



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 6, 2026 – 09:18 PM UTC

PDB ID : 1R6X / pdb_00001r6x
Title : The Crystal Structure of a Truncated Form of Yeast ATP Sulfurylase, Lacking the C-Terminal APS Kinase-like Domain, in complex with Sulfate
Authors : Lalor, D.J.; Schnyder, T.; Saridakis, V.; Pilloff, D.E.; Dong, A.; Tang, H.; Leyh, T.S.; Pai, E.F.
Deposited on : 2003-10-17
Resolution : 1.40 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

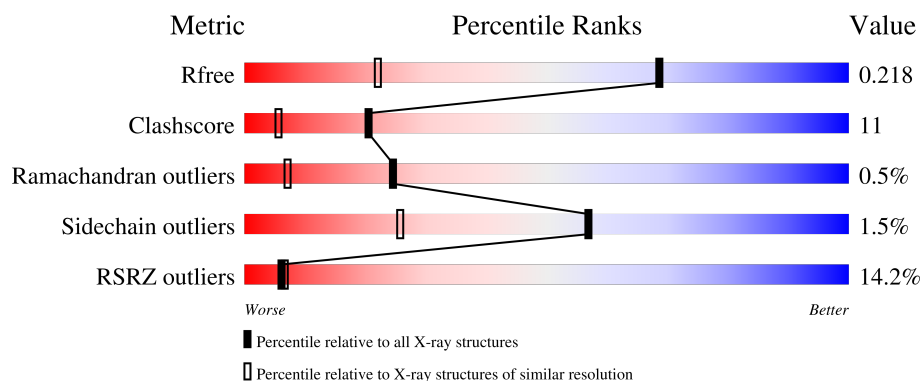
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 1.40 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	2563 (1.40-1.40)
Clashscore	190562	2660 (1.40-1.40)
Ramachandran outliers	187476	2611 (1.40-1.40)
Sidechain outliers	187428	2610 (1.40-1.40)
RSRZ outliers	180081	2561 (1.40-1.40)

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	395	14% 78% 18% ..

2 Entry composition [i](#)

There are 4 unique types of molecules in this entry. The entry contains 3546 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.

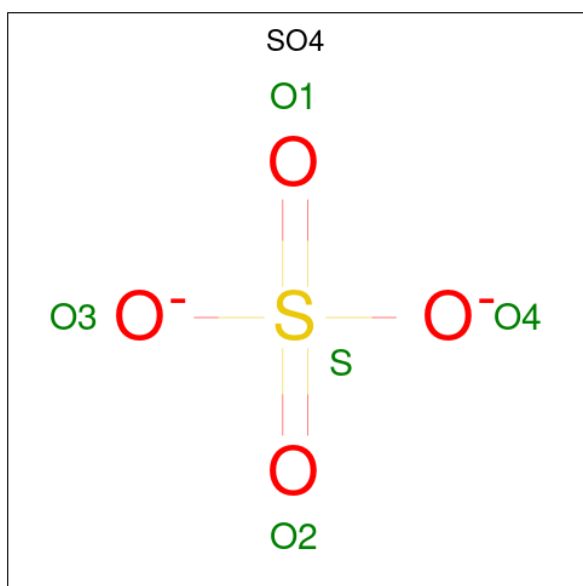
- Molecule 1 is a protein called ATP:sulfate adenylyltransferase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	386	Total	C	N	O	S	0	0	0
			3098	1971	547	575	5			

There are 3 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	394	GLY	-	cloning artifact	UNP P08536
A	395	SER	-	cloning artifact	UNP P08536
A	396	SER	-	cloning artifact	UNP P08536

- Molecule 2 is SULFATE ION (CCD ID: SO4) (formula: O₄S).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
2	A	1	Total	O	S	0	0
			5	4	1		
2	A	1	Total	O	S	0	0
			5	4	1		

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Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
2	A	1	Total	O	S	0	0
			5	4	1		

- Molecule 3 is COBALT (II) ION (CCD ID: CO) (formula: Co).

