



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 9, 2026 – 11:03 AM UTC

PDB ID : 5U90 / pdb_00005u90
Title : Crystal structure of Co-CAO1 in complex with resveratrol
Authors : Sui, X.; Palczewski, k.; Banerjee, S.; Kiser, P.D.
Deposited on : 2016-12-15
Resolution : 1.90 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 : 4-5-2 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

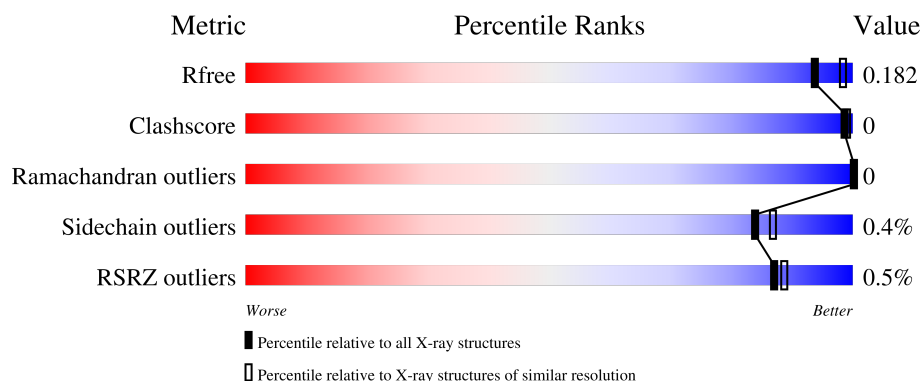
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

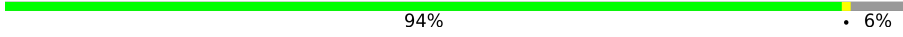
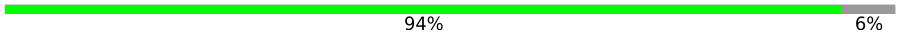
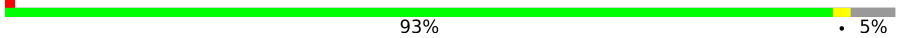
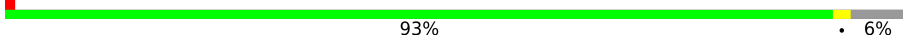
The reported resolution of this entry is 1.90 Å.

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}	180053	7789 (1.90-1.90)
Clashscore	190562	8410 (1.90-1.90)
Ramachandran outliers	187476	8333 (1.90-1.90)
Sidechain outliers	187428	8333 (1.90-1.90)
RSRZ outliers	180081	7790 (1.90-1.90)

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	526	 94% 6%
1	B	526	 94% 6%
1	C	526	 93% 5%
1	D	526	 93% 6%

2 Entry composition

There are 5 unique types of molecules in this entry. The entry contains 17855 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.

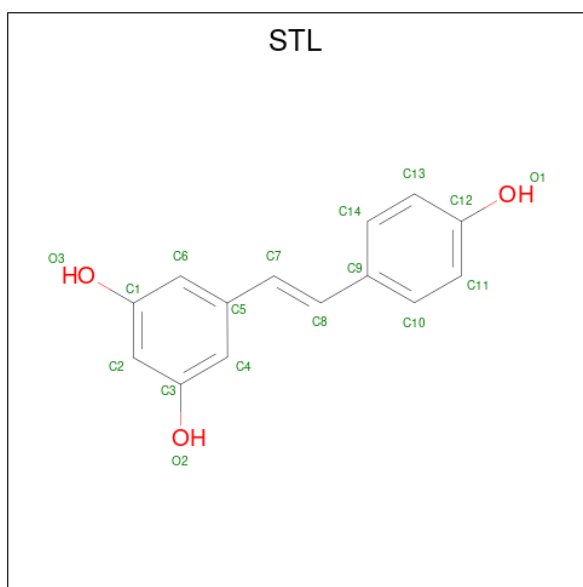
- Molecule 1 is a protein called Carotenoid oxygenase 1.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	497	Total	C	N	O	S	0	3	0
			4010	2573	679	738	20			
1	B	497	Total	C	N	O	S	0	4	0
			4019	2578	680	741	20			
1	C	501	Total	C	N	O	S	0	4	0
			4052	2597	686	749	20			
1	D	497	Total	C	N	O	S	0	4	0
			4017	2578	681	738	20			

- Molecule 2 is COBALT (II) ION (CCD ID: CO) (formula: Co).

