



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 6, 2026 – 03:05 PM UTC

PDB ID : 5KJB / pdb_00005kjb
Title : Synechocystis apocarotenoid oxygenase (ACO) mutant - Glu150Asp
Authors : Sui, X.; Kiser, P.D.; Palczewski, K.
Deposited on : 2016-06-18
Resolution : 2.81 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

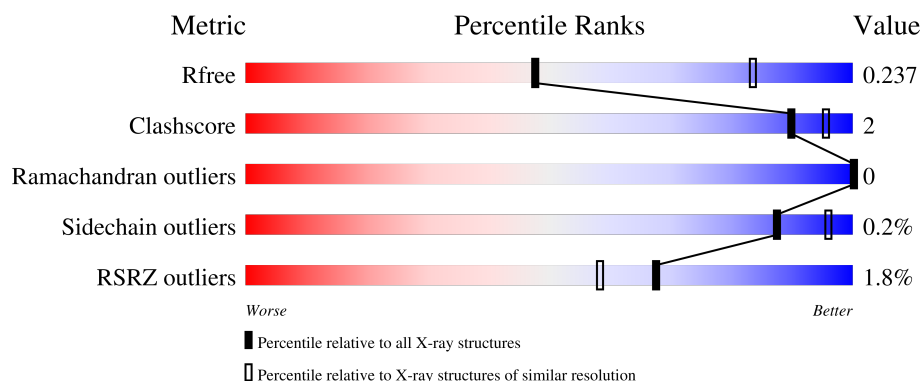
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.81 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	4591 (2.84-2.80)
Clashscore	190562	5010 (2.84-2.80)
Ramachandran outliers	187476	4916 (2.84-2.80)
Sidechain outliers	187428	4918 (2.84-2.80)
RSRZ outliers	180081	4594 (2.84-2.80)

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	94%
1	B	490	93%
1	C	490	% 93% 5%
1	D	490	% 92% 6%
1	E	490	6% 94%

2 Entry composition

There are 3 unique types of molecules in this entry. The entry contains 18909 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	479	Total	C	N	O	S	0	0	0
			3767	2416	650	691	10			
1	B	479	Total	C	N	O	S	0	0	0
			3767	2416	650	691	10			
1	C	479	Total	C	N	O	S	0	0	0
			3767	2416	650	691	10			
1	D	479	Total	C	N	O	S	0	0	0
			3767	2416	650	691	10			
1	E	479	Total	C	N	O	S	0	0	0
			3767	2416	650	691	10			

There are 5 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	150	ASP	GLU	engineered mutation	UNP P74334
B	150	ASP	GLU	engineered mutation	UNP P74334
C	150	ASP	GLU	engineered mutation	UNP P74334
D	150	ASP	GLU	engineered mutation	UNP P74334
E	150	ASP	GLU	engineered mutation	UNP P74334

- 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		
2	E	1	Total	Fe	0	0
			1	1		

- Molecule 3 is water.

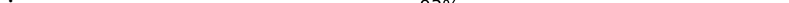
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	A	16	Total 16	O 16	0	0
3	B	21	Total 21	O 21	0	0
3	C	18	Total 18	O 18	0	0
3	D	12	Total 12	O 12	0	0
3	E	2	Total 2	O 2	0	0

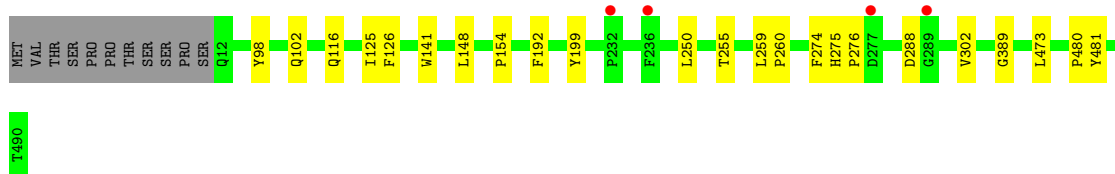
- Molecule 1: Apocarotenoid-15,15'-oxygenase

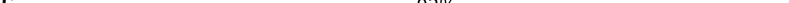


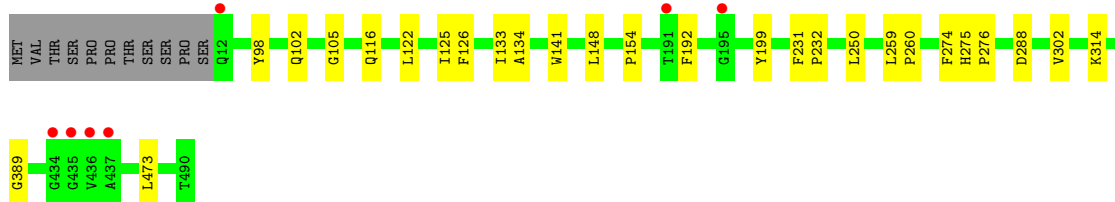
- Chain B: 93% . .



