



# wwPDB X-ray Structure Validation Summary Report ⓘ

Mar 9, 2026 – 12:28 AM UTC

PDB ID : 5CF2 / pdb\_00005cf2  
Title : Crystal Structure of the I80Y/L114V/I116V mutant of LEH  
Authors : Wu, L.; Sun, Z.T.; Reetz, M.T.; Zhou, J.H.  
Deposited on : 2015-07-08  
Resolution : 3.00 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](mailto: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>.

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

MolProbity : 4-5-2 with Phenix2.0  
Xtrriage (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

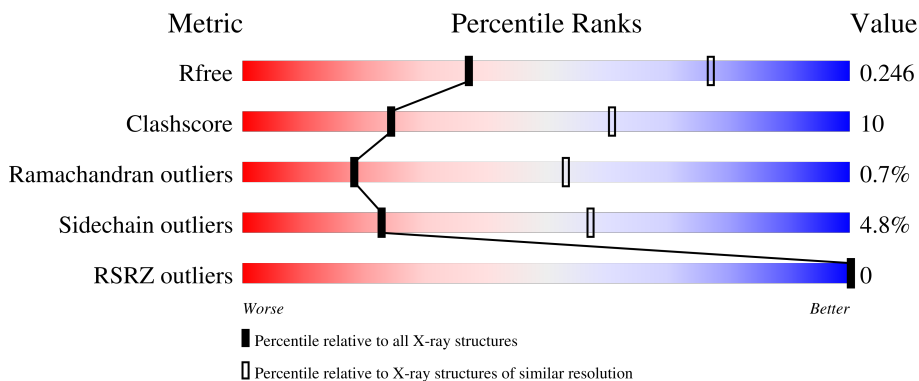
# 1 Overall quality at a glance

The following experimental techniques were used to determine the structure:

*X-RAY DIFFRACTION*

The reported resolution of this entry is 3.00 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	2672 (3.00-3.00)
Clashscore	190562	2977 (3.00-3.00)
Ramachandran outliers	187476	2877 (3.00-3.00)
Sidechain outliers	187428	2880 (3.00-3.00)
RSRZ outliers	180081	2671 (3.00-3.00)

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  $\geq 3$ , 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	155	 75% 15% • 6%
1	B	155	 57% 35% • 5%
1	C	155	 74% 15% • • 6%
1	D	155	 73% 18% • 5%

## 2 Entry composition [i](#)

There is only 1 type of molecule in this entry. The entry contains 4570 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 Limonene-1,2-epoxide hydrolase.

Mol	Chain	Residues	Atoms					ZeroOcc	AltConf	Trace
			Total	C	N	O	S			
1	A	145	1135	722	183	226	4	0	0	0
1	B	147	1150	731	186	229	4	0	0	0
1	C	145	1135	722	183	226	4	0	0	0
1	D	147	1150	731	186	229	4	0	0	0

There are 40 discrepancies between the modelled and reference sequences:

Chain	Residue	Modelled	Actual	Comment	Reference
A	-5	MET	-	expression tag	UNP Q9ZAG3
A	-4	HIS	-	expression tag	UNP Q9ZAG3
A	-3	HIS	-	expression tag	UNP Q9ZAG3
A	-2	HIS	-	expression tag	UNP Q9ZAG3
A	-1	HIS	-	expression tag	UNP Q9ZAG3
A	0	HIS	-	expression tag	UNP Q9ZAG3
A	1	HIS	-	expression tag	UNP Q9ZAG3
A	80	TYR	ILE	engineered mutation	UNP Q9ZAG3
A	114	VAL	LEU	engineered mutation	UNP Q9ZAG3
A	116	VAL	ILE	engineered mutation	UNP Q9ZAG3
B	-5	MET	-	expression tag	UNP Q9ZAG3
B	-4	HIS	-	expression tag	UNP Q9ZAG3
B	-3	HIS	-	expression tag	UNP Q9ZAG3
B	-2	HIS	-	expression tag	UNP Q9ZAG3
B	-1	HIS	-	expression tag	UNP Q9ZAG3
B	0	HIS	-	expression tag	UNP Q9ZAG3
B	1	HIS	-	expression tag	UNP Q9ZAG3
B	80	TYR	ILE	engineered mutation	UNP Q9ZAG3
B	114	VAL	LEU	engineered mutation	UNP Q9ZAG3
B	116	VAL	ILE	engineered mutation	UNP Q9ZAG3
C	-5	MET	-	expression tag	UNP Q9ZAG3

