



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 9, 2026 – 04:32 AM UTC

PDB ID : 9F28 / pdb_00009f28
Title : Crystal structure of the heterodimeric primase from pyrococcus abyssi (deletion of the PriL-CTD domain)
Authors : Madru, C.; Sauguet, L.
Deposited on : 2024-04-22
Resolution : 1.85 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

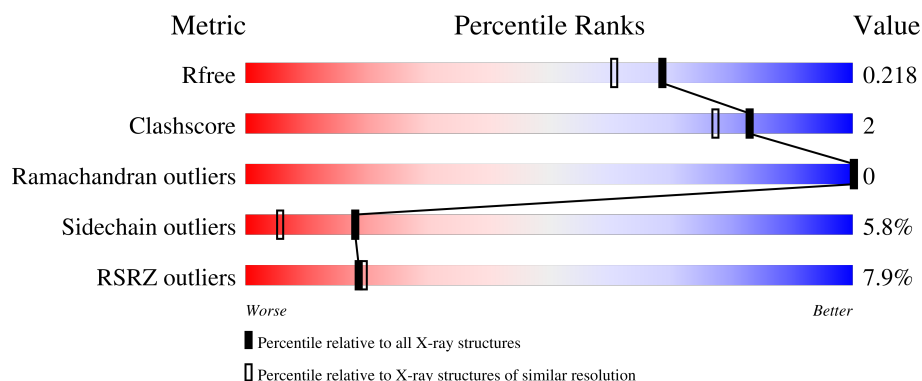
1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

X-RAY DIFFRACTION

The reported resolution of this entry is 1.85 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	3428 (1.86-1.86)
Clashscore	190562	3579 (1.86-1.86)
Ramachandran outliers	187476	3553 (1.86-1.86)
Sidechain outliers	187428	3553 (1.86-1.86)
RSRZ outliers	180081	3429 (1.86-1.86)

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	351	9% 87% 9% ..
2	B	223	6% 87% 7% 5%

2 Entry composition

There are 6 unique types of molecules in this entry. The entry contains 5234 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 DNA primase small subunit PriS.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	344	Total	C	N	O	S	0	1	0
			2861	1836	507	510	8			

There are 6 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	-5	GLY	-	expression tag	UNP Q9V292
A	-4	THR	-	expression tag	UNP Q9V292
A	-3	GLY	-	expression tag	UNP Q9V292
A	-2	ASP	-	expression tag	UNP Q9V292
A	-1	GLY	-	expression tag	UNP Q9V292
A	0	SER	-	expression tag	UNP Q9V292

- Molecule 2 is a protein called DNA primase large subunit PriL.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	B	211	Total	C	N	O	S	0	0	0
			1753	1140	284	326	3			

There are 8 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
B	216	ASP	-	expression tag	UNP Q9V291
B	217	ILE	-	expression tag	UNP Q9V291
B	218	GLY	-	expression tag	UNP Q9V291
B	219	ARG	-	expression tag	UNP Q9V291
B	220	PRO	-	expression tag	UNP Q9V291
B	221	ARG	-	expression tag	UNP Q9V291
B	222	ASP	-	expression tag	UNP Q9V291
B	223	ARG	-	expression tag	UNP Q9V291

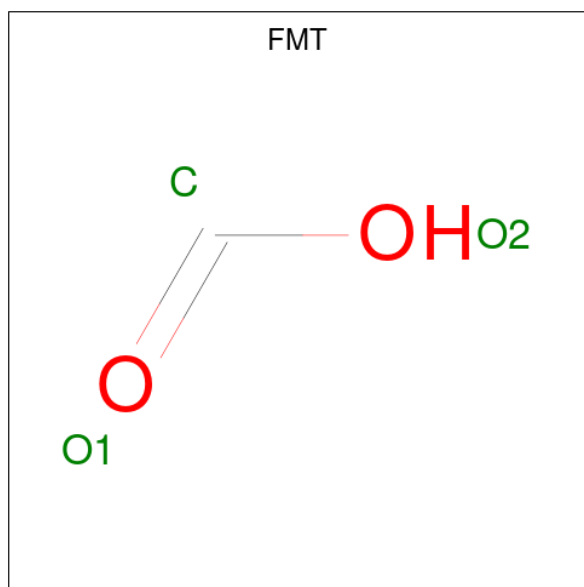
- Molecule 3 is ZINC ION (CCD ID: ZN) (formula: Zn).