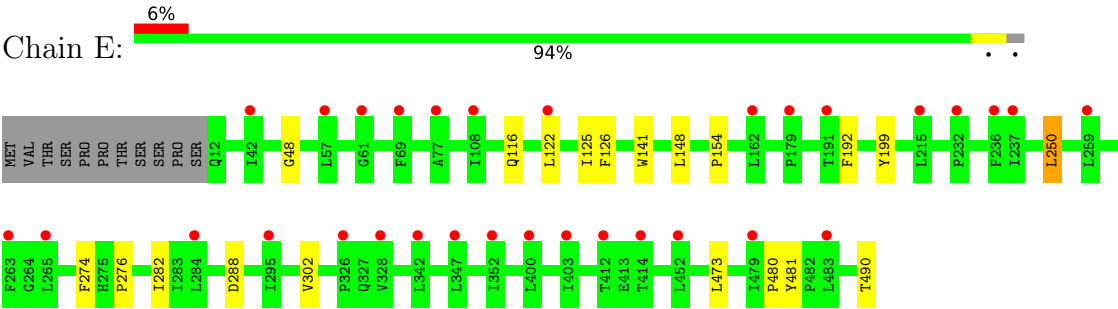
- Chain C:  93% 5% 2%



- Chain D:  92% 6% 2%



- 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	118.42Å 124.95Å 203.97Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	48.58 – 2.81 48.58 – 2.81	Depositor EDS
% Data completeness (in resolution range)	99.7 (48.58-2.81) 100.0 (48.58-2.81)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.35 (at 2.81Å)	Xtriage
Refinement program	REFMAC 5.8.0049	Depositor
R, R_{free}	0.202 , 0.233 0.207 , 0.237	Depositor DCC
R_{free} test set	3583 reflections (4.80%)	wwPDB-VP
Wilson B-factor (Å ²)	62.5	Xtriage
Anisotropy	0.063	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.30 , 48.4	EDS
L-test for twinning ²	$\langle L \rangle = 0.46$, $\langle L^2 \rangle = 0.29$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.94	EDS
Total number of atoms	18909	wwPDB-VP
Average B, all atoms (Å ²)	73.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 2.72% 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

Bond lengths and bond angles in the following residue types are not validated in this section: 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	0.79	0/3880	0.87	3/5284 (0.1%)
1	B	0.81	0/3880	0.88	1/5284 (0.0%)
1	C	0.77	0/3880	0.87	2/5284 (0.0%)
1	D	0.76	0/3880	0.88	5/5284 (0.1%)
1	E	0.66	0/3880	0.83	1/5284 (0.0%)
All	All	0.76	0/19400	0.87	12/26420 (0.0%)

There are no bond length outliers.

All (12) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	B	277	ASP	N-CA-C	9.45	121.27	110.97
1	D	116	GLN	N-CA-C	5.89	115.70	108.11
1	C	116	GLN	N-CA-C	5.56	115.29	108.11
1	D	314	LYS	N-CA-C	5.54	118.72	110.14
1	D	275	HIS	CA-C-N	5.51	125.35	119.28
1	D	275	HIS	C-N-CA	5.51	125.35	119.28
1	A	116	GLN	N-CA-C	5.40	115.07	108.11
1	E	116	GLN	N-CA-C	5.36	115.03	108.11
1	D	389	GLY	N-CA-C	-5.14	105.18	112.37
1	C	389	GLY	N-CA-C	-5.11	105.22	112.37
1	A	275	HIS	CA-C-N	5.01	124.80	119.28
1	A	275	HIS	C-N-CA	5.01	124.80	119.28

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	3767	0	3657	12	0
1	B	3767	0	3657	14	0
1	C	3767	0	3657	14	0
1	D	3767	0	3657	15	0
1	E	3767	0	3657	14	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
2	E	1	0	0	0	0
3	A	16	0	0	0	0
3	B	21	0	0	1	0
3	C	18	0	0	0	0
3	D	12	0	0	0	0
3	E	2	0	0	0	0
All	All	18909	0	18285	68	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 (68) 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:274:PHE:CZ	1:A:276:PRO:HA	2.18	0.79
1:C:274:PHE:CZ	1:C:276:PRO:HA	2.24	0.72
1:E:274:PHE:CZ	1:E:276:PRO:HA	2.25	0.71
1:D:274:PHE:CZ	1:D:276:PRO:HA	2.29	0.67
1:E:250:LEU:CD1	1:E:282:ILE:HG12	2.29	0.63
1:A:250:LEU:HD22	1:A:302:VAL:HB	1.85	0.59
1:D:250:LEU:HD22	1:D:302:VAL:HB	1.85	0.58
1:B:250:LEU:HD22	1:B:302:VAL:HB	1.85	0.58
1:C:250:LEU:HD22	1:C:302:VAL:HB	1.85	0.58
1:B:90:SER:OG	3:B:601:HOH:O	2.18	0.56
1:B:125:ILE:HG12	1:B:126:PHE:CD2	2.45	0.52
1:E:125:ILE:HG12	1:E:126:PHE:CD2	2.46	0.51