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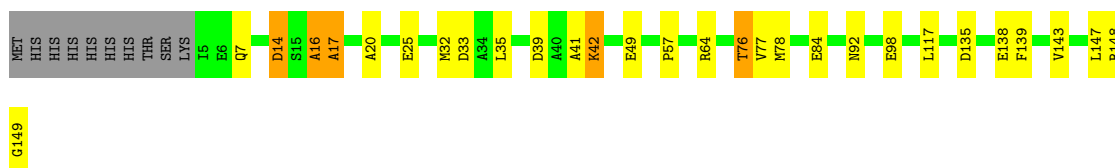
Chain	Residue	Modelled	Actual	Comment	Reference
C	-4	HIS	-	expression tag	UNP Q9ZAG3
C	-3	HIS	-	expression tag	UNP Q9ZAG3
C	-2	HIS	-	expression tag	UNP Q9ZAG3
C	-1	HIS	-	expression tag	UNP Q9ZAG3
C	0	HIS	-	expression tag	UNP Q9ZAG3
C	1	HIS	-	expression tag	UNP Q9ZAG3
C	80	TYR	ILE	engineered mutation	UNP Q9ZAG3
C	114	VAL	LEU	engineered mutation	UNP Q9ZAG3
C	116	VAL	ILE	engineered mutation	UNP Q9ZAG3
D	-5	MET	-	expression tag	UNP Q9ZAG3
D	-4	HIS	-	expression tag	UNP Q9ZAG3
D	-3	HIS	-	expression tag	UNP Q9ZAG3
D	-2	HIS	-	expression tag	UNP Q9ZAG3
D	-1	HIS	-	expression tag	UNP Q9ZAG3
D	0	HIS	-	expression tag	UNP Q9ZAG3
D	1	HIS	-	expression tag	UNP Q9ZAG3
D	80	TYR	ILE	engineered mutation	UNP Q9ZAG3
D	114	VAL	LEU	engineered mutation	UNP Q9ZAG3
D	116	VAL	ILE	engineered mutation	UNP Q9ZAG3

### 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.

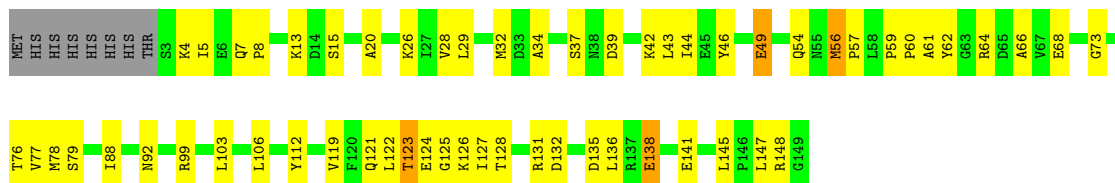
- Molecule 1: Limonene-1,2-epoxide hydrolase

Chain A: 



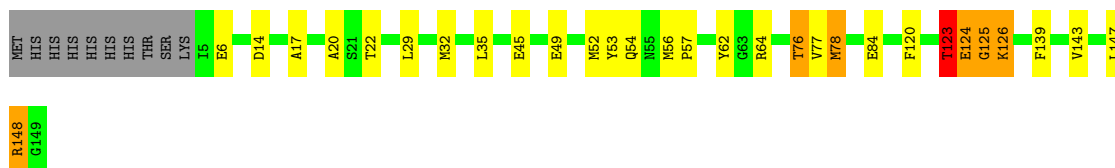
- Molecule 1: Limonene-1,2-epoxide hydrolase

Chain B: 



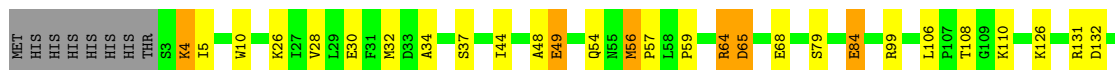
- Molecule 1: Limonene-1,2-epoxide hydrolase

Chain C: 



- Molecule 1: Limonene-1,2-epoxide hydrolase

Chain D: 



D135	L136	E141	D144	L147	R148	G149
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## 4 Data and refinement statistics

Property	Value	Source
Space group	P 3	Depositor
Cell constants a, b, c, $\alpha$ , $\beta$ , $\gamma$	103.65Å 103.65Å 73.26Å 90.00° 90.00° 120.00°	Depositor
Resolution (Å)	36.63 – 3.00 36.63 – 3.00	Depositor EDS
% Data completeness (in resolution range)	99.5 (36.63-3.00) 99.8 (36.63-3.00)	Depositor EDS
$R_{merge}$	(Not available)	Depositor
$R_{sym}$	(Not available)	Depositor
$\langle I/\sigma(I) \rangle$ <sup>1</sup>	3.69 (at 3.01Å)	Xtrriage
Refinement program	PHENIX 1.9_1692	Depositor
R, $R_{free}$	0.186 , 0.241 0.192 , 0.246	Depositor DCC
$R_{free}$ test set	863 reflections (4.88%)	wwPDB-VP
Wilson B-factor (Å <sup>2</sup> )	56.9	Xtrriage
Anisotropy	0.706	Xtrriage
Bulk solvent $k_{sol}$ (e/Å <sup>3</sup> ), $B_{sol}$ (Å <sup>2</sup> )	0.39 , 60.0	EDS
L-test for twinning <sup>2</sup>	$\langle  L  \rangle = 0.49$ , $\langle L^2 \rangle = 0.32$	Xtrriage
Estimated twinning fraction	0.467 for -h,-k,l 0.047 for h,-h-k,-l 0.048 for -k,-h,-l	Xtrriage
$F_o, F_c$ correlation	0.96	EDS
Total number of atoms	4570	wwPDB-VP
Average B, all atoms (Å <sup>2</sup> )	58.0	wwPDB-VP

