wwPDB X-ray Structure Validation Summary Report (i)

Aug 22, 2026 – 06:54 am BST

PDB ID	:	1H9M / pdb_00001h9m
Title	:	Two crystal structures of the cytoplasmic molybdate-binding protein ModG suggest a novel cooperative binding mechanism and provide insights into ligand-binding specificity. PEG-grown form with molybdate bound
Authors	:	Delarbre, L.; Stevenson, C.E.M.; White, D.J.; Mitchenall, L.A.; Pau, R.N.; Lawson, D.M.
Deposited on	:	2001-03-13
Resolution	:	1.65 Å(reported)

This is a wwPDB X-ray Structure Validation Summary 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 (i) 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 (i)) were used in the production of this report:

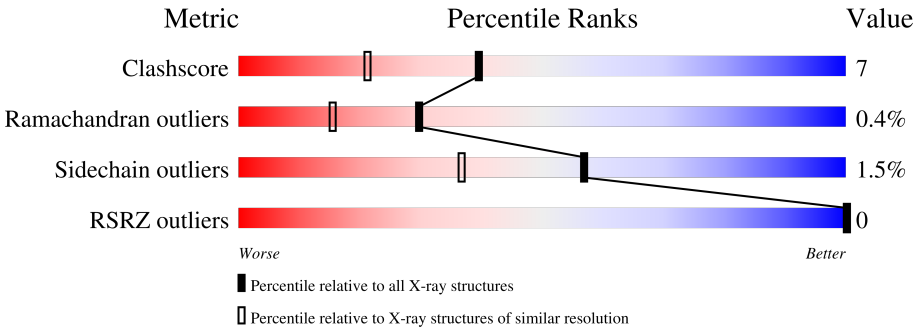
MolProbity	:	4-5-2 with Phenix2.0
Mogul	:	1.8.4, CSD as541be (2020)
Xtriage (Phenix)	:	2.0
EDS	:	3.0
Percentile statistics	:	20250101.v01 (using entries in the PDB archive January 1st 2025)
CCP4	:	9.0.015 (Gargrove)
Density-Fitness	:	1.0.12
Ideal geometry (proteins)	:	Engh & Huber (2001)
Ideal geometry (DNA, RNA)	:	Parkinson et al. (1996)
Validation Pipeline (wwPDB-VP)	:	2.50

1 Overall quality at a glance (i)

The following experimental techniques were used to determine the structure:
X-RAY DIFFRACTION

The reported resolution of this entry is 1.65 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))
Clashscore	190562	2662 (1.66-1.66)
Ramachandran outliers	187476	2621 (1.66-1.66)
Sidechain outliers	187428	2621 (1.66-1.66)
RSRZ outliers	180081	2564 (1.66-1.66)

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 <=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	145	72% 21% 5% .
1	B	145	75% 18% . . .

2 Entry composition (i)

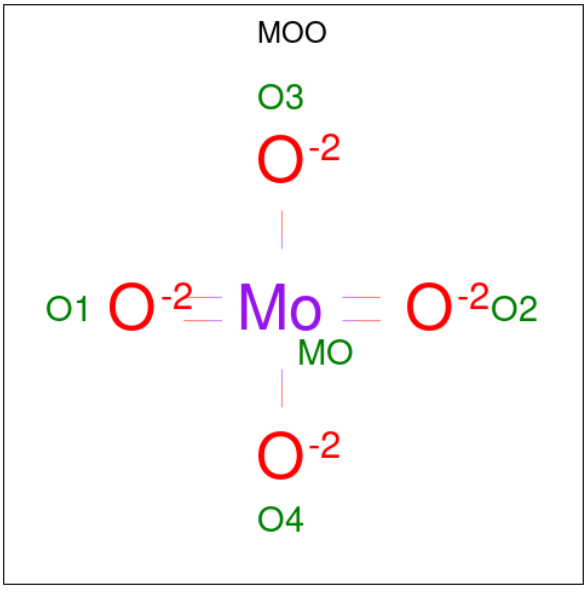
There are 3 unique types of molecules in this entry. The entry contains 2109 atoms, of which 0 are hydrogens and 0 are deuteriums.

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 MOLYBDENUM-BINDING-PROTEIN.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
1	A	141	Total	C	N	O	S	0	5	0
			1000	634	171	192	3			
1	B	141	Total	C	N	O	S	0	6	0
			998	637	167	192	2			

- Molecule 2 is MOLYBDATE ION (CCD ID: MOO) (formula: MoO_4).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf
2	A	1	Total	Mo	O	0	0
			3	1	2		
2	A	1	Total	Mo	O	0	0
			3	1	2		
2	A	1	Total	Mo	O	0	0
			5	1	4		
2	A	1	Total	Mo	O	0	0
			5	1	4		

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Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
2	B	1	Total Mo O 3 1 2	0	0
2	B	1	Total Mo O 3 1 2	0	0
2	B	1	Total Mo O 5 1 4	0	0
2	B	1	Total Mo O 5 1 4	0	0

- Molecule 3 is water.