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:E:250:LEU:HD22	1:E:302:VAL:HG21	1.93	0.51
1:D:192:PHE:CE1	1:D:288:ASP:HB3	2.46	0.51
1:D:231:PHE:CD1	1:D:232:PRO:HD2	2.46	0.51
1:D:250:LEU:C	1:D:250:LEU:HD23	2.36	0.50
1:C:125:ILE:HG12	1:C:126:PHE:CD2	2.45	0.50
1:B:192:PHE:CE1	1:B:288:ASP:HB3	2.47	0.50
1:D:231:PHE:CE2	1:D:232:PRO:O	2.64	0.50
1:A:125:ILE:HG12	1:A:126:PHE:CD2	2.46	0.50
1:D:125:ILE:HG12	1:D:126:PHE:CD2	2.46	0.49
1:E:148:LEU:HD23	1:E:154:PRO:HB3	1.95	0.49
1:C:192:PHE:CE1	1:C:288:ASP:HB3	2.48	0.49
1:A:192:PHE:CE1	1:A:288:ASP:HB3	2.47	0.49
1:C:255:THR:HG23	1:C:275:HIS:HE1	1.78	0.49
1:E:192:PHE:CE1	1:E:288:ASP:HB3	2.49	0.48
1:D:148:LEU:HD23	1:D:154:PRO:HB3	1.95	0.48
1:E:250:LEU:HD12	1:E:282:ILE:HG12	1.96	0.47
1:A:22:ARG:HG3	1:A:25:GLN:HE21	1.79	0.47
1:C:148:LEU:HD23	1:C:154:PRO:HB3	1.96	0.47
1:A:141:TRP:CE2	1:A:199:TYR:HB2	2.50	0.46
1:A:148:LEU:HD23	1:A:154:PRO:HB3	1.97	0.46
1:B:141:TRP:CE2	1:B:199:TYR:HB2	2.50	0.46
1:B:250:LEU:C	1:B:250:LEU:HD23	2.40	0.46
1:C:473:LEU:CD1	1:C:473:LEU:N	2.79	0.46
1:A:480:PRO:O	1:A:481:TYR:C	2.58	0.46
1:B:148:LEU:HD23	1:B:154:PRO:HB3	1.96	0.45
1:E:141:TRP:CE2	1:E:199:TYR:HB2	2.51	0.45
1:C:473:LEU:N	1:C:473:LEU:HD12	2.31	0.45
1:A:250:LEU:C	1:A:250:LEU:HD23	2.42	0.44
1:D:141:TRP:CE2	1:D:199:TYR:HB2	2.51	0.44
1:C:250:LEU:HD23	1:C:250:LEU:C	2.43	0.44
1:C:255:THR:HG23	1:C:275:HIS:CE1	2.53	0.44
1:B:473:LEU:N	1:B:473:LEU:CD1	2.81	0.43
1:C:141:TRP:CE2	1:C:199:TYR:HB2	2.53	0.43
1:A:473:LEU:N	1:A:473:LEU:CD1	2.81	0.43
1:B:274:PHE:CG	1:B:325:LEU:HD12	2.53	0.43
1:C:98:TYR:O	1:C:102:GLN:HG2	2.18	0.43
1:E:250:LEU:HD22	1:E:302:VAL:CG2	2.47	0.43
1:B:473:LEU:N	1:B:473:LEU:HD12	2.33	0.43
1:D:473:LEU:CD1	1:D:473:LEU:N	2.82	0.43
1:D:473:LEU:N	1:D:473:LEU:HD12	2.34	0.43
1:B:22:ARG:NH2	1:D:105:GLY:HA2	2.34	0.43

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:E:480:PRO:O	1:E:481:TYR:C	2.61	0.42
1:A:473:LEU:N	1:A:473:LEU:HD12	2.34	0.42
1:B:254:VAL:HG12	1:B:274:PHE:CD1	2.55	0.42
1:E:250:LEU:HD22	1:E:302:VAL:HB	2.01	0.42
1:E:473:LEU:HD12	1:E:473:LEU:N	2.34	0.41
1:C:259:LEU:N	1:C:260:PRO:CD	2.83	0.41
1:E:473:LEU:N	1:E:473:LEU:CD1	2.83	0.41
1:B:48:GLY:HA2	1:B:490:THR:HG23	2.02	0.41
1:B:133:ILE:O	1:B:134:ALA:C	2.63	0.41
1:D:98:TYR:O	1:D:102:GLN:HG2	2.21	0.41
1:D:259:LEU:N	1:D:260:PRO:CD	2.83	0.41
1:D:133:ILE:O	1:D:134:ALA:C	2.64	0.41
1:A:212:LEU:C	1:A:212:LEU:HD13	2.46	0.41
1:E:48:GLY:HA2	1:E:490:THR:HG23	2.03	0.41
1:C:480:PRO:O	1:C:481:TYR:C	2.64	0.41

