

Table 1 - Summary site statistics for paleomagnetic data

Site	Lat	Lon	Level (m)	S	D	N	D ₀	L ₀	D ₁	L ₁	R	κ	α _{as}	φ _p	λ _p	Formation	Section
BH0414 ^β	N44.69721	W108.34584	0.0	123	12S	3	196.2	-46.3	191.6	-59.9	2.8	9.8	41.8	182.3	-80.6	Fort Union	FG 47-48
BH0401 ^α	N44.69736	W108.34660	11.3	123	12S	3	183.2	-31.9	178.4	-42.1	2.8	10.0	41.3	255.8	-69.6	Fort Union	FG 47-48
BH0403 ^α	N44.69695	W108.34664	24.8	123	12S	3	19.3	62.1	10.0	73.5	2.94	35.3	21.1	270.6	74.1	Fort Union	FG 47-48
BH0404 ^α	N44.69677	W108.34651	32.3	123	12S	3	31.5	68.4	29.7	80.4	2.82	11.4	38.4	270.0	59.8	Fort Union	FG 47-48
BH0405 ^α	N44.69627	W108.34615	39.3	123	12S	3	5.7	52.3	355.6	62.5	2.67	6.1	54.9	148.1	86.7	Fort Union	FG 47-48
BH0407 ^α	N44.69558	W108.34757	53.8	123	12S	3	1.9	55.2	349.2	64.8	2.99	159.4	9.8	180.6	82.2	Fort Union	FG 47-48
BH0408 ^α	N44.69559	W108.34747	57.0	123	12S	3	16.2	44.0	11.5	55.4	2.96	46.9	18.2	22.8	77.6	Fort Union	FG 47-48
BH0410 ^α	N44.69464	W108.34767	73.4	118	14S	3	343.6	48.9	328.7	57.7	2.93	29.7	23.0	157.4	65.9	Fort Union	FG 47-48
BH0412 ^β	N44.69390	W108.34623	97.4	118	14S	3	152.9	-61.5	125.6	-66.7	2.69	6.4	53.4	8.7	-53.4	Fort Union	FG 47-48
BH02015 ^α	N44.69375	W108.35215	143.1	118	10S	3	154.6	-51.1	142.9	-56.2	2.86	14.7	33.4	338.8	-61.1	Fort Union	FG 47-48
BH02016 ^β	N44.69342	W108.35196	147.7	118	10S	3	179.9	-48.1	173.1	-56.6	2.58	4.8	64.3	288.7	-80.9	Fort Union	FG 47-48
BH02019 ^β	N44.69043	W108.35602	183.7	118	10S	3	178.3	-63.5	163.7	-71.6	2.96	50.2	17.6	36.1	-74.5	Fort Union	FG 47-48
BH02018 ^β	N44.69029	W108.35599	185.8	118	10S	3	156.6	-69.3	129.2	-73.6	2.98	120.0	11.3	26.2	-56.5	Fort Union	FG 47-48
BH02020 ^β	N44.68957	W108.35555	199.2	118	10S	3	194.1	-66.5	184.7	-76.0	2.94	31.4	22.4	78.1	-71.0	Fort Union	FG 47-48
BH02021 ^β	N44.68953	W108.35563	205.0	118	10S	3	158.4	-62.8	139.5	-68.0	2.59	4.9	63.3	9.6	-62.5	Fort Union	FG 47-48
BH0415 ^α	N44.68957	W108.35573	207.6	118	14S	3	168.4	-24.1	163.1	-34.5	2.82	11.4	38.3	285.8	-60.7	Fort Union	FG 47-48
BH0416 ^α	N44.68882	W108.35562	227.2	118	14S	3	50.3	59.0	65.5	71.3	2.99	227.2	8.2	301.8	48.4	Fort Union	FG 47-48