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

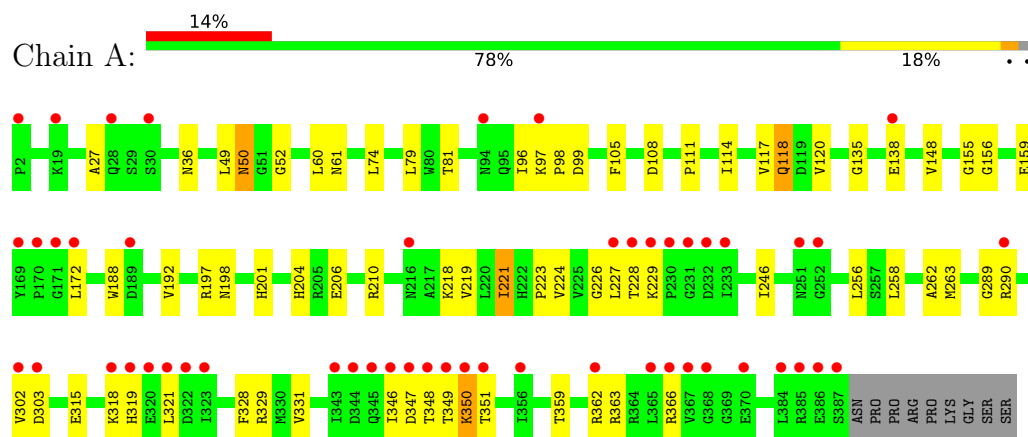
- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	432	Total	O	0	0
			432	432		

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: ATP:sulfate adenylyltransferase



4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, α , β , γ	50.19Å 59.11Å 131.16Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	39.86 – 1.40 39.86 – 1.40	Depositor EDS
% Data completeness (in resolution range)	86.0 (39.86-1.40) 86.1 (39.86-1.40)	Depositor EDS
R_{merge}	(Not available)	Depositor
R_{sym}	0.04	Depositor
$\langle I/\sigma(I) \rangle$ ¹	3.42 (at 1.40Å)	Xtriage
Refinement program	CNS	Depositor
R, R_{free}	0.197 , 0.217 0.197 , 0.218	Depositor DCC
R_{free} test set	1342 reflections (1.98%)	wwPDB-VP
Wilson B-factor (Å ²)	12.4	Xtriage
Anisotropy	0.039	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.36 , 35.2	EDS
L-test for twinning ²	$\langle L \rangle = 0.49$, $\langle L^2 \rangle = 0.32$	Xtriage
Estimated twinning fraction	No twinning to report.	Xtriage
F_o, F_c correlation	0.95	EDS
Total number of atoms	3546	wwPDB-VP
Average B, all atoms (Å ²)	16.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 5.43% 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: CO, SO4

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	0.32	0/3173	0.87	12/4315 (0.3%)

There are no bond length outliers.

All (12) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	135	GLY	N-CA-C	8.39	126.67	115.59
1	A	161	ILE	N-CA-C	-7.50	105.11	111.56
1	A	60	LEU	N-CA-C	6.56	119.87	110.10
1	A	81	THR	N-CA-C	6.08	120.97	113.50
1	A	118	GLN	N-CA-C	-5.84	106.19	113.55
1	A	74	LEU	N-CA-C	-5.79	103.29	110.41
1	A	219	VAL	N-CA-C	5.67	116.11	108.17
1	A	290	ARG	N-CA-C	-5.67	101.46	109.96
1	A	117	VAL	N-CA-C	5.50	116.17	109.30
1	A	159	GLU	N-CA-C	-5.21	100.41	108.90
1	A	148	VAL	N-CA-C	5.07	116.48	111.67
1	A	221	ILE	N-CA-C	-5.02	100.55	108.23

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	3098	0	3073	69	0
2	A	15	0	0	0	0
3	A	1	0	0	0	0
4	A	432	0	0	5	0
All	All	3546	0	3073	69	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 11.