Mol	Chain	Residues	Atoms	ZeroOcc	AltConf
3	A	36	Total O 36 36	0	0
3	B	43	Total O 43 43	0	0

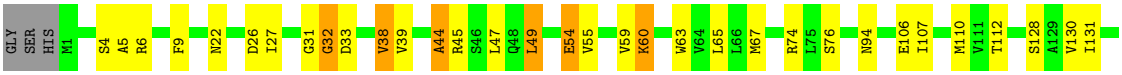
3 Residue-property plots (i)

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: MOLYBDENUM-BINDING-PROTEIN

Chain A:



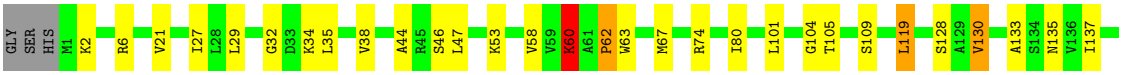




- Molecule 1: MOLYBDENUM-BINDING-PROTEIN

Chain B:







4 Data and refinement statistics (i)

Property	Value	Source
Space group	H 3	Depositor
Cell constants a, b, c, α, β, γ	81.96Å 81.96Å 93.42Å 90.00° 90.00° 120.00°	Depositor
Resolution (Å)	40.00 – 1.65 40.00 – 1.65	Depositor EDS
% Data completeness (in resolution range)	98.7 (40.00-1.65) 98.2 (40.00-1.65)	Depositor EDS
R_{merge}	0.04	Depositor
R_{sym}	(Not available)	Depositor
$< I/\sigma(I) >$ [1]	6.30 (at 1.65Å)	Xtriage
Refinement program	REFMAC	Depositor
R, R_{free}	0.191 , 0.226 0.189 , (Not available)	Depositor DCC
R_{free} test set	No test flags present.	wwPDB-VP
Wilson B-factor (Å^2)	17.4	Xtriage
Anisotropy	0.455	Xtriage
Bulk solvent k_{sol}(e/Å^3), B_{sol}(Å^2)	0.38 , 31.8	EDS
L-test for twinning[2]	$< \|L\| > = 0.50$, $< L^2 > = 0.34$	Xtriage
Estimated twinning fraction	0.488 for h,-h-k,-l	Xtriage
F_o,F_c correlation	0.97	EDS
Total number of atoms	2109	wwPDB-VP
Average B, all atoms (Å^2)	27.0	wwPDB-VP

Xtriage's analysis on translational NCS is as follows: *The analyses of the Patterson function reveals a significant off-origin peak that is 39.85 % of the origin peak, indicating pseudo-translational symmetry. The chance of finding a peak of this or larger height randomly in a structure without pseudo-translational symmetry is equal to 2.9829e-04. The detected translational NCS is most likely also responsible for the elevated intensity ratio.*

[1] Intensities estimated from amplitudes.

[2] Theoretical values of $< |L| >$, $< L^2 >$ 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: MOO

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	2.01	4/1027 (0.4%)	2.02	32/1396 (2.3%)
1	B	1.24	3/1028 (0.3%)	1.99	23/1399 (1.6%)
All	All	1.67	7/2055 (0.3%)	2.01	55/2795 (2.0%)

Chiral center outliers are detected by calculating the chiral volume of a chiral center and verifying if the center is modelled as a planar moiety or with the opposite hand.A planarity outlier is detected by checking planarity of atoms in a peptide group, atoms in a mainchain group or atoms of a sidechain that are expected to be planar.

Mol	Chain	#Chirality outliers	#Planarity outliers
1	A	0	1
1	B	0	4
All	All	0	5

The worst 5 of 7 bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
1	A	38	VAL	C-O	-48.74	0.71	1.24
1	A	38	VAL	C-N	18.06	1.56	1.33
1	B	38	VAL	C-O	-13.13	1.09	1.24
1	A	38	VAL	CA-C	10.15	1.65	1.52
1	A	141	PRO	N-CD	6.01	1.56	1.47

The worst 5 of 55 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
1	B	6	ARG	NE-CZ-NH2	9.90	128.11	119.20
1	A	38	VAL	CA-C-N	-9.32	109.50	122.92
1	A	38	VAL	C-N-CA	-9.32	109.50	122.92
1	A	38	VAL	CA-C-O	8.68	129.50	120.39

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Mol	Chain	Res	Type	Atoms	Z	Observed(^{o})	Ideal(^{o})
1	B	62	PRO	O-C-N	-8.14	110.95	122.35

There are no chirality outliers.