Xtrriage's analysis on translational NCS is as follows: *The largest off-origin peak in the Patterson function is 3.78% of the height of the origin peak. No significant pseudotranslation is detected.*

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

<sup>2</sup>Theoretical 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](#)

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	0.60	0/1160	0.99	5/1576 (0.3%)
1	B	0.60	0/1175	0.99	4/1595 (0.3%)
1	C	0.63	0/1160	0.97	5/1576 (0.3%)
1	D	0.61	0/1175	0.96	3/1595 (0.2%)
All	All	0.61	0/4670	0.98	17/6342 (0.3%)

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	D	0	1

There are no bond length outliers.

The worst 5 of 17 bond angle outliers are listed below:

Mol	Chain	Res	Type	Atoms	Z	Observed( $^{\circ}$ )	Ideal( $^{\circ}$ )
1	C	56	MET	CA-C-N	-6.61	113.33	121.00
1	C	56	MET	C-N-CA	-6.61	113.33	121.00
1	A	7	GLN	CA-C-N	6.28	127.69	119.84
1	A	7	GLN	C-N-CA	6.28	127.69	119.84
1	A	16	ALA	CA-C-N	5.81	132.16	121.70

There are no chirality outliers.

All (1) planarity outliers are listed below:

Mol	Chain	Res	Type	Group
1	D	64	ARG	Peptide

## 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	1135	0	1093	20	0
1	B	1150	0	1111	37	0
1	C	1135	0	1093	21	0
1	D	1150	0	1111	20	0
All	All	4570	0	4408	89	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 10.

The worst 5 of 89 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:B:49:GLU:HA	1:B:64:ARG:HG3	1.53	0.90
1:D:49:GLU:HA	1:D:64:ARG:HG3	1.57	0.86
1:B:121:GLN:OE1	1:B:128:THR:HB	1.80	0.81
1:D:56:MET:HE3	1:D:131:ARG:HB3	1.67	0.75
1:D:26:LYS:O	1:D:30:GLU:HG3	1.89	0.72

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	143/155 (92%)	133 (93%)	8 (6%)	2 (1%)	9 36
1	B	145/155 (94%)	138 (95%)	7 (5%)	0	100 100

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Mol	Chain	Analysed	Favoured	Allowed	Outliers	Percentiles	
1	C	143/155 (92%)	135 (94%)	8 (6%)	0	100	100
1	D	145/155 (94%)	136 (94%)	7 (5%)	2 (1%)	9	36
All	All	576/620 (93%)	542 (94%)	30 (5%)	4 (1%)	18	53

All (4) Ramachandran outliers are listed below:

Mol	Chain	Res	Type
1	D	65	ASP
1	A	14	ASP
1	A	17	ALA
1	D	148	ARG

### 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	120/130 (92%)	116 (97%)	4 (3%)	33	67
1	B	122/130 (94%)	116 (95%)	6 (5%)	22	56
1	C	120/130 (92%)	111 (92%)	9 (8%)	12	41
1	D	122/130 (94%)	118 (97%)	4 (3%)	33	67
All	All	484/520 (93%)	461 (95%)	23 (5%)	23	57

5 of 23 residues with a non-rotameric sidechain are listed below:

Mol	Chain	Res	Type
1	C	78	MET
1	C	126	LYS
1	C	123	THR
1	C	148	ARG
1	B	119	VAL

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	92	ASN
1	B	92	ASN
1	D	92	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](#)

There are no ligands in this entry.

### 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 [i](#)

### 6.1 Protein, DNA and RNA chains [i](#)

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	145/155 (93%)	-1.41	0 100 100	38, 57, 83, 115	0
1	B	147/155 (94%)	-1.39	0 100 100	42, 56, 72, 107	0
1	C	145/155 (93%)	-1.42	0 100 100	39, 58, 80, 114	0
1	D	147/155 (94%)	-1.41	0 100 100	41, 56, 73, 115	0
All	All	584/620 (94%)	-1.40	0 100 100	38, 57, 79, 115	0

There are no RSRZ outliers to report.

### 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](#)

There are no ligands in this entry.

### 6.5 Other polymers [i](#)

There are no such residues in this entry.