All (69) 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:346:ILE:HD12	1:A:351:THR:HG21	1.57	0.86
1:A:201:HIS:H	1:A:204:HIS:HD2	1.24	0.81
1:A:201:HIS:H	1:A:204:HIS:CD2	2.08	0.72
1:A:172:LEU:HD23	1:A:258:LEU:HD11	1.74	0.70
1:A:228:THR:HA	1:A:263:MET:HE3	1.73	0.69
1:A:228:THR:HG22	1:A:263:MET:CE	2.25	0.67
1:A:36:ASN:ND2	1:A:108:ASP:H	1.94	0.66
1:A:36:ASN:HD21	1:A:108:ASP:H	1.42	0.65
1:A:298:ASN:ND2	1:A:302:VAL:H	1.94	0.65
1:A:224:VAL:HG11	1:A:263:MET:HE2	1.78	0.65
1:A:298:ASN:C	1:A:298:ASN:HD22	2.05	0.64
1:A:50:ASN:C	1:A:50:ASN:HD22	2.05	0.64
1:A:289:GLY:HA2	1:A:328:PHE:HB2	1.80	0.63
1:A:363:ARG:HG2	1:A:366:ARG:HH21	1.61	0.63
1:A:50:ASN:ND2	1:A:52:GLY:H	1.97	0.62
1:A:79:LEU:HD23	1:A:321:LEU:HD21	1.80	0.62
1:A:197:ARG:HB3	1:A:263:MET:HE1	1.83	0.60
1:A:359:THR:HA	1:A:362:ARG:HH12	1.67	0.59
1:A:50:ASN:HD22	1:A:52:GLY:H	1.51	0.59
1:A:297:LYS:HB2	1:A:297:LYS:NZ	2.20	0.57
1:A:172:LEU:HG	1:A:258:LEU:HG	1.87	0.56
1:A:227:LEU:HB2	1:A:262:ALA:HA	1.87	0.56
1:A:362:ARG:HB3	1:A:362:ARG:NH1	2.22	0.55
1:A:329:ARG:HD3	4:A:4236:HOH:O	2.06	0.55
1:A:224:VAL:CG1	1:A:263:MET:HE2	2.37	0.53
1:A:297:LYS:HG2	1:A:303:ASP:OD1	2.09	0.53
1:A:289:GLY:HA2	1:A:328:PHE:CB	2.39	0.53
1:A:192:VAL:HG12	1:A:218:LYS:O	2.10	0.52
1:A:197:ARG:HH21	1:A:229:LYS:CD	2.22	0.52
1:A:49:LEU:HD22	1:A:160:ALA:HB2	1.90	0.52

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Atom-1	Atom-2	Interatomic distance (Å)	Clash overlap (Å)
1:A:228:THR:HG22	1:A:263:MET:HE3	1.91	0.51
1:A:210:ARG:HB2	1:A:210:ARG:NH1	2.26	0.50
1:A:197:ARG:HH21	1:A:229:LYS:HD2	1.77	0.50
1:A:98:PRO:O	1:A:99:ASP:HB2	2.12	0.49
1:A:362:ARG:HB3	1:A:362:ARG:HH11	1.77	0.49
1:A:297:LYS:HB2	1:A:297:LYS:HZ2	1.78	0.49
1:A:298:ASN:HD21	1:A:302:VAL:H	1.58	0.49
1:A:118:GLN:HG3	1:A:156:GLY:HA2	1.94	0.48
1:A:298:ASN:ND2	1:A:298:ASN:C	2.72	0.47
1:A:197:ARG:HH11	1:A:197:ARG:HG2	1.79	0.47
1:A:359:THR:HA	1:A:362:ARG:NH1	2.30	0.47
1:A:192:VAL:HG13	1:A:192:VAL:O	2.15	0.47
1:A:349:THR:OG1	1:A:350:LYS:N	2.47	0.46
1:A:315:GLU:O	1:A:318:LYS:HG2	2.16	0.46
1:A:96:ILE:HB	1:A:120:VAL:HG21	1.98	0.46
1:A:362:ARG:HH11	1:A:362:ARG:CB	2.29	0.46
1:A:138:GLU:HG2	4:A:4220:HOH:O	2.16	0.45
1:A:210:ARG:HD2	4:A:4079:HOH:O	2.16	0.45
1:A:50:ASN:C	1:A:50:ASN:ND2	2.72	0.45
1:A:188:TRP:CE2	1:A:218:LYS:HG3	2.51	0.45
1:A:318:LYS:HG3	1:A:319:HIS:ND1	2.32	0.45
1:A:224:VAL:CB	1:A:263:MET:HE2	2.47	0.45
1:A:206:GLU:HB2	1:A:331:VAL:HG21	1.99	0.44
1:A:27:ALA:HB2	1:A:114:ILE:HD11	1.99	0.43
1:A:61:ASN:HA	1:A:155:GLY:HA3	1.99	0.43
1:A:188:TRP:CD2	1:A:218:LYS:HG3	2.53	0.43
1:A:79:LEU:HD23	1:A:321:LEU:CD2	2.45	0.43
1:A:318:LYS:HG2	4:A:4373:HOH:O	2.17	0.43
1:A:228:THR:CA	1:A:263:MET:HE3	2.47	0.42
1:A:297:LYS:HZ2	1:A:297:LYS:CB	2.32	0.42
1:A:221:ILE:C	1:A:223:PRO:HD3	2.45	0.42
1:A:246:ILE:HD12	1:A:256:LEU:HB2	2.00	0.42
1:A:197:ARG:CB	1:A:263:MET:HE1	2.49	0.41
1:A:347:ASP:O	1:A:349:THR:N	2.53	0.41
1:A:105:PHE:CE2	1:A:111:PRO:HG3	2.56	0.40
1:A:298:ASN:ND2	1:A:300:LYS:H	2.18	0.40
1:A:197:ARG:HE	1:A:229:LYS:CB	2.34	0.40
1:A:198:ASN:ND2	4:A:4122:HOH:O	2.55	0.40
1:A:347:ASP:O	1:A:349:THR:HG22	2.22	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	384/395 (97%)	372 (97%)	10 (3%)	2 (0%)	24 7