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

- Molecule 3 is RESVERATROL (CCD ID: STL) (formula: C₁₄H₁₂O₃).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
3	A	1	Total	C	O	0	0
			17	14	3		
3	A	1	Total	C	O	0	0
			17	14	3		
3	A	1	Total	C	O	0	0
			17	14	3		
3	A	1	Total	C	O	0	0
			17	14	3		
3	B	1	Total	C	O	0	0
			17	14	3		
3	C	1	Total	C	O	0	0
			17	14	3		
3	C	1	Total	C	O	0	0
			17	14	3		
3	D	1	Total	C	O	0	0
			17	14	3		
3	D	1	Total	C	O	0	0
			17	14	3		
3	D	1	Total	C	O	0	0
			17	14	3		

- Molecule 4 is DIMETHYL SULFOXIDE (CCD ID: DMS) (formula: C₂H₆OS).



Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
4	A	1	Total	C	O	S	0	0
			4	2	1	1		
4	A	1	Total	C	O	S	0	0
			4	2	1	1		
4	B	1	Total	C	O	S	0	0
			4	2	1	1		
4	B	1	Total	C	O	S	0	0
			4	2	1	1		
4	B	1	Total	C	O	S	0	0
			4	2	1	1		
4	B	1	Total	C	O	S	0	0
			4	2	1	1		
4	D	1	Total	C	O	S	0	0
			4	2	1	1		
4	D	1	Total	C	O	S	0	0
			4	2	1	1		
4	D	1	Total	C	O	S	0	0
			4	2	1	1		

- Molecule 5 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
5	A	367	Total	O	0	0
			367	367		
5	B	385	Total	O	0	0
			385	385		

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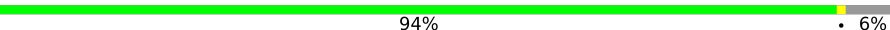
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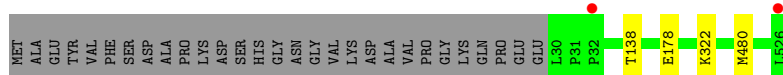
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
5	C	392	Total 392	O 392	0	0
5	D	399	Total 399	O 399	0	0

3 Residue-property plots

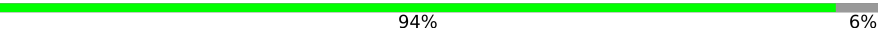
These plots are drawn for all protein, RNA, DNA and oligosaccharide chains in the entry. The first graphic for a chain summarises the proportions of the various outlier classes displayed in the second graphic. The second graphic shows the sequence view annotated by issues in geometry and electron density. 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.