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

- Molecule 4 is MAGNESIUM ION (CCD ID: MG) (formula: Mg).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	2	Total	Mg	0	0
			2	2		

- Molecule 5 is FORMIC ACID (CCD ID: FMT) (formula: CH₂O₂).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
5	A	1	Total	C	O	0	0
			3	1	2		
5	B	1	Total	C	O	0	0
			3	1	2		

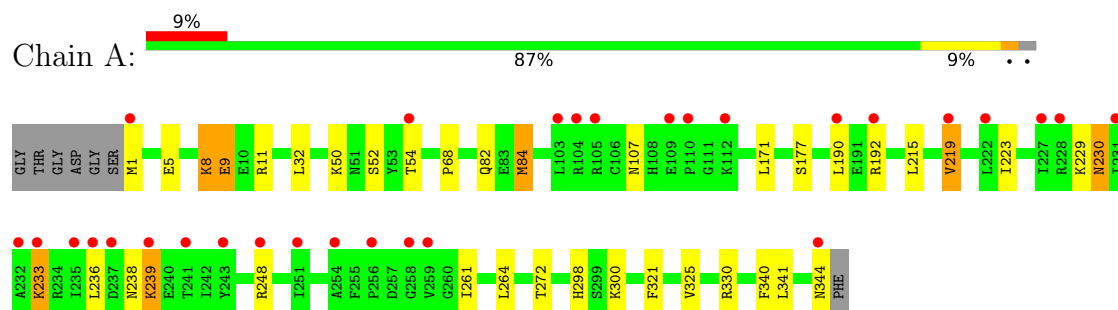
- Molecule 6 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
6	A	365	Total	O	0	0
			365	365		
6	B	246	Total	O	0	0
			246	246		

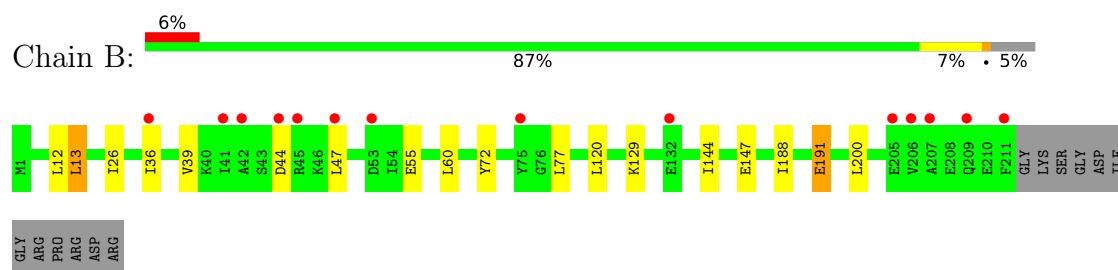
3 Residue-property plots

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: DNA primase small subunit PriS



