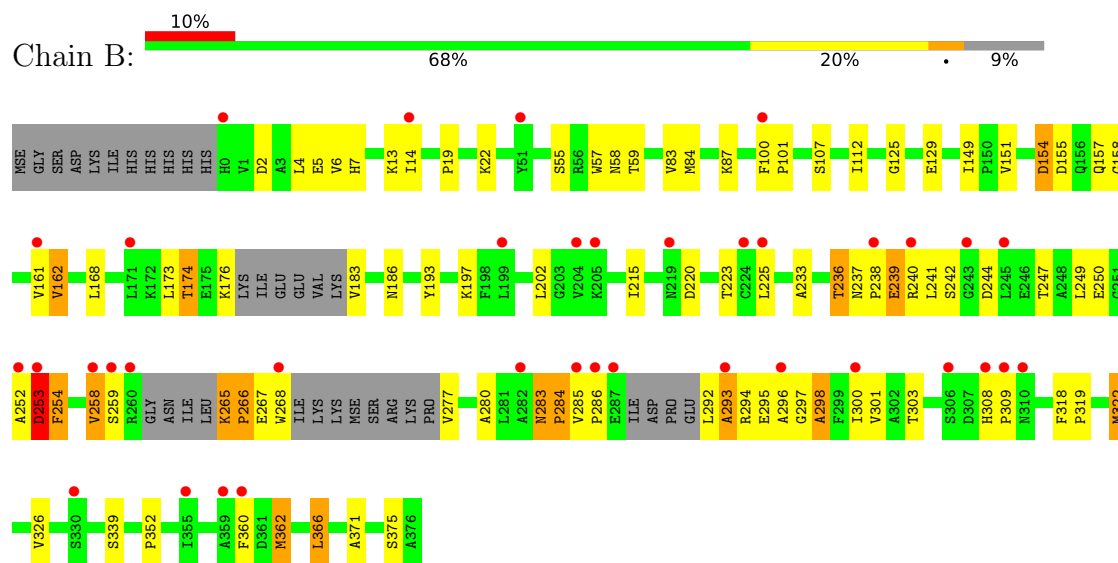
3 Residue-property plots

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.

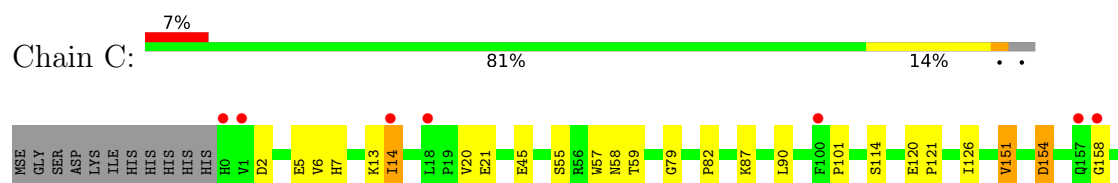
- Molecule 1: malate oxidoreductase

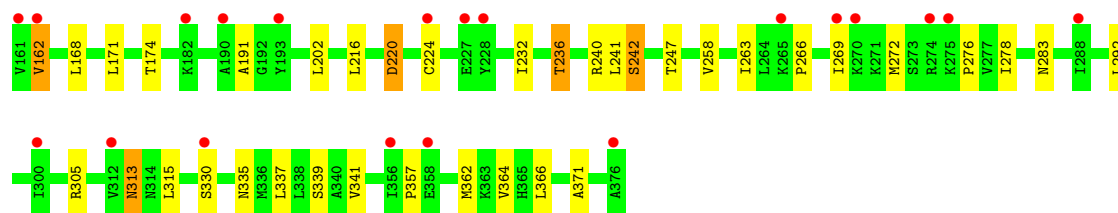


- Molecule 1: malate oxidoreductase

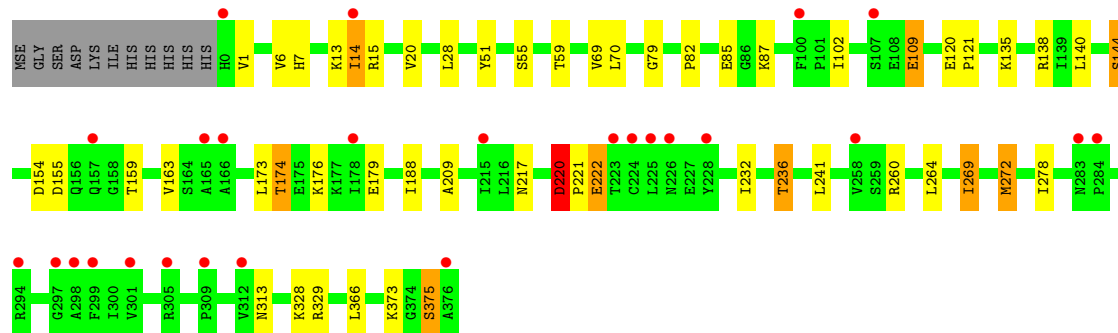
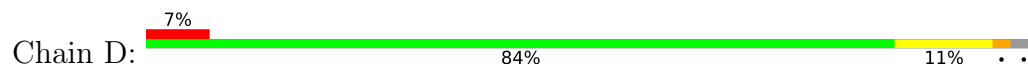