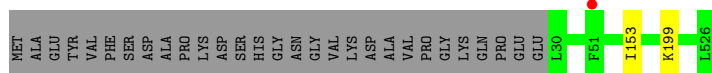
• Molecule 1: Carotenoid oxygenase 1

Chain A:  94% 6%

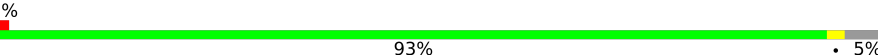


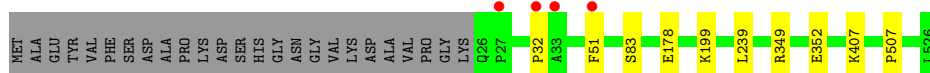
• Molecule 1: Carotenoid oxygenase 1

Chain B:  94% 6%

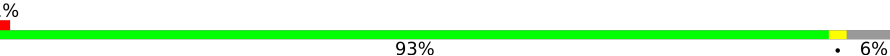


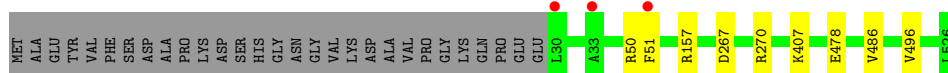
• Molecule 1: Carotenoid oxygenase 1

Chain C:  93% 5%



• Molecule 1: Carotenoid oxygenase 1

Chain D:  93% 6%



4 Data and refinement statistics

Property	Value	Source
Space group	P 32 2 1	Depositor
Cell constants a, b, c, α , β , γ	101.05Å 101.05Å 447.54Å 90.00° 90.00° 120.00°	Depositor
Resolution (Å)	49.28 – 1.90 49.28 – 1.90	Depositor EDS
% Data completeness (in resolution range)	100.0 (49.28-1.90) 100.0 (49.28-1.90)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.04 (at 1.90Å)	Xtriage
Refinement program	REFMAC 5.8.0155	Depositor
R, R_{free}	0.168 , 0.194 (Not available) , 0.182	Depositor DCC
R_{free} test set	9432 reflections (4.50%)	wwPDB-VP
Wilson B-factor (Å ²)	40.1	Xtriage
Anisotropy	0.190	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.34 , 34.9	EDS
L-test for twinning ²	$\langle L \rangle = 0.47$, $\langle L^2 \rangle = 0.30$	Xtriage
Estimated twinning fraction	0.032 for -h,-k,l	Xtriage
F_o, F_c correlation	0.97	EDS
Total number of atoms	17855	wwPDB-VP
Average B, all atoms (Å ²)	42.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 2.42% 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: STL, DMS, CO

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	0.86	0/4135	0.85	0/5620
1	B	0.88	0/4144	0.86	1/5632 (0.0%)
1	C	0.87	0/4178	0.85	0/5679
1	D	0.89	0/4142	0.85	1/5630 (0.0%)
All	All	0.87	0/16599	0.85	2/22561 (0.0%)

There are no bond length outliers.

All (2) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	B	153	ILE	CB-CA-C	5.11	116.23	110.41
1	D	270	ARG	NE-CZ-NH2	5.03	123.73	119.20

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	4010	0	3826	3	0
1	B	4019	0	3831	1	0
1	C	4052	0	3858	6	0
1	D	4017	0	3836	6	0
2	A	1	0	0	0	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
2	B	1	0	0	0	0
2	C	1	0	0	0	0
2	D	1	0	0	0	0
3	A	68	0	44	0	0
3	B	17	0	10	0	0
3	C	34	0	21	0	0
3	D	51	0	32	0	0
4	A	8	0	12	2	0
4	B	20	0	30	0	0
4	D	12	0	18	0	0
5	A	367	0	0	1	1
5	B	385	0	0	1	0
5	C	392	0	0	5	2
5	D	399	0	0	5	0
All	All	17855	0	15518	16	2

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 0.

All (16) 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:C:32:PRO:O	5:C:701:HOH:O	1.88	0.91
1:C:507:PRO:O	5:C:702:HOH:O	2.05	0.73
1:D:267:ASP:OD2	5:D:701:HOH:O	2.14	0.65
1:A:138:THR:HG22	4:A:604:DMS:H12	1.88	0.54
1:A:178[A]:GLU:HG3	5:A:1002:HOH:O	2.09	0.53
1:C:178:GLU:HB2	5:C:1046:HOH:O	2.12	0.49
1:C:349:ARG:HG3	1:C:352:GLU:OE1	2.12	0.49
1:C:83:SER:HB2	5:C:1037:HOH:O	2.13	0.48
1:D:157:ARG:NH2	5:D:702:HOH:O	2.42	0.45
1:D:486:VAL:O	1:D:496:VAL:HG22	2.15	0.45
1:B:199:LYS:NZ	5:B:716:HOH:O	2.48	0.45
1:D:157:ARG:NE	5:D:702:HOH:O	2.24	0.43
1:D:407:LYS:CE	5:D:736:HOH:O	2.66	0.43
1:A:480:MET:HG3	4:A:603:DMS:H23	2.01	0.42
1:C:199:LYS:NZ	5:C:717:HOH:O	2.53	0.42
1:D:50:ARG:CZ	5:D:758:HOH:O	2.67	0.41

