



# Full wwPDB X-ray Structure Validation Report

Mar 31, 2014 – 02:08 PM BST

PDB ID : 4M0A  
Title : Human DNA Polymerase Mu post-catalytic complex  
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Deposited on : 2013-08-01  
Resolution : 1.85 Å(reported)

This is a full wwPDB validation report for a publicly released PDB entry.  
We welcome your comments at [validation@mail.wwpdb.org](mailto:validation@mail.wwpdb.org)  
A user guide is available at <http://wwpdb.org/ValidationPDFNotes.html>

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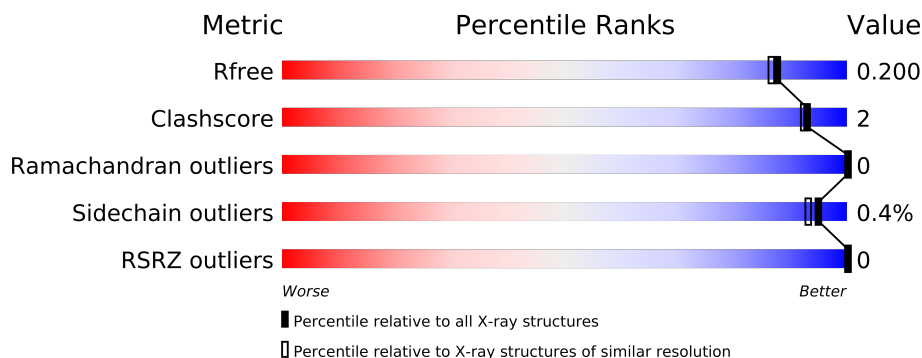
The following versions of software and data (see [references](#)) were used in the production of this report:

MolProbity	:	4.02b-467
Mogul	:	1.15 2013
Xtriage (Phenix)	:	dev-1323
EDS	:	stable23004
Percentile statistics	:	21963
Refmac	:	5.8.0049
CCP4	:	6.3.0 (Settle)
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et. al. (1996)
Validation Pipeline (wwPDB-VP)	:	stable23004

# 1 Overall quality at a glance

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))
$R_{free}$	66092	1269 (1.86-1.86)
Clashscore	79885	1470 (1.86-1.86)
Ramachandran outliers	78287	1451 (1.86-1.86)
Sidechain outliers	78261	1451 (1.86-1.86)
RSRZ outliers	66119	1269 (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 on the lower bar indicate the fraction of residues that contain outliers for  $\geq 3$ , 2, 1 and 0 types of geometric quality criteria. The upper red bar (where present) indicates the fraction of residues that have poor fit to the electron density.

Mol	Chain	Length	Quality of chain
1	A	356	
2	T	9	
3	P	5	
4	D	4	

The following table lists non-polymeric compounds that are outliers for geometric or electron-density-fit criteria:

Mol	Type	Chain	Res	Geometry	Electron density
6	PPV	A	503	-	X
7	EDO	A	504	-	X
7	EDO	A	507	-	X
7	EDO	P	101	-	X
9	EPE	A	508	-	X

## 2 Entry composition

There are 10 unique types of molecules in this entry. The entry contains 3405 atoms, of which 0 are hydrogen and 0 are deuterium.

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-directed DNA/RNA polymerase mu.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	325	Total	C	N	O	S	0	13	0
			2612	1667	468	469	8			

There are 19 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	127	GLY	-	EXPRESSION TAG	UNP Q9NP87
A	128	SER	-	EXPRESSION TAG	UNP Q9NP87
A	129	ALA	-	EXPRESSION TAG	UNP Q9NP87
A	130	ALA	-	EXPRESSION TAG	UNP Q9NP87
A	131	ALA	-	EXPRESSION TAG	UNP Q9NP87
A	?	-	PRO	DELETION	UNP Q9NP87
A	?	-	GLY	DELETION	UNP Q9NP87
A	?	-	ALA	DELETION	UNP Q9NP87
A	?	-	ALA	DELETION	UNP Q9NP87
A	?	-	VAL	DELETION	UNP Q9NP87
A	?	-	GLY	DELETION	UNP Q9NP87
A	?	-	GLY	DELETION	UNP Q9NP87
A	?	-	SER	DELETION	UNP Q9NP87
A	?	-	THR	DELETION	UNP Q9NP87
A	?	-	ARG	DELETION	UNP Q9NP87
A	?	-	PRO	DELETION	UNP Q9NP87
A	?	-	CYS	DELETION	UNP Q9NP87
A	?	-	PRO	DELETION	UNP Q9NP87
A	410	GLY	-	INSERTION	UNP Q9NP87