- Molecule 1: malate oxidoreductase





● Molecule 1: malate oxidoreductase



4 Data and refinement statistics

Property	Value	Source
Space group	P 65	Depositor
Cell constants a, b, c, α , β , γ	143.96Å 143.96Å 163.43Å 90.00° 90.00° 120.00°	Depositor
Resolution (Å)	47.12 – 2.61 47.12 – 2.61	Depositor EDS
% Data completeness (in resolution range)	98.5 (47.12-2.61) 98.6 (47.12-2.61)	Depositor EDS
R_{merge}	0.05	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	2.45 (at 2.61Å)	Xtriage
Refinement program	REFMAC 5.2.0003	Depositor
R, R_{free}	0.192 , 0.239 0.201 , 0.234	Depositor DCC
R_{free} test set	2919 reflections (4.98%)	wwPDB-VP
Wilson B-factor (Å ²)	60.8	Xtriage
Anisotropy	0.185	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.31 , 68.9	EDS
L-test for twinning ²	$\langle L \rangle = 0.53$, $\langle L^2 \rangle = 0.37$	Xtriage
Estimated twinning fraction	0.022 for h,-h-k,-l	Xtriage
F_o, F_c correlation	0.94	EDS
Total number of atoms	11180	wwPDB-VP
Average B, all atoms (Å ²)	64.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 2.29% 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

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	1.13	5/2926 (0.2%)	1.11	13/3964 (0.3%)
1	B	1.01	7/2640 (0.3%)	1.09	5/3577 (0.1%)
1	C	0.93	1/2860 (0.0%)	0.98	1/3883 (0.0%)
1	D	1.04	2/2890 (0.1%)	1.05	5/3917 (0.1%)
All	All	1.03	15/11316 (0.1%)	1.06	24/15341 (0.2%)

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	2
1	D	0	1
All	All	0	3

The worst 5 of 15 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	B	253	ASP	CG-OD2	7.12	1.38	1.25
1	D	272	MSE	SE-CE	-6.69	1.75	1.95
1	B	362	MSE	SE-CE	6.40	2.14	1.95
1	C	14	ILE	CA-CB	5.83	1.60	1.54
1	A	224	CYS	C-O	5.66	1.30	1.23

The worst 5 of 24 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	364	VAL	CB-CA-C	-7.91	101.85	111.97
1	A	258	VAL	CB-CA-C	7.38	123.40	111.29
1	A	1	VAL	N-CA-C	6.78	118.21	107.98
1	B	284	PRO	N-CD-CG	-6.02	94.17	103.20
1	A	349	GLU	CA-C-O	6.01	123.20	119.29

There are no chirality outliers.

All (3) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	B	258	VAL	Peptide
1	B	283	ASN	Peptide
1	D	220	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	2879	0	2907	39	0
1	B	2600	0	2550	59	0
1	C	2813	0	2779	34	0
1	D	2844	0	2850	30	0
2	A	29	0	0	0	0
2	B	1	0	0	0	0
2	C	2	0	0	0	0
2	D	12	0	0	0	0
All	All	11180	0	11086	147	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 7.

The worst 5 of 147 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:362:MSE:SE	1:B:362:MSE:CE	2.14	1.46
1:A:100[A]:PHE:CE2	1:B:100[A]:PHE:CD1	2.50	0.99
1:A:100[A]:PHE:CE2	1:B:100[A]:PHE:CE1	2.51	0.98
1:A:100[A]:PHE:CD2	1:B:100[A]:PHE:CD1	2.58	0.92
1:C:272:MSE:HE1	1:C:278:ILE:HD11	1.52	0.91

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	377/388 (97%)	361 (96%)	16 (4%)	0	100	100
1	B	346/388 (89%)	311 (90%)	23 (7%)	12 (4%)	3	4
1	C	375/388 (97%)	357 (95%)	18 (5%)	0	100	100
1	D	376/388 (97%)	356 (95%)	18 (5%)	2 (0%)	24	44
All	All	1474/1552 (95%)	1385 (94%)	75 (5%)	14 (1%)	12	28

5 of 14 Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	B	267	GLU
1	B	284	PRO
1	B	238	PRO
1	B	240	ARG
1	B	295	GLU

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	304/316 (96%)	285 (94%)	19 (6%)	16	34
1	B	265/316 (84%)	246 (93%)	19 (7%)	13	28
1	C	294/316 (93%)	273 (93%)	21 (7%)	13	29
1	D	297/316 (94%)	281 (95%)	16 (5%)	20	40
All	All	1160/1264 (92%)	1085 (94%)	75 (6%)	15	33

5 of 75 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	C	335	ASN
1	D	236	THR
1	D	6	VAL
1	D	144	SER
1	B	154	ASP

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. 5 of 10 such sidechains are listed below:

Mol	Chain	Res	Type
1	C	310	ASN
1	D	217	ASN
1	D	308	HIS
1	A	313	ASN
1	A	335	ASN

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](#)

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 ⓘ

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	371/388 (95%)	0.17	4 (1%) 78 74	31, 64, 75, 86	2 (0%)
1	B	350/388 (90%)	0.79	37 (10%) 11 9	40, 63, 73, 82	1 (0%)
1	C	371/388 (95%)	0.70	27 (7%) 21 17	54, 63, 72, 90	0
1	D	371/388 (95%)	0.76	26 (7%) 22 18	31, 64, 75, 95	1 (0%)
All	All	1463/1552 (94%)	0.60	94 (6%) 25 21	31, 64, 75, 95	4 (0%)

The worst 5 of 94 RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	100[A]	PHE	5.6
1	B	306	SER	4.1
1	D	224	CYS	3.8
1	C	228	TYR	3.8
1	B	359	ALA	3.7

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](#)

There are no ligands in this entry.

6.5 Other polymers [i](#)

There are no such residues in this entry.