All (5) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	A	49	LEU	Mainchain
1	B	119	LEU	Mainchain
1	B	135	ASN	Mainchain
1	B	137	ILE	Mainchain
1	B	80	ILE	Mainchain

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	1000	0	1065	14	0
1	B	998	0	1063	13	0
2	A	16	0	0	0	2
2	B	16	0	0	1	2
3	A	36	0	0	0	0
3	B	43	0	0	2	0
All	All	2109	0	2128	28	4

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 7.

The worst 5 of 28 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:38:VAL:C	1:A:38:VAL:O	0.72	0.96
1:B:47[A]:LEU:HD22	1:B:140:VAL:HG22	1.46	0.94
1:A:38:VAL:O	1:A:38:VAL:CA	2.17	0.92
1:A:38:VAL:O	1:A:39:VAL:N	2.10	0.85
1:A:47:LEU:HD22	1:A:140:VAL:HG22	1.63	0.80

All (4) 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)
2:B:1143:MOO:MO	2:B:1143:MOO:O2[3_665]	1.72	0.48
2:A:1143:MOO:MO	2:A:1143:MOO:O2[2_665]	1.73	0.47
2:B:1142:MOO:MO	2:B:1142:MOO:O2[3_665]	1.76	0.44
2:A:1142:MOO:MO	2:A:1142:MOO:O2[2_665]	1.77	0.43

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	144/145 (99%)	142 (99%)	1 (1%)	1 (1%)	18 6
1	B	145/145 (100%)	143 (99%)	2 (1%)	0	100 100
All	All	289/290 (100%)	285 (99%)	3 (1%)	1 (0%)	30 21

All (1) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	A	32	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	105/108 (97%)	104 (99%)	1 (1%)	68 52
1	B	103/108 (95%)	100 (97%)	3 (3%)	37 14

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Mol	Chain	Analysed	Rotameric	Outliers	Percentiles
All	All	208/216 (96%)	204 (98%)	4 (2%)	57 28

All (4) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	54	GLU
1	B	60[A]	LYS
1	B	60[B]	LYS
1	B	141	PRO

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	135	ASN
1	B	135	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)

8 ligands are modelled in this entry.

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	MOO	A	1143	-	0,2,4	-	-	-		
2	MOO	B	1143	-	0,2,4	-	-	-		
2	MOO	B	1144	-	2,4,4	1.65	1 (50%)	-		
2	MOO	B	1145	-	2,4,4	1.37	0	-		
2	MOO	A	1142	-	0,2,4	-	-	-		
2	MOO	A	1144	-	2,4,4	2.05	1 (50%)	-		
2	MOO	B	1142	-	0,2,4	-	-	-		
2	MOO	A	1145	-	2,4,4	1.10	0	-		

All (2) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	1144	MOO	O2-MO	2.38	1.80	1.75
2	B	1144	MOO	O2-MO	2.16	1.80	1.75

There are no bond angle outliers.

There are no chirality outliers.

There are no torsion outliers.

There are no ring outliers.

5 monomers are involved in 5 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
2	A	1143	MOO	0	1
2	B	1143	MOO	0	1
2	B	1145	MOO	1	0
2	A	1142	MOO	0	1
2	B	1142	MOO	0	1

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, 95^{th} 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	141/145 (97%)	-1.09	0	100	100	12, 24, 44, 61	5 (3%)
1	B	141/145 (97%)	-1.09	0	100	100	11, 24, 45, 66	6 (4%)
All	All	282/290 (97%)	-1.09	0	100	100	11, 24, 45, 66	11 (3%)

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 oligosaccharides 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. The B-factors column lists the minimum, median, 95^{th} 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
2	MOO	B	1142	3/5	0.94	0.27	40,40,46,54	2
2	MOO	B	1143	3/5	0.97	0.13	12,12,14,37	2
2	MOO	A	1144	5/5	1.00	0.04	19,20,20,26	0
2	MOO	A	1145	5/5	1.00	0.02	14,15,17,21	0
2	MOO	A	1142	3/5	1.00	0.04	17,17,18,21	2
2	MOO	A	1143	3/5	1.00	0.05	18,18,18,24	2
2	MOO	B	1144	5/5	1.00	0.04	19,20,22,27	0

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Mol	Type	Chain	Res	Atoms	RSCC	RSR	B-factors(Å^2)	Q<0.9
2	MOO	B	1145	5/5	1.00	0.01	14,15,18,21	0

6.5 Other polymers (i)

There are no such residues in this entry.