- Molecule 2 is a DNA chain called template strand.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
2	T	9	Total	C	N	O	P	0	0	0
			182	87	36	51	8			

- Molecule 3 is a DNA chain called upstream primer strand.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
3	P	5	Total	C	N	O	P	0	0	0
			99	49	17	29	4			

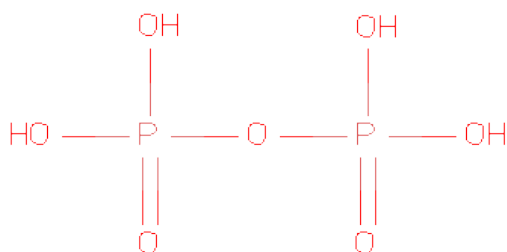
- Molecule 4 is a DNA chain called downstream primer strand.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
4	D	4	Total	C	N	O	P	0	0	0
			83	38	16	25	4			

- Molecule 5 is MAGNESIUM ION (three-letter code: MG) (formula: Mg).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
5	A	3	Total	Mg	0	0
			3	3		

- Molecule 6 is PYROPHOSPHATE (three-letter code: PPV) (formula: H<sub>4</sub>O<sub>7</sub>P<sub>2</sub>).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
6	A	1	Total	O	P	0	0
			9	7	2		

- Molecule 7 is 1,2-ETHANEDIOL (three-letter code: EDO) (formula: C<sub>2</sub>H<sub>6</sub>O<sub>2</sub>).

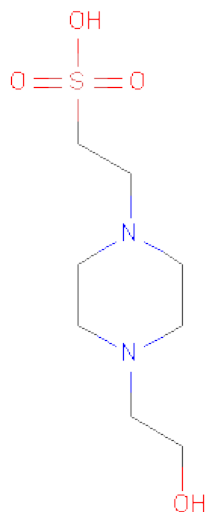


Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
7	A	1	Total	C	O	0	0
			4	2	2		
7	A	1	Total	C	O	0	0
			4	2	2		
7	P	1	Total	C	O	0	0
			4	2	2		

- Molecule 8 is MANGANESE (II) ION (three-letter code: MN) (formula: Mn).

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
8	A	1	Total	Mn	0	0
			1	1		

- Molecule 9 is 4-(2-HYDROXYETHYL)-1-PIPERAZINEETHANESULFONIC ACID (three-letter code: EPE) (formula: C<sub>8</sub>H<sub>18</sub>N<sub>2</sub>O<sub>4</sub>S).



Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
9	A	1	Total	C	O	S	0	0
			5	1	3	1		

- Molecule 10 is water.

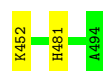
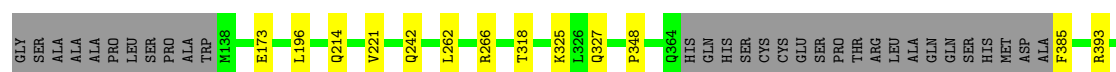
Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
10	A	326	Total	O	0	1
			327	327		
10	T	35	Total	O	0	0
			35	35		
10	P	21	Total	O	0	0
			21	21		
10	D	16	Total	O	0	2
			16	16		

### 3 Residue-property plots

These plots are drawn for all protein, RNA and DNA chains in the entry. The first graphic for a chain summarises the proportions of errors 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.

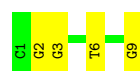
- Molecule 1: DNA-directed DNA/RNA polymerase mu

Chain A: 



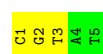
- Molecule 2: template strand

Chain T: 



- Molecule 3: upstream primer strand

Chain P: 



- Molecule 4: downstream primer strand

Chain D: 



