



Full wwPDB X-ray Structure Validation Report ⓘ

Mar 6, 2026 – 10:36 AM UTC

PDB ID : 5FA9 / pdb_00005fa9
Title : Bifunctional Methionine Sulfoxide Reductase AB (MsrAB) from *Treponema denticola*
Authors : Han, A.; Son, J.; Kim, H.-Y.; Hwang, K.Y.
Deposited on : 2015-12-11
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

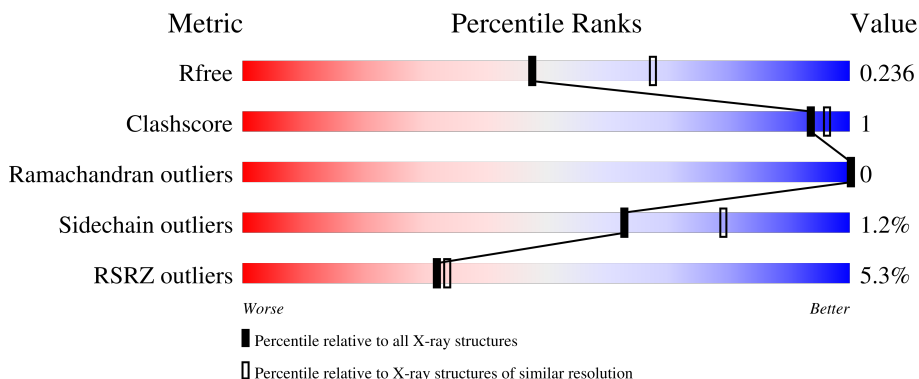
1 Overall quality at a glance

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	325	 4% 89% 7%
1	B	325	 6% 90% 6%

2 Entry composition [i](#)

There are 4 unique types of molecules in this entry. The entry contains 5144 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.

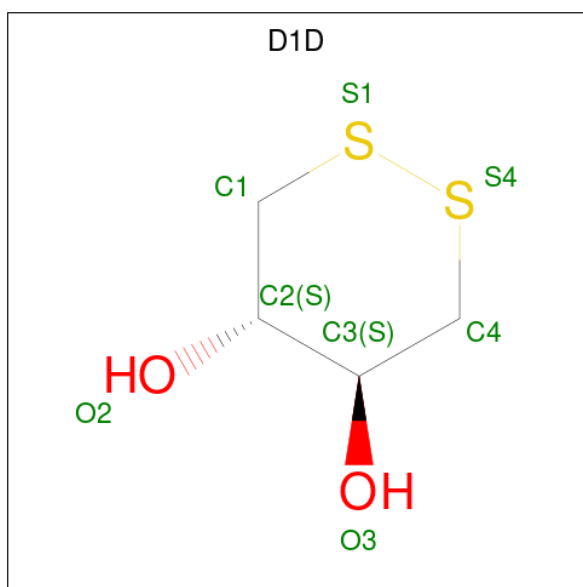
- Molecule 1 is a protein called Peptide methionine sulfoxide reductase MsrA.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	303	Total	C	N	O	S	0	0	0
			2418	1553	394	464	7			
1	B	304	Total	C	N	O	S	0	0	0
			2429	1562	395	465	7			

There are 20 discrepancies between the modelled and reference sequences:

