



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 9, 2026 – 09:49 PM UTC

PDB ID : 1T2X / pdb_00001t2x
Title : Glactose oxidase C383S mutant identified by directed evolution
Authors : Wilkinson, D.; Akumanyi, N.; Hurtado-Guerrero, R.; Dawkes, H.; Knowles, P.F.; Phillips, S.E.V.; McPherson, M.J.
Deposited on : 2004-04-23
Resolution : 2.30 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

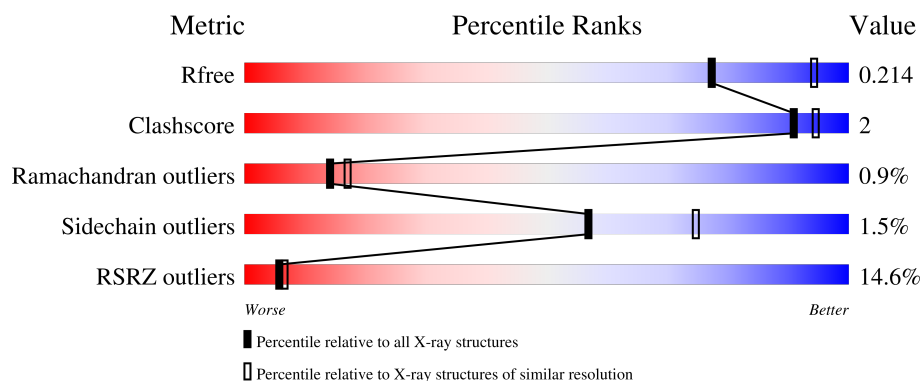
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 2.30 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	6319 (2.30-2.30)
Clashscore	190562	6919 (2.30-2.30)
Ramachandran outliers	187476	6854 (2.30-2.30)
Sidechain outliers	187428	6854 (2.30-2.30)
RSRZ outliers	180081	6325 (2.30-2.30)

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	639	15% 91% 8%

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	ACT	A	643	-	-	-	X

2 Entry composition [i](#)

There are 5 unique types of molecules in this entry. The entry contains 5156 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 Galactose Oxidase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	639	Total	C	N	O	S	0	0	0
			4829	3017	840	954	18			

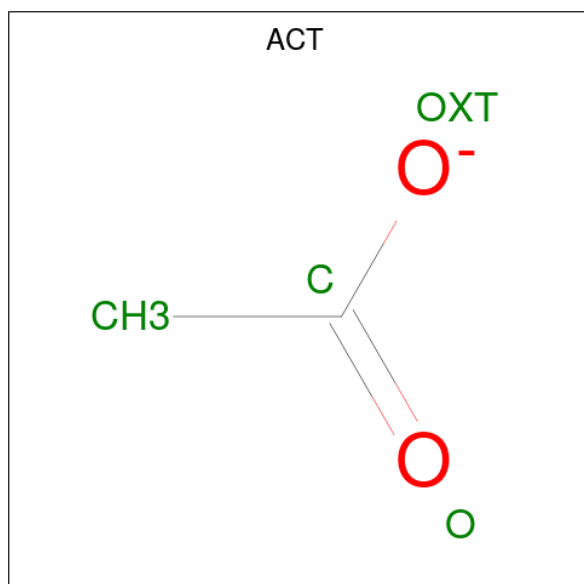
- Molecule 2 is SODIUM ION (CCD ID: NA) (formula: Na).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
2	A	1	Total	Na	0	0
			1	1		

- Molecule 3 is COPPER (II) ION (CCD ID: CU) (formula: Cu).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
3	A	1	Total	Cu	0	0
			1	1		

- Molecule 4 is ACETATE ION (CCD ID: ACT) (formula: C₂H₃O₂).