## 4 Data and refinement statistics

Property	Value	Source
Space group	P 21 21 21	Depositor
Cell constants a, b, c, $\alpha$ , $\beta$ , $\gamma$	60.02Å 68.67Å 110.44Å 90.00° 90.00° 90.00°	Depositor
Resolution (Å)	31.38 – 1.85 43.03 – 1.85	Depositor EDS
% Data completeness (in resolution range)	98.2 (31.38-1.85) 94.9 (43.03-1.85)	Depositor EDS
$R_{merge}$	(Not available)	Depositor
$R_{sym}$	0.07	Depositor
$\langle I/\sigma(I) \rangle$ <sup>1</sup>	3.28 (at 1.86Å)	Xtriage
Refinement program	PHENIX (phenix.refine: 1.8.1069)	Depositor
R, $R_{free}$	0.163 , 0.200 0.163 , 0.200	Depositor DCC
$R_{free}$ test set	1887 reflections (5.01%)	DCC
Wilson B-factor (Å <sup>2</sup> )	21.7	Xtriage
Anisotropy	0.105	Xtriage
Bulk solvent $k_{sol}$ (e/Å <sup>3</sup> ), $B_{sol}$ (Å <sup>2</sup> )	0.36 , 28.1	EDS
Estimated twinning fraction	No twinning to report.	Xtriage
L-test for twinning	$\langle  L  \rangle = 0.49$ , $\langle L^2 \rangle = 0.32$	Xtriage
Outliers	0 of 38963 reflections	Xtriage
$F_o, F_c$ correlation	0.96	EDS
Total number of atoms	3405	wwPDB-VP
Average B, all atoms (Å <sup>2</sup> )	13.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 5.13% of the height of the origin peak. No significant pseudotranslation is detected.*

<sup>1</sup>Intensities estimated from amplitudes.



## 5 Model quality

### 5.1 Standard geometry

Bond lengths and bond angles in the following residue types are not validated in this section: EPE, MG, MN, EDO, PPV

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	0.63	0/2699	0.70	1/3655 (0.0%)
2	T	1.28	0/204	1.77	5/313 (1.6%)
3	P	1.23	0/110	1.90	4/168 (2.4%)
4	D	1.53	1/92 (1.1%)	2.08	4/138 (2.9%)
All	All	0.76	1/3105 (0.0%)	0.97	14/4274 (0.3%)

All (1) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
4	D	1	DG	OP3-P	-9.70	1.49	1.61

All (14) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(°)	Ideal(°)
4	D	3	DC	O4'-C1'-N1	-11.61	99.88	108.00
4	D	1	DG	O4'-C1'-N9	-10.72	100.50	108.00
3	P	1	DC	O4'-C4'-C3'	-8.63	100.82	106.00
2	T	9	DG	O4'-C1'-N9	-8.32	102.17	108.00
2	T	6	DT	O4'-C1'-N1	7.21	113.05	108.00
2	T	6	DT	C1'-O4'-C4'	-7.19	102.91	110.10
1	A	393	ARG	NE-CZ-NH2	-6.51	117.05	120.30
2	T	2	DG	O4'-C1'-N9	-6.06	103.76	108.00
4	D	3	DC	N1-C1'-C2'	5.76	123.54	112.60
4	D	2	DC	C1'-O4'-C4'	-5.49	104.61	110.10
2	T	3	DG	OP1-P-OP2	5.39	127.69	119.60
3	P	2	DG	O4'-C4'-C3'	-5.33	102.37	104.50
3	P	2	DG	C4'-C3'-C2'	-5.28	98.35	103.10
3	P	3	DT	C2-N3-C4	-5.02	124.19	127.20

There are no chirality outliers.

There are no planarity outliers.

## 5.2 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 hydrogens added by MolProbity. The Clashes column lists the number of clashes within the asymmetric unit, and the number in parentheses is this value normalized per 1000 atoms of the molecule in the chain. The Symm-Clashes column gives symmetry related clashes, in the same way as for the Clashes column.

Mol	Chain	Non-H	H(model)	H(added)	Clashes	Symm-Clashes
1	A	2612	0	2567	10	0
2	T	182	0	102	0	0
3	P	99	0	59	0	0
4	D	83	0	45	0	0
5	A	3	0	0	0	0
6	A	9	0	0	1	0
7	A	8	0	12	0	0
7	P	4	0	6	0	0
8	A	1	0	0	0	0
9	A	5	0	0	0	0
10	A	327	0	0	5	0
10	D	16	0	0	0	0
10	P	21	0	0	0	0
10	T	35	0	0	0	0
All	All	3405	0	2791	10	0

Clashscore is defined as the number of clashes calculated for the entry per 1000 atoms (including hydrogens) of the entry. The overall clashscore for this entry is 2.

All (10) close contacts within the same asymmetric unit are listed below.