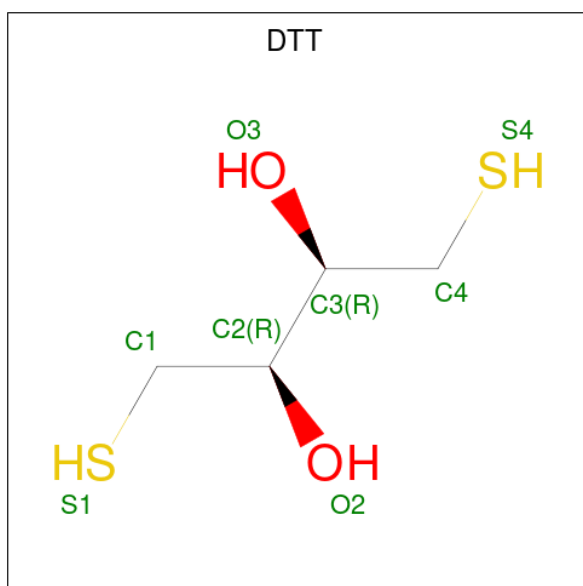
Chain	Residue	Modelled	Actual	Comment	Reference
A	11	SER	CYS	engineered mutation	UNP Q73PT7
A	285	SER	CYS	engineered mutation	UNP Q73PT7
A	318	LEU	-	expression tag	UNP Q73PT7
A	319	GLU	-	expression tag	UNP Q73PT7
A	320	HIS	-	expression tag	UNP Q73PT7
A	321	HIS	-	expression tag	UNP Q73PT7
A	322	HIS	-	expression tag	UNP Q73PT7
A	323	HIS	-	expression tag	UNP Q73PT7
A	324	HIS	-	expression tag	UNP Q73PT7
A	325	HIS	-	expression tag	UNP Q73PT7
B	11	SER	CYS	engineered mutation	UNP Q73PT7
B	285	SER	CYS	engineered mutation	UNP Q73PT7
B	318	LEU	-	expression tag	UNP Q73PT7
B	319	GLU	-	expression tag	UNP Q73PT7
B	320	HIS	-	expression tag	UNP Q73PT7
B	321	HIS	-	expression tag	UNP Q73PT7
B	322	HIS	-	expression tag	UNP Q73PT7
B	323	HIS	-	expression tag	UNP Q73PT7
B	324	HIS	-	expression tag	UNP Q73PT7
B	325	HIS	-	expression tag	UNP Q73PT7

- Molecule 2 is (4S,5S)-1,2-DITHIANE-4,5-DIOL (CCD ID: D1D) (formula: C₄H₈O₂S₂).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf	
2	A	1	Total	C	O	S	0	0
			8	4	2	2		
2	B	1	Total	C	O	S	0	0
			8	4	2	2		

- Molecule 3 is 2,3-DIHYDROXY-1,4-DITHIOBUTANE (CCD ID: DTT) (formula: $C_4H_{10}O_2S_2$).



Mol	Chain	Residues	Atoms			ZeroOcc	AltConf	
3	A	1	Total	C	O	S	0	0
			8	4	2	2		

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Mol	Chain	Residues	Atoms				ZeroOcc	AltConf
3	A	1	Total	C	O	S	0	0
			8	4	2	2		
3	B	1	Total	C	O	S	0	0
			8	4	2	2		
3	B	1	Total	C	O	S	0	0
			8	4	2	2		
3	B	1	Total	C	O	S	0	0
			8	4	2	2		

- Molecule 4 is water.

Mol	Chain	Residues	Atoms		ZeroOcc	AltConf
4	A	125	Total	O	0	0
			125	125		
4	B	116	Total	O	0	0
			116	116		

4 Data and refinement statistics

Property	Value	Source
Space group	C 1 2 1	Depositor
Cell constants a, b, c, α , β , γ	144.96Å 95.58Å 81.39Å 90.00° 116.24° 90.00°	Depositor
Resolution (Å)	29.63 – 2.30 29.63 – 2.30	Depositor EDS
% Data completeness (in resolution range)	97.3 (29.63-2.30) 97.2 (29.63-2.30)	Depositor EDS
R_{merge}	0.08	Depositor
R_{sym}	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ ¹	1.79 (at 2.29Å)	Xtrriage
Refinement program	PHENIX 1.9_1692, Coot	Depositor
R, R_{free}	0.205 , 0.234 0.210 , 0.236	Depositor DCC
R_{free} test set	1990 reflections (4.50%)	wwPDB-VP
Wilson B-factor (Å ²)	38.6	Xtrriage
Anisotropy	0.090	Xtrriage
Bulk solvent k_{sol} (e/Å ³), B_{sol} (Å ²)	0.36 , 44.6	EDS
L-test for twinning ²	$\langle L \rangle = 0.47$, $\langle L^2 \rangle = 0.30$	Xtrriage
Estimated twinning fraction	No twinning to report.	Xtrriage
F_o, F_c correlation	0.94	EDS
Total number of atoms	5144	wwPDB-VP
Average B, all atoms (Å ²)	47.0	wwPDB-VP

Xtrriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 6.35% 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: D1D, DTT

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	0.27	0/2477	0.68	0/3345
1	B	0.26	0/2489	0.67	0/3361
All	All	0.26	0/4966	0.67	0/6706

There are no bond length outliers.