- Molecule 2: DNA primase large subunit PriL



4 Data and refinement statistics

Property	Value	Source
Space group	P 43 21 2	Depositor
Cell constants a, b, c, α , β , γ	116.57Å 116.57Å 121.08Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	39.51 – 1.85 39.51 – 1.85	Depositor EDS
% Data completeness (in resolution range)	93.4 (39.51-1.85) 93.8 (39.51-1.85)	Depositor EDS
R_{merge}	0.11	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.33 (at 1.84Å)	Xtriage
Refinement program	BUSTER 2.10.4	Depositor
R, R_{free}	0.199 , 0.224 0.192 , 0.218	Depositor DCC
R_{free} test set	3348 reflections (4.99%)	wwPDB-VP
Wilson B-factor (Å ²)	31.1	Xtriage
Anisotropy	0.014	Xtriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.32 , 51.7	EDS
L-test for twinning ²	$\langle L \rangle = 0.50$, $\langle L^2 \rangle = 0.33$	Xtriage
Estimated twinning fraction	0.011 for -h,l,k 0.000 for -l,-k,-h	Xtriage
F_o, F_c correlation	0.96	EDS
Total number of atoms	5234	wwPDB-VP
Average B, all atoms (Å ²)	40.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 2.75% 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: FMT, MG, ZN

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	0.78	1/2929 (0.0%)	1.04	2/3937 (0.1%)
2	B	0.72	1/1785 (0.1%)	0.96	0/2400
All	All	0.76	2/4714 (0.0%)	1.01	2/6337 (0.0%)

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	84	MET	SD-CE	-5.52	1.65	1.79
2	B	26	ILE	CA-CB	5.30	1.56	1.54

All (2) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
1	A	321	PHE	CA-CB-CG	-5.82	107.98	113.80
1	A	325	VAL	N-CA-C	5.82	113.63	107.76

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	2861	0	2869	16	0
2	B	1753	0	1792	5	0

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Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
3	A	1	0	0	0	0
4	A	2	0	0	0	0
5	A	3	0	2	0	0
5	B	3	0	1	1	0
6	A	365	0	0	0	1
6	B	246	0	0	1	2
All	All	5234	0	4664	22	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 2.

All (22) 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:340:PHE:O	1:A:344:ASN:HB2	1.89	0.70
1:A:223:ILE:HD12	1:A:229:LYS:HA	1.75	0.66
1:A:50:LYS:HG3	1:A:84:MET:HE3	1.78	0.65
2:B:144:ILE:HG12	2:B:147:GLU:HG2	1.82	0.61
1:A:215:LEU:HA	1:A:239:LYS:HZ1	1.66	0.59
1:A:223:ILE:CD1	1:A:229:LYS:HA	2.33	0.59
1:A:11:ARG:HD2	1:A:68:PRO:O	2.04	0.58
1:A:8:LYS:H	1:A:8:LYS:NZ	2.02	0.57
1:A:219:VAL:O	1:A:223:ILE:HG12	2.05	0.57
1:A:215:LEU:HA	1:A:239:LYS:NZ	2.22	0.54
5:B:301:FMT:H	6:B:592:HOH:O	2.10	0.50
2:B:188:ILE:O	2:B:191:GLU:HG2	2.15	0.46
2:B:72:TYR:HB2	2:B:200:LEU:HD22	2.00	0.44
1:A:219:VAL:HG13	1:A:236:LEU:HD12	2.00	0.44
1:A:177:SER:HA	1:A:272:THR:HG23	2.00	0.44
1:A:230:ASN:H	1:A:230:ASN:HD22	1.66	0.44
2:B:44:ASP:HB3	2:B:47:LEU:HD12	1.99	0.44
1:A:230:ASN:O	1:A:233:LYS:HG3	2.18	0.43
1:A:52:SER:OG	1:A:82:GLN:HG3	2.19	0.42
1:A:9:GLU:CD	1:A:9:GLU:H	2.28	0.41
1:A:298:HIS:HE1	1:A:300:LYS:HB3	1.86	0.40
2:B:13:LEU:HD13	2:B:60:LEU:HD13	2.03	0.40

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)
6:B:494:HOH:O	6:B:494:HOH:O[8_555]	1.19	1.01
6:A:501:HOH:O	6:B:402:HOH:O[5_545]	2.18	0.02