BH0417 ^α	N44.68832	W108.35592	245.8	118	14S	3	168.7	-28.7	162.3	-39.1	2.61	5.1	61.4	290.2	-63.2	Fort Union	FG 47-48
BH0418 ^β	N44.68824	W108.35583	250.8	118	14S	3	165.2	-43.3	153.5	-52.6	2.47	3.8	75.0	321.4	-66.5	Fort Union	FG 47-48
BH0419 ^α	N44.68565	W108.35233	290.7	118	10S	3	348.6	70.8	320.5	76.9	2.96	46.9	18.2	218.8	60.3	Fort Union	FG 47-48
BH0420 ^α	N44.68430	W108.35224	311.7	118	10S	3	346.2	73.2	311.4	78.6	2.83	11.6	38.0	221.6	55.9	Fort Union	FG 47-48
BH0421 ^α	N44.68416	W108.35199	318.6	118	10S	3	51.2	53.1	58.3	62.1	2.93	30.1	22.9	322.1	49.0	Fort Union	FG 47-48
BH0422 ^α	N44.68322	W108.35223	325.3	118	10S	3	50.5	68.7	67.5	77.4	2.92	25.0	25.2	286.6	48.9	Fort Union	FG 47-48
BH02034 ^α	N44.67970	W108.33768	3.2	118	12S	3	36.1	35.4	37.7	47.3	2.92	26.2	24.6	357.3	56.1	Fort Union	FG 36-37
BH02035 ^α	N44.67902	W108.33731	6.7	118	12S	3	345.1	51.0	332.0	58.9	2.96	54.6	16.8	157.8	68.8	Fort Union	FG 36-37
BH02037 ^α	N44.67840	W108.33732	16.3	118	12S	3	2.6	66.6	341.2	76.5	2.96	49.4	17.7	230.1	67.7	Fort Union	FG 36-37
BH02038 ^α	N44.67852	W108.33729	18.3	118	12S	3	5.4	67.7	343.9	77.9	2.88	17.3	30.6	235.9	66.3	Fort Union	FG 36-37
BH02039 ^α	N44.67783	W108.33772	27.3	118	12S	3	19.3	66.9	10.5	78.6	2.89	18.7	29.3	261.3	66.0	Fort Union	FG 36-37
BH02040 ^α	N44.67775	W108.33757	29.7	118	12S	3	0.7	49.5	351.8	59.7	2.68	6.3	54.1	130.1	82.7	Fort Union	FG 36-37
BH02041 ^α	N44.67763	W108.33748	32.7	118	12S	3	325.0	66.5	295.8	69.2	2.93	29.4	23.1	196.6	48.3	Fort Union	FG 36-37
BH02042 ^α	N44.67675	W108.33808	43.0	118	12S	3	349.6	54.8	335.2	63.3	2.97	73.2	14.5	171.0	72.5	Fort Union	FG 36-37
BH02043 ^α	N44.67668	W108.33822	47.8	118	12S	3	350.5	56.2	335.4	64.8	2.85	13.7	34.7	177.3	72.8	Fort Union	FG 36-37
BH02044 ^α	N44.67668	W108.33840	55.4	118	12S	3	299.0	66.4	273.4	63.9	2.65	5.7	57.2	196.1	32.1	Fort Union	FG 36-37
BH0423 ^α	N44.67356	W108.33524	65.6	118	10S	3	16.8	65.0	9.9	74.7	2.92	23.8	25.8	267.5	72.4	Fort Union	FG 36-37
BH0424 ^α	N44.67377	W108.33471	72.3	118	10S	3	18.9	34.8	17.5	44.7	2.93	30.1	22.9	28.3	66.9	Fort Union	FG 36-37
BH0425 ^α	N44.67128	W108.33351	85.7	118	10S	3	157.1	-32.7	151.3	-38.6	2.63	5.4	59.6	306.9	-57.1	Fort Union	FG 36-37