There are no bond angle outliers.

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	2418	0	2369	9	0
1	B	2429	0	2378	5	0
2	A	8	0	6	0	0
2	B	8	0	6	0	0
3	A	16	0	20	3	0
3	B	24	0	30	0	0
4	A	125	0	0	2	0
4	B	116	0	0	0	0
All	All	5144	0	4809	14	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 1.

All (14) 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:262:LYS:NZ	3:A:402:DTT:S1	2.65	0.69
1:B:130:LYS:O	1:B:131:HIS:ND1	2.33	0.61
1:A:242:GLN:HB3	3:A:402:DTT:H41	1.88	0.55
1:A:252:LEU:HB2	1:A:254:MET:HE2	1.92	0.51
1:A:223:LEU:HD23	3:A:403:DTT:H42	1.91	0.51
1:A:175:GLU:OE1	1:A:175:GLU:N	2.33	0.50
1:A:312:LYS:NZ	4:A:504:HOH:O	2.38	0.46
1:B:248:GLU:CD	1:B:248:GLU:H	2.25	0.44
1:B:49:ASP:OD1	1:B:49:ASP:N	2.51	0.42
1:B:173:LYS:H	1:B:173:LYS:HG3	1.49	0.42
1:A:130:LYS:HE3	1:A:131:HIS:ND1	2.35	0.41
1:A:296:TYR:CZ	1:A:312:LYS:HD2	2.55	0.41
1:A:83:LYS:NZ	4:A:509:HOH:O	2.45	0.41
1:B:180:LEU:HB3	1:B:184:GLN:HB2	2.03	0.41

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	299/325 (92%)	295 (99%)	4 (1%)	0	100	100
1	B	300/325 (92%)	296 (99%)	4 (1%)	0	100	100
All	All	599/650 (92%)	591 (99%)	8 (1%)	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	260/279 (93%)	258 (99%)	2 (1%)	73 86
1	B	261/279 (94%)	257 (98%)	4 (2%)	57 75
All	All	521/558 (93%)	515 (99%)	6 (1%)	63 79

All (6) residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	A	181	LYS
1	A	260	VAL
1	B	105	LYS
1	B	120	ARG
1	B	211	VAL
1	B	248	GLU

Sometimes sidechains can be flipped to improve hydrogen bonding and reduce clashes. All (3) such sidechains are listed below:

Mol	Chain	Res	Type
1	A	152	HIS
1	B	224	ASN
1	B	270	HIS

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](#)

7 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
3	DTT	B	402	-	7,7,7	0.58	0	4,8,8	0.38	0
2	D1D	B	401	-	8,8,8	10.78	8 (100%)	6,10,10	0.41	0
3	DTT	B	404	-	7,7,7	0.56	0	4,8,8	0.43	0
3	DTT	A	403	-	7,7,7	0.58	0	4,8,8	0.40	0
2	D1D	A	401	-	8,8,8	10.80	8 (100%)	6,10,10	0.44	0
3	DTT	A	402	-	7,7,7	0.57	0	4,8,8	0.33	0
3	DTT	B	403	-	7,7,7	0.56	0	4,8,8	0.34	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. '2' means no outliers of that kind were identified.

Mol	Type	Chain	Res	Link	Chirals	Torsions	Rings
3	DTT	B	402	-	-	4/8/8/8	-
2	D1D	B	401	-	-	-	0/1/1/1
3	DTT	B	404	-	-	2/8/8/8	-
3	DTT	A	403	-	-	6/8/8/8	-
2	D1D	A	401	-	-	-	0/1/1/1
3	DTT	A	402	-	-	5/8/8/8	-
3	DTT	B	403	-	-	2/8/8/8	-