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	343/351 (98%)	336 (98%)	7 (2%)	0	100	100
2	B	209/223 (94%)	205 (98%)	4 (2%)	0	100	100
All	All	552/574 (96%)	541 (98%)	11 (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	306/309 (99%)	286 (94%)	20 (6%)	15	4
2	B	191/200 (96%)	182 (95%)	9 (5%)	23	9
All	All	497/509 (98%)	468 (94%)	29 (6%)	18	6

All (29) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	1	MET
1	A	5	GLU

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Mol	Chain	Res	Type
1	A	8	LYS
1	A	9	GLU
1	A	32	LEU
1	A	54	THR
1	A	107	ASN
1	A	171	LEU
1	A	190	LEU
1	A	192	ARG
1	A	219	VAL
1	A	230	ASN
1	A	233	LYS
1	A	238	ASN
1	A	239	LYS
1	A	248	ARG
1	A	261	ILE
1	A	264	LEU
1	A	330	ARG
1	A	341	LEU
2	B	12	LEU
2	B	13	LEU
2	B	36	ILE
2	B	39	VAL
2	B	55	GLU
2	B	77	LEU
2	B	120	LEU
2	B	129	LYS
2	B	191	GLU

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (2) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	108	HIS
1	A	199	ASN

5.3.3 RNA ⓘ

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, 3 are monoatomic - leaving 2 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	$\# Z > 2$
5	FMT	B	301	-	2,2,2	0.93	0	1,1,1	0.20	0
5	FMT	A	404	-	2,2,2	1.22	0	1,1,1	0.27	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.

1 monomer is involved in 1 short contact:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
5	B	301	FMT	1	0

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

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	344/351 (98%)	0.36	30 (8%) 16 16	20, 34, 64, 78	1 (0%)
2	B	211/223 (94%)	0.37	14 (6%) 24 26	21, 37, 65, 103	0
All	All	555/574 (96%)	0.36	44 (7%) 18 19	20, 36, 64, 103	1 (0%)

All (44) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
2	B	211	PHE	6.1
1	A	233	LYS	4.2
2	B	75	TYR	3.8
2	B	47	LEU	3.7
1	A	243	TYR	3.6
1	A	258	GLY	3.5
2	B	205	GLU	3.3
1	A	344	ASN	3.3
1	A	235	ILE	3.0
2	B	206	VAL	2.8
1	A	190	LEU	2.8
1	A	231	ILE	2.8
1	A	228[A]	ARG	2.7
2	B	207	ALA	2.7
1	A	239	LYS	2.7
2	B	42	ALA	2.6
1	A	103	LEU	2.6
1	A	254	ALA	2.6
1	A	259	VAL	2.5
2	B	45	ARG	2.5
1	A	236	LEU	2.4
1	A	219	VAL	2.4
2	B	44	ASP	2.4
1	A	192	ARG	2.4

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Mol	Chain	Res	Type	RSRZ
1	A	105	ARG	2.3
1	A	241	THR	2.3
1	A	1	MET	2.2
1	A	256	PRO	2.2
1	A	227	ILE	2.2
1	A	112	LYS	2.2
1	A	104	ARG	2.1
2	B	36	ILE	2.1
1	A	109	GLU	2.1
2	B	132	GLU	2.1
1	A	222	LEU	2.1
1	A	232	ALA	2.1
2	B	41	ILE	2.1
1	A	248	ARG	2.1
1	A	251	ILE	2.0
1	A	54	THR	2.0
2	B	209	GLN	2.0
1	A	237	ASP	2.0
2	B	53	ASP	2.0
1	A	110	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(Å ²)	Q<0.9
5	FMT	B	301	3/3	0.84	0.21	50,50,51,52	0
5	FMT	A	404	3/3	0.87	0.11	49,49,49,50	0
4	MG	A	402	1/1	0.98	0.10	40,40,40,40	0

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Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors($\text{\AA}^2$)	Q<0.9
4	MG	A	403	1/1	0.99	0.07	35,35,35,35	0
3	ZN	A	401	1/1	1.00	0.02	42,42,42,42	0

6.5 Other polymers [i](#)

There are no such residues in this entry.