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

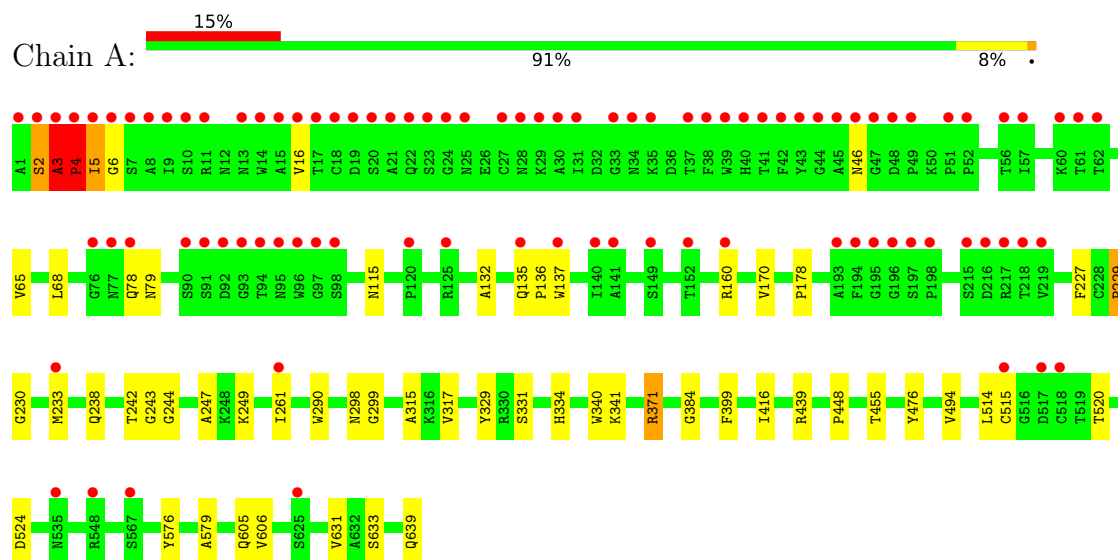
- Molecule 5 is water.

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
5	A	313	Total O 313 313	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: Galactose Oxidase



4 Data and refinement statistics

Property	Value	Source
Space group	C 1 2 1	Depositor
Cell constants a, b, c, α , β , γ	97.38Å 89.00Å 85.80Å 90.00° 117.49° 90.00°	Depositor
Resolution (Å)	61.98 – 2.30 61.98 – 2.30	Depositor EDS
% Data completeness (in resolution range)	99.2 (61.98-2.30) 99.2 (61.98-2.30)	Depositor EDS
R_{merge}	0.10	Depositor
R_{sym}	0.09	Depositor
$\langle I/\sigma(I) \rangle$ ¹	3.00 (at 2.29Å)	Xtriage
Refinement program	CNS	Depositor
R, R_{free}	0.218 , 0.228 0.217 , 0.214	Depositor DCC
R_{free} test set	1463 reflections (5.10%)	wwPDB-VP
Wilson B-factor (Å ²)	26.0	Xtriage
Anisotropy	0.206	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.37 , 41.8	EDS
L-test for twinning ²	$\langle L \rangle = 0.50$, $\langle L^2 \rangle = 0.33$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.92	EDS
Total number of atoms	5156	wwPDB-VP
Average B, all atoms (Å ²)	30.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 5.58% 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: ACT, NA, CU

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	0.69	2/4958 (0.0%)	1.36	37/6765 (0.5%)

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	639	GLN	C-O	6.86	1.37	1.23
1	A	3	ALA	CA-C	5.28	1.59	1.52

All (37) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	3	ALA	CA-C-N	47.91	179.73	119.84
1	A	3	ALA	C-N-CA	47.91	179.73	119.84
1	A	2	SER	N-CA-C	13.57	126.15	108.24
1	A	3	ALA	C-N-CD	-11.56	77.60	125.00
1	A	247	ALA	N-CA-C	8.86	123.09	111.75
1	A	4	PRO	N-CA-C	8.78	130.56	112.47
1	A	639	GLN	CA-C-O	-8.52	106.31	120.80
1	A	3	ALA	N-CA-C	8.46	128.50	109.81
1	A	606	VAL	N-CA-C	-8.25	101.53	108.63
1	A	631	VAL	N-CA-C	-8.17	101.14	110.05
1	A	5	ILE	N-CA-C	8.05	126.09	109.34
1	A	299	GLY	N-CA-C	7.49	120.57	112.33
1	A	4	PRO	CA-N-CD	-6.97	102.24	112.00
1	A	137	TRP	N-CA-C	6.79	120.51	110.46
1	A	170	VAL	N-CA-C	-6.65	101.51	107.56
1	A	524	ASP	N-CA-C	6.57	117.25	108.38
1	A	230	GLY	N-CA-C	-6.51	99.59	111.25
1	A	249	LYS	N-CA-C	6.30	119.06	110.55
1	A	242	THR	N-CA-C	6.27	119.69	109.59