All (2) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	348	THR
1	A	226	GLY

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	334/342 (98%)	329 (98%)	5 (2%)	57 26

All (5) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	50	ASN
1	A	97	LYS
1	A	297	LYS
1	A	298	ASN
1	A	350	LYS

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (9) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	28	GLN
1	A	36	ASN
1	A	50	ASN
1	A	63	ASN
1	A	95	GLN
1	A	198	ASN
1	A	204	HIS
1	A	298	ASN
1	A	345	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 4 ligands modelled in this entry, 1 is 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	$\# Z > 2$
2	SO4	A	2002	-	4,4,4	0.36	0	6,6,6	0.07	0
2	SO4	A	2005	-	4,4,4	0.38	0	6,6,6	0.07	0
2	SO4	A	2004	-	4,4,4	0.38	0	6,6,6	0.10	0

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	386/395 (97%)	0.61	55 (14%) 6 7	6, 13, 28, 60	0

All (55) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	A	348	THR	10.3
1	A	347	ASP	9.0
1	A	346	ILE	8.8
1	A	349	THR	8.3
1	A	344	ASP	7.0
1	A	345	GLN	6.6
1	A	387	SER	6.5
1	A	231	GLY	5.4
1	A	386	GLU	5.3
1	A	350	LYS	4.9
1	A	351	THR	4.9
1	A	251	ASN	4.4
1	A	385	ARG	4.4
1	A	232	ASP	4.3
1	A	172	LEU	4.1
1	A	168	ASP	3.7
1	A	228	THR	3.6
1	A	216	ASN	3.6
1	A	94	ASN	3.5
1	A	169	TYR	3.4
1	A	319	HIS	3.3
1	A	227	LEU	3.2
1	A	28	GLN	3.2
1	A	366	ARG	3.1
1	A	362	ARG	3.1
1	A	322	ASP	3.1
1	A	229	LYS	3.1

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Mol	Chain	Res	Type	RSRZ
1	A	321	LEU	3.0
1	A	2	PRO	2.9
1	A	302	VAL	2.9
1	A	171	GLY	2.9
1	A	320	GLU	2.9
1	A	230	PRO	2.8
1	A	365	LEU	2.8
1	A	367	VAL	2.7
1	A	138	GLU	2.7
1	A	189	ASP	2.7
1	A	323	ILE	2.6
1	A	303	ASP	2.6
1	A	19	LYS	2.5
1	A	97	LYS	2.5
1	A	356	ILE	2.5
1	A	252	GLY	2.5
1	A	299	SER	2.5
1	A	370	GLU	2.4
1	A	30	SER	2.3
1	A	167	TYR	2.3
1	A	384	LEU	2.3
1	A	300	LYS	2.2
1	A	343	ILE	2.1
1	A	318	LYS	2.1
1	A	233	ILE	2.1
1	A	368	GLY	2.1
1	A	290	ARG	2.1
1	A	170	PRO	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	SO4	A	2004	5/5	0.81	0.16	28,29,31,31	0
2	SO4	A	2005	5/5	0.96	0.08	27,27,28,28	0
2	SO4	A	2002	5/5	0.97	0.08	15,16,17,19	0
3	CO	A	3000	1/1	0.97	0.18	24,24,24,24	0

6.5 Other polymers [i](#)

There are no such residues in this entry.