All (16) bond length outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed(Å)	Ideal(Å)
2	A	401	D1D	C1-S1	-16.92	1.62	1.82
2	B	401	D1D	C4-S4	-16.83	1.62	1.82
2	A	401	D1D	C4-S4	-16.83	1.62	1.82
2	B	401	D1D	C1-S1	-16.78	1.62	1.82
2	B	401	D1D	C3-C2	13.25	1.72	1.52
2	A	401	D1D	C3-C2	13.22	1.72	1.52
2	B	401	D1D	O2-C2	-8.15	1.26	1.43
2	A	401	D1D	O3-C3	-8.13	1.26	1.43
2	A	401	D1D	O2-C2	-8.11	1.26	1.43
2	B	401	D1D	O3-C3	-8.10	1.26	1.43
2	B	401	D1D	C4-C3	4.93	1.61	1.52
2	B	401	D1D	C1-C2	4.91	1.61	1.52
2	A	401	D1D	C4-C3	4.89	1.61	1.52
2	A	401	D1D	C1-C2	4.88	1.61	1.52
2	B	401	D1D	S4-S1	-3.13	1.73	2.02
2	A	401	D1D	S4-S1	-3.13	1.73	2.02

There are no bond angle outliers.

There are no chirality outliers.

All (19) torsion outliers are listed below:

Mol	Chain	Res	Type	Atoms
3	A	402	DTT	S1-C1-C2-O2
3	A	402	DTT	S1-C1-C2-C3
3	A	403	DTT	C1-C2-C3-O3
3	A	403	DTT	C1-C2-C3-C4
3	A	403	DTT	O2-C2-C3-O3
3	A	403	DTT	O2-C2-C3-C4
3	B	402	DTT	S1-C1-C2-O2
3	B	402	DTT	S1-C1-C2-C3
3	B	402	DTT	C2-C3-C4-S4
3	B	402	DTT	O3-C3-C4-S4
3	B	403	DTT	S1-C1-C2-O2
3	B	403	DTT	S1-C1-C2-C3
3	B	404	DTT	S1-C1-C2-O2
3	B	404	DTT	C1-C2-C3-C4
3	A	402	DTT	C1-C2-C3-O3
3	A	402	DTT	O2-C2-C3-C4
3	A	402	DTT	C1-C2-C3-C4
3	A	403	DTT	S1-C1-C2-O2
3	A	403	DTT	S1-C1-C2-C3

There are no ring outliers.

2 monomers are involved in 3 short contacts:

Mol	Chain	Res	Type	Clashes	Symm-Clashes
3	A	403	DTT	1	0
3	A	402	DTT	2	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	303/325 (93%)	0.19	14 (4%) 37 39	28, 43, 69, 88	0
1	B	304/325 (93%)	0.45	18 (5%) 28 30	31, 47, 72, 93	0
All	All	607/650 (93%)	0.32	32 (5%) 32 34	28, 45, 71, 93	0

All (32) RSRZ outliers are listed below:

Mol	Chain	Res	Type	RSRZ
1	B	48	SER	3.8
1	B	152	HIS	3.4
1	B	173	LYS	3.3
1	A	173	LYS	2.9
1	A	264	GLY	2.9
1	A	167	LYS	2.9
1	A	316	ASN	2.9
1	B	50	HIS	2.7
1	A	1	MET	2.7
1	B	153	ILE	2.7
1	A	250	LYS	2.7
1	A	49	ASP	2.7
1	A	205	ASP	2.7
1	B	172	SER	2.4
1	B	264	GLY	2.3
1	B	136	GLU	2.3
1	A	12	PHE	2.3
1	B	170	VAL	2.2
1	A	292	ARG	2.2
1	A	48	SER	2.2
1	B	12	PHE	2.2
1	B	248	GLU	2.2
1	B	178	LYS	2.2
1	B	250	LYS	2.2

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Mol	Chain	Res	Type	RSRZ
1	B	297	ASP	2.1
1	B	265	GLY	2.1
1	B	130	LYS	2.1
1	B	174	GLU	2.1
1	B	49	ASP	2.1
1	A	50	HIS	2.0
1	A	152	HIS	2.0
1	A	172	SER	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
2	D1D	A	401	8/8	0.73	0.18	63,80,101,113	0
2	D1D	B	401	8/8	0.76	0.18	52,77,104,117	0
3	DTT	B	402	8/8	0.81	0.14	49,57,84,86	0
3	DTT	B	403	8/8	0.84	0.16	61,69,82,84	0
3	DTT	A	403	8/8	0.85	0.15	30,47,63,67	0
3	DTT	A	402	8/8	0.87	0.15	45,59,78,79	0
3	DTT	B	404	8/8	0.92	0.10	48,62,71,73	0

6.5 Other polymers [i](#)

There are no such residues in this entry.