All (2) symmetry-related close contacts are listed below. The label for Atom-2 includes the symmetry operator and encoded unit-cell translations to be applied.

Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
5:C:1080:HOH:O	5:C:1080:HOH:O[4_555]	1.59	0.61
5:A:997:HOH:O	5:C:763:HOH:O[1_665]	2.16	0.04

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	498/526 (95%)	488 (98%)	10 (2%)	0	100	100
1	B	499/526 (95%)	488 (98%)	11 (2%)	0	100	100
1	C	503/526 (96%)	490 (97%)	13 (3%)	0	100	100
1	D	499/526 (95%)	488 (98%)	11 (2%)	0	100	100
All	All	1999/2104 (95%)	1954 (98%)	45 (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	425/445 (96%)	424 (100%)	1 (0%)	87	90
1	B	426/445 (96%)	426 (100%)	0	100	100
1	C	430/445 (97%)	427 (99%)	3 (1%)	76	78
1	D	426/445 (96%)	424 (100%)	2 (0%)	81	84
All	All	1707/1780 (96%)	1701 (100%)	6 (0%)	84	87

All (6) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	322	LYS
1	C	51	PHE
1	C	239	LEU
1	C	407	LYS
1	D	51	PHE
1	D	478	GLU

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (3) such sidechains are listed below:

Mol	Chain	Res	Type
1	B	159	GLN
1	B	344	ASN
1	B	356	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 24 ligands modelled in this entry, 4 are monoatomic - leaving 20 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
3	STL	A	605	-	18,18,18	0.57	0	24,24,24	0.35	0
3	STL	A	606	-	18,18,18	0.35	0	24,24,24	0.29	0
3	STL	A	607	-	18,18,18	0.33	0	24,24,24	0.13	0
4	DMS	A	603	-	3,3,3	0.39	0	3,3,3	1.17	0
3	STL	C	602	-	18,18,18	0.33	0	24,24,24	0.38	0
3	STL	D	602	-	18,18,18	0.81	0	24,24,24	0.70	0
4	DMS	B	604	-	3,3,3	0.46	0	3,3,3	0.82	0
3	STL	C	603	-	18,18,18	0.60	0	24,24,24	0.50	0
3	STL	D	607	-	18,18,18	0.38	0	24,24,24	0.23	0
4	DMS	D	604	-	3,3,3	0.67	0	3,3,3	0.86	0
3	STL	D	606	-	18,18,18	0.37	0	24,24,24	0.21	0
4	DMS	D	605	-	3,3,3	0.48	0	3,3,3	1.18	1 (33%)
3	STL	B	602	-	18,18,18	0.30	0	24,24,24	0.34	0
4	DMS	B	605	-	3,3,3	0.45	0	3,3,3	0.58	0
4	DMS	B	607	-	3,3,3	0.50	0	3,3,3	0.89	0
4	DMS	B	603	-	3,3,3	0.72	0	3,3,3	1.35	1 (33%)
4	DMS	A	604	-	3,3,3	0.48	0	3,3,3	1.09	0
3	STL	A	602	-	18,18,18	0.57	0	24,24,24	0.53	0
4	DMS	D	603	-	3,3,3	0.70	0	3,3,3	0.28	0
4	DMS	B	606	-	3,3,3	0.47	0	3,3,3	1.10	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
3	STL	B	602	-	-	0/5/5/5	0/2/2/2
3	STL	C	602	-	-	0/5/5/5	0/2/2/2
3	STL	D	607	-	-	0/5/5/5	0/2/2/2
3	STL	A	605	-	-	0/5/5/5	0/2/2/2
3	STL	A	606	-	-	0/5/5/5	0/2/2/2
3	STL	A	607	-	-	0/5/5/5	0/2/2/2
3	STL	D	602	-	-	0/5/5/5	0/2/2/2
3	STL	D	606	-	-	0/5/5/5	0/2/2/2
3	STL	C	603	-	-	0/5/5/5	0/2/2/2
3	STL	A	602	-	-	0/5/5/5	0/2/2/2