Atom-1	Atom-2	Distance(Å)	Clash(Å)
1:A:242:GLN:OE1	10:A:906:HOH:O	2.02	0.77
1:A:327:GLN:OE1	10:A:901:HOH:O	2.09	0.70
1:A:481[B]:HIS:ND1	10:A:776:HOH:O	2.17	0.60
1:A:173:GLU:HG2	10:A:792:HOH:O	2.12	0.48
1:A:196:LEU:HD13	1:A:214:GLN:HB2	1.96	0.47
1:A:348[B]:PRO:HG3	1:A:385:PHE:CE1	2.51	0.47
1:A:452:LYS:HD2	10:A:716:HOH:O	2.16	0.45
1:A:325:LYS:NZ	6:A:503:PPV:O21	2.38	0.44
1:A:262:LEU:O	1:A:266:ARG:HG3	2.20	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	334/356 (94%)	323 (97%)	11 (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	273/301 (91%)	271 (99%)	2 (1%)	91	87

All (2) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	221[A]	VAL
1	A	221[B]	VAL

Some sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (1) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	327	GLN

### 5.3.3 RNA ⓘ

There are no RNA chains in this entry.

## 5.4 Non-standard residues in protein, DNA, RNA chains ⓘ

There are no non-standard protein/DNA/RNA residues in this entry.

## 5.5 Carbohydrates ⓘ

There are no carbohydrates in this entry.

## 5.6 Ligand geometry ⓘ

Of 9 ligands modelled in this entry, 4 are monoatomic - leaving 5 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	$\# Z  > 2$
6	PPV	A	503	5	8,8,8	1.50	1 (12%)	13,13,13	1.12	2 (15%)
7	EDO	A	504	-	3,3,3	0.76	0	2,2,2	0.43	0
7	EDO	A	507	-	3,3,3	0.58	0	2,2,2	0.74	0
9	EPE	A	508	-	3,4,15	2.25	2 (66%)	3,6,20	0.21	0
7	EDO	P	101	-	3,3,3	0.57	0	2,2,2	0.72	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
6	PPV	A	503	5	-	0/6/6/6	0/0/0/0
7	EDO	A	504	-	-	0/1/1/1	0/0/0/0
7	EDO	A	507	-	-	0/1/1/1	0/0/0/0
9	EPE	A	508	-	-	0/0/0/19	0/0/0/1
7	EDO	P	101	-	-	0/1/1/1	0/0/0/0

All (3) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
9	A	508	EPE	O2S-S	3.00	1.46	1.42
6	A	503	PPV	P1-OPP	-2.94	1.55	1.60
9	A	508	EPE	O1S-S	2.48	1.45	1.42

All (2) bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed( $^{\circ}$ )	Ideal( $^{\circ}$ )
6	A	503	PPV	O11-P1-OPP	2.32	116.16	105.14
6	A	503	PPV	P2-OPP-P1	-2.09	125.56	131.68

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

## 5.7 Other polymers ⓘ

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, 95<sup>th</sup> 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 <sup>2</sup> )	Q<0.9
1	A	325/356 (91%)	-0.37	0 100 100	1, 11, 27, 51	2 (0%)
2	T	9/9 (100%)	-0.68	0 100 100	6, 10, 17, 23	0
3	P	5/5 (100%)	-0.67	0 100 100	4, 5, 9, 12	0
4	D	4/4 (100%)	-0.73	0 100 100	10, 11, 15, 17	0
All	All	343/374 (91%)	-0.38	0 100 100	1, 11, 27, 51	2 (0%)

There are no RSRZ outliers to report.

### 6.2 Non-standard residues in protein, DNA, RNA chains ⓘ

There are no non-standard protein/DNA/RNA residues in this entry.

### 6.3 Carbohydrates ⓘ

There are no carbohydrates 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. LLDF column lists the quality of electron density of the group with respect to its neighbouring residues in protein, DNA or RNA chains. The B-factors column lists the minimum, median, 95<sup>th</sup> 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	RSR	LLDF	B-factors(Å <sup>2</sup> )	Q<0.9
9	EPE	A	508	5/15	0.17	6.26	13,20,26,28	5
7	EDO	A	507	4/4	0.11	6.04	24,29,29,43	0

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Mol	Type	Chain	Res	Atoms	RSR	LLDF	B-factors( $\text{\AA}^2$ )	Q<0.9
7	EDO	P	101	4/4	0.10	4.98	10,11,13,20	0
7	EDO	A	504	4/4	0.14	3.21	15,18,20,25	0
6	PPV	A	503	9/9	0.12	2.37	1,9,16,17	9
5	MG	A	502	1/1	0.10	0.75	10,10,10,10	0
5	MG	A	506	1/1	0.06	-2.07	22,22,22,22	0
5	MG	A	501	1/1	0.06	-2.11	5,5,5,5	0
8	MN	A	505	1/1	0.03	-4.07	15,15,15,15	0

## 6.5 Other polymers ⓘ

There are no such residues in this entry.