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	477/490 (97%)	461 (97%)	16 (3%)	0	100	100
1	B	477/490 (97%)	461 (97%)	16 (3%)	0	100	100
1	C	477/490 (97%)	462 (97%)	15 (3%)	0	100	100
1	D	477/490 (97%)	460 (96%)	17 (4%)	0	100	100
1	E	477/490 (97%)	463 (97%)	14 (3%)	0	100	100
All	All	2385/2450 (97%)	2307 (97%)	78 (3%)	0	100	100

There are no Ramachandran outliers to report.

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	399/410 (97%)	399 (100%)	0	100	100
1	B	399/410 (97%)	399 (100%)	0	100	100
1	C	399/410 (97%)	399 (100%)	0	100	100
1	D	399/410 (97%)	398 (100%)	1 (0%)	86	95
1	E	399/410 (97%)	397 (100%)	2 (0%)	81	93
All	All	1995/2050 (97%)	1992 (100%)	3 (0%)	87	96

All (3) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	D	122	LEU
1	E	122	LEU
1	E	250	LEU

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (18) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	29	GLN
1	A	253	ASN
1	A	298	GLN
1	B	25	GLN
1	B	27	GLN
1	B	29	GLN
1	B	253	ASN
1	B	298	GLN
1	B	401	GLN
1	C	12	GLN
1	C	253	ASN
1	C	298	GLN
1	D	253	ASN
1	D	298	GLN
1	E	12	GLN

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Mol	Chain	Res	Type
1	E	29	GLN
1	E	253	ASN
1	E	298	GLN

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 5 ligands modelled in this entry, 5 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	479/490 (97%)	-0.26	1 (0%) 91 89	29, 54, 92, 128	0
1	B	479/490 (97%)	-0.31	1 (0%) 91 89	27, 51, 84, 131	0
1	C	479/490 (97%)	-0.27	4 (0%) 82 75	30, 56, 95, 148	0
1	D	479/490 (97%)	-0.01	7 (1%) 72 63	30, 60, 107, 135	0
1	E	479/490 (97%)	0.86	31 (6%) 25 18	78, 131, 174, 227	0
All	All	2395/2450 (97%)	0.00	44 (1%) 67 58	27, 61, 148, 227	0

All (44) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	D	436	VAL	3.4
1	E	42	ILE	3.3
1	E	452	LEU	3.2
1	D	195	GLY	3.2
1	E	236	PHE	3.1
1	C	277	ASP	3.1
1	E	259	LEU	3.1
1	E	191	THR	3.0
1	C	289	GLY	3.0
1	E	352	ILE	2.8
1	D	434	GLY	2.7
1	E	215	LEU	2.6
1	E	483	LEU	2.6
1	D	191	THR	2.6
1	E	479	ILE	2.5
1	E	414	THR	2.5
1	D	435	GLY	2.4
1	E	412	THR	2.4
1	E	342	LEU	2.4
1	B	236	PHE	2.3

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Mol	Chain	Res	Type	RSRZ
1	E	237	ILE	2.3
1	E	69	PHE	2.3
1	A	121	TRP	2.3
1	E	122	LEU	2.2
1	E	284	LEU	2.2
1	E	232	PRO	2.2
1	E	61	GLY	2.2
1	D	12	GLN	2.2
1	C	232	PRO	2.2
1	C	236	PHE	2.2
1	E	326	PRO	2.2
1	E	162	LEU	2.2
1	E	108	ILE	2.1
1	E	403	ILE	2.1
1	E	347	LEU	2.1
1	E	263	PHE	2.1
1	E	265	LEU	2.1
1	D	437	ALA	2.1
1	E	57	LEU	2.1
1	E	77	ALA	2.1
1	E	295	ILE	2.1
1	E	400	LEU	2.0
1	E	179	PRO	2.0
1	E	328	VAL	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 [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($\text{\AA}^2$)	Q<0.9
2	FE2	E	501	1/1	0.81	0.15	147,147,147,147	0
2	FE2	B	501	1/1	0.88	0.12	86,86,86,86	0
2	FE2	D	501	1/1	0.89	0.11	87,87,87,87	0
2	FE2	C	501	1/1	0.93	0.08	89,89,89,89	0
2	FE2	A	501	1/1	0.94	0.08	85,85,85,85	0

6.5 Other polymers [i](#)

There are no such residues in this entry.