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Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	399	PHE	N-CA-C	6.21	118.57	108.76
1	A	331	SER	N-CA-C	6.17	119.91	112.38
1	A	65	VAL	N-CA-C	5.98	116.78	109.30
1	A	384	GLY	N-CA-C	-5.87	104.16	112.37
1	A	315	ALA	N-CA-C	-5.76	98.54	108.56
1	A	243	GLY	N-CA-C	5.71	121.44	111.50
1	A	371	ARG	N-CA-C	-5.56	101.42	109.59
1	A	136	PRO	N-CA-C	5.47	120.76	114.03
1	A	178	PRO	N-CA-C	5.46	121.88	113.75
1	A	520	THR	N-CA-C	5.43	118.91	112.72
1	A	455	THR	N-CA-C	5.34	117.37	108.99
1	A	2	SER	CA-C-N	5.25	134.61	121.80
1	A	2	SER	C-N-CA	5.25	134.61	121.80
1	A	132	ALA	N-CA-C	5.22	118.44	111.75
1	A	334	HIS	N-CA-C	5.21	118.39	111.30
1	A	16	VAL	N-CA-C	5.19	115.44	108.17
1	A	633	SER	N-CA-C	-5.13	100.16	108.52
1	A	579	ALA	N-CA-C	5.00	117.30	108.75

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	4829	0	4603	16	0
2	A	1	0	0	0	0
3	A	1	0	0	0	0
4	A	12	0	9	2	0
5	A	313	0	0	0	0
All	All	5156	0	4612	16	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 (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:A:78:GLN:HE21	1:A:135:GLN:HE22	1.43	0.67
1:A:371:ARG:HE	4:A:642:ACT:H3	1.59	0.65
1:A:298:ASN:HD22	1:A:317:VAL:H	1.50	0.58
1:A:3:ALA:CB	1:A:115:ASN:HD21	2.18	0.56
1:A:3:ALA:HB1	1:A:115:ASN:HD21	1.73	0.54
1:A:78:GLN:NE2	1:A:135:GLN:HE22	2.08	0.50
1:A:298:ASN:ND2	1:A:317:VAL:H	2.10	0.50
1:A:233:MET:HE1	1:A:576:TYR:HB2	1.96	0.48
1:A:605:GLN:NE2	4:A:644:ACT:O	2.47	0.48
1:A:290:TRP:CD1	1:A:329:TYR:HH	2.32	0.47
1:A:238:GLN:HE22	1:A:261:ILE:HD11	1.80	0.47
1:A:340:TRP:CG	1:A:341:LYS:H	2.35	0.44
1:A:4:PRO:O	1:A:6:GLY:N	2.52	0.43
1:A:416:ILE:HD11	1:A:476:TYR:OH	2.19	0.42
1:A:2:SER:OG	1:A:3:ALA:N	2.50	0.41
1:A:227:PHE:O	1:A:244:GLY:HA3	2.21	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	637/639 (100%)	603 (95%)	28 (4%)	6 (1%)	14 17

All (6) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	3	ALA
1	A	4	PRO
1	A	5	ILE
1	A	79	ASN
1	A	494	VAL
1	A	229	PRO

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	526/526 (100%)	518 (98%)	8 (2%)	57 75

All (8) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	46	ASN
1	A	68	LEU
1	A	160	ARG
1	A	229	PRO
1	A	439	ARG
1	A	448	PRO
1	A	514	LEU
1	A	515	CYS

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (14) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	25	ASN
1	A	64	ASN
1	A	115	ASN
1	A	135	GLN
1	A	144	ASN
1	A	155	GLN
1	A	238	GLN
1	A	267	GLN
1	A	298	ASN
1	A	333	ASN
1	A	385	ASN
1	A	413	ASN
1	A	597	ASN
1	A	600	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](#)

Of 5 ligands modelled in this entry, 2 are monoatomic - leaving 3 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	ACT	A	643	-	3,3,3	1.27	1 (33%)	3,3,3	0.76	0
4	ACT	A	644	-	3,3,3	1.28	1 (33%)	3,3,3	0.76	0
4	ACT	A	642	-	3,3,3	1.08	0	3,3,3	0.71	0

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
4	A	644	ACT	O-C	2.14	1.31	1.22
4	A	643	ACT	O-C	2.13	1.31	1.22

There are no bond angle outliers.