There are no bond length outliers.

All (2) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed($^{\circ}$)	Ideal($^{\circ}$)
4	B	603	DMS	O-S-C1	2.22	117.62	106.49
4	D	605	DMS	C2-S-C1	2.03	108.81	98.42

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

2 monomers are involved in 2 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
4	A	603	DMS	1	0
4	A	604	DMS	1	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 [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	497/526 (94%)	-0.17	2 (0%) 88 90	18, 41, 61, 81	3 (0%)
1	B	497/526 (94%)	-0.25	1 (0%) 91 92	19, 39, 58, 81	4 (0%)
1	C	501/526 (95%)	-0.21	4 (0%) 82 85	18, 40, 58, 107	4 (0%)
1	D	497/526 (94%)	-0.33	3 (0%) 85 87	17, 38, 55, 83	4 (0%)
All	All	1992/2104 (94%)	-0.24	10 (0%) 87 89	17, 40, 58, 107	15 (0%)

All (10) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	C	27	PRO	2.9
1	D	30	LEU	2.7
1	D	51	PHE	2.7
1	A	526	LEU	2.5
1	C	32	PRO	2.5
1	C	51	PHE	2.4
1	C	33	ALA	2.4
1	A	32	PRO	2.4
1	D	33	ALA	2.2
1	B	51	PHE	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 ⓘ

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	STL	A	607	17/17	0.68	0.18	82,87,95,99	0
4	DMS	A	603	4/4	0.77	0.22	78,86,87,98	0
4	DMS	D	605	4/4	0.78	0.21	78,88,98,99	0
4	DMS	B	607	4/4	0.81	0.21	89,90,101,115	0
3	STL	A	605	17/17	0.82	0.17	56,67,101,105	0
3	STL	D	606	17/17	0.83	0.16	50,65,101,102	0
4	DMS	A	604	4/4	0.87	0.17	91,95,96,103	0
4	DMS	B	605	4/4	0.87	0.15	73,85,88,93	0
4	DMS	B	606	4/4	0.88	0.20	85,91,96,96	0
4	DMS	B	604	4/4	0.88	0.18	80,92,93,93	0
3	STL	D	607	17/17	0.88	0.13	53,57,67,68	0
3	STL	A	606	17/17	0.89	0.13	54,66,83,84	0
4	DMS	D	603	4/4	0.90	0.19	71,72,81,84	0
3	STL	C	603	17/17	0.91	0.10	44,52,64,67	0
4	DMS	D	604	4/4	0.92	0.16	66,71,83,91	0
4	DMS	B	603	4/4	0.94	0.12	62,65,66,77	0
3	STL	B	602	17/17	0.97	0.06	31,34,41,44	0
3	STL	A	602	17/17	0.97	0.06	35,36,40,44	0
3	STL	D	602	17/17	0.97	0.06	32,35,39,41	0
3	STL	C	602	17/17	0.98	0.05	31,35,39,39	0
2	CO	A	601	1/1	1.00	0.01	35,35,35,35	0
2	CO	B	601	1/1	1.00	0.01	33,33,33,33	0
2	CO	C	601	1/1	1.00	0.01	35,35,35,35	0
2	CO	D	601	1/1	1.00	0.01	33,33,33,33	0

6.5 Other polymers ⓘ

There are no such residues in this entry.