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	644	ACT	1	0
4	A	642	ACT	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

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	639/639 (100%)	0.69	93 (14%) 6 6	9, 26, 66, 80	0

All (93) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	5	ILE	7.1
1	A	3	ALA	6.5
1	A	1	ALA	6.1
1	A	46	ASN	5.2
1	A	45	ALA	5.0
1	A	94	THR	4.9
1	A	96	TRP	4.4
1	A	2	SER	4.4
1	A	47	GLY	4.2
1	A	14	TRP	4.0
1	A	195	GLY	4.0
1	A	8	ALA	3.9
1	A	16	VAL	3.8
1	A	6	GLY	3.7
1	A	28	ASN	3.6
1	A	91	SER	3.6
1	A	135	GLN	3.6
1	A	38	PHE	3.6
1	A	57	ILE	3.6
1	A	15	ALA	3.6
1	A	44	GLY	3.5
1	A	61	THR	3.3
1	A	4	PRO	3.3
1	A	13	ASN	3.2
1	A	41	THR	3.2
1	A	42	PHE	3.2
1	A	29	LYS	3.2

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Mol	Chain	Res	Type	RSRZ
1	A	97	GLY	3.1
1	A	196	GLY	3.1
1	A	30	ALA	3.1
1	A	34	ASN	3.1
1	A	9	ILE	3.1
1	A	22	GLN	3.0
1	A	20	SER	3.0
1	A	198	PRO	3.0
1	A	21	ALA	2.9
1	A	24	GLY	2.9
1	A	219	VAL	2.9
1	A	31	ILE	2.9
1	A	43	TYR	2.8
1	A	37	THR	2.8
1	A	78	GLN	2.8
1	A	25	ASN	2.7
1	A	23	SER	2.7
1	A	197	SER	2.7
1	A	137	TRP	2.7
1	A	233	MET	2.6
1	A	18	CYS	2.6
1	A	92	ASP	2.6
1	A	10	SER	2.6
1	A	125	ARG	2.6
1	A	216	ASP	2.6
1	A	215	SER	2.6
1	A	535	ASN	2.5
1	A	140	ILE	2.5
1	A	27	CYS	2.5
1	A	625	SER	2.5
1	A	62	THR	2.4
1	A	261	ILE	2.4
1	A	19	ASP	2.4
1	A	39	TRP	2.4
1	A	40	HIS	2.4
1	A	160	ARG	2.3
1	A	49	PRO	2.3
1	A	193	ALA	2.3
1	A	17	THR	2.3
1	A	11	ARG	2.3
1	A	548	ARG	2.3
1	A	218	THR	2.3

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Mol	Chain	Res	Type	RSRZ
1	A	217	ARG	2.2
1	A	141	ALA	2.2
1	A	515	CYS	2.2
1	A	7	SER	2.2
1	A	98	SER	2.2
1	A	517	ASP	2.2
1	A	51	PRO	2.2
1	A	35	LYS	2.2
1	A	33	GLY	2.2
1	A	93	GLY	2.2
1	A	52	PRO	2.1
1	A	90	SER	2.1
1	A	194	PHE	2.1
1	A	76	GLY	2.1
1	A	149	SER	2.1
1	A	518	CYS	2.1
1	A	567	SER	2.1
1	A	48	ASP	2.1
1	A	77	ASN	2.1
1	A	120	PRO	2.1
1	A	60	LYS	2.0
1	A	56	THR	2.0
1	A	152	THR	2.0
1	A	95	ASN	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
4	ACT	A	644	4/4	0.68	0.25	40,41,42,42	0
4	ACT	A	642	4/4	0.69	0.22	18,20,22,25	0
4	ACT	A	643	4/4	0.71	0.72	37,37,37,37	4
2	NA	A	640	1/1	0.89	0.16	30,30,30,30	0
3	CU	A	641	1/1	0.97	0.06	30,30,30,30	0

6.5 Other polymers [i](#)

There are no such residues in this entry.