BH0426a	N44.67047	W108.33414	95.5	118	10S	3	117.3	-39.8	109.1	-39.0	2.92	26.5	24.4	345.2	-28.7	Fort Union	FG 36-37
BH0427 ^β	N44.66419	W108.33118	143.8	118	10S	3	138.8	-29.9	133.0	-33.0	2.58	4.8	63.9	322.9	-42.7	Fort Union	FG 36-37
BH0433 ^β	N44.65185	W108.32861	255.4	118	10S	3	154.1	-29.7	148.8	-35.2	2.49	3.9	73.0	307.6	-53.9	Fort Union	FG 36-37
BH01025 ^α	N44.17225	W107.82779	10.0	149	20W	3	9.9	62.4	326.0	69.5	2.95	44.2	18.8	196.5	66.1	Fort Union	SCD
BH01027 ^α	N44.17173	W107.82805	20.0	149	20W	3	27.0	50.0	5.3	65.0	2.95	38.1	20.3	303.0	85.3	Fort Union	SCD
BH01028 ^α	N44.17166	W107.82817	21.4	149	20W	3	11.3	46.2	349.4	56.9	2.96	50.3	17.6	125.9	79.6	Fort Union	SCD
BH01031 ^α	N44.17063	W107.82834	59.6	136	14S	3	187.2	-44.5	175.6	-54.5	2.99	140.3	10.4	274.0	-80.3	Fort Union	SCD
BH01033 ^β	N44.17162	W107.82983	67.5	136	14S	3	195.4	-74.1	134.4	-82.0	2.83	11.5	38.1	53.1	-53.8	Fort Union	SCD
BH01036 ^β	N44.17154	W107.83078	75.0	133	14S	3	196.3	-73.1	141.9	-82.4	2.63	5.3	59.7	56.1	-55.0	Fort Union	SCD
BH01037 ^β	N44.17147	W107.83077	78.2	133	14S	3	149.6	-53.9	129.7	-55.6	2.94	35.5	21.0	348.0	-51.3	Fort Union	SCD
BH01038 ^α	N44.17128	W107.83067	86.0	133	14S	3	192.0	-36.2	184.8	-47.8	2.89	18.9	29.2	236.5	-74.2	Fort Union	SCD
BH01039 ^α	N44.17137	W107.83159	90.2	133	14S	3	356.3	63.4	327.1	70.4	2.96	46.3	18.3	200.0	66.5	Fort Union	SCD
BH01040 ^α	N44.17114	W107.83140	99.7	133	14S	3	165.6	-43.5	152.2	-49.7	2.66	5.9	56.2	319.6	-64.2	Fort Union	SCD
BH01041 ^β	N44.16997	W107.83095	107.0	133	14S	3	189.3	-48.9	176.7	-59.7	2.56	4.6	66.1	287.3	-85.6	Fort Union	SCD
BH01042 ^β	N44.16987	W107.83110	111.0	133	14S	3	210.5	-66.2	194.5	-79.4	2.9	19.9	28.4	83.6	-63.6	Fort Union	SCD
BH01043 ^α	N44.16962	W107.83066	116.5	133	14S	3	197.2	-47.6	187.4	-59.7	2.9	19.9	28.4	191.1	-83.4	Fort Union	SCD
BH01045 ^α	N44.16970	W107.83242	142.8	133	14S	3	151.9	-21.3	146.1	-25.2	3	480.5	5.6	305.9	-47.7	Fort Union	SCD
BH01046 ^α	N44.16960	W107.83317	160.0	133	14S	3	168.4	-38.9	157.2	-45.9	2.87	15.8	32.1	307.1	-65.1	Fort Union	SCD
BH01049 ^α	N44.16765	W107.83229	183.5	133	14S	3	11.5	61.0	349.8	71.6	2.94	33.5	21.7	227.9	76.2	Fort Union	SCD
BH01050 ^α	N44.16728	W107.83233	193.8	133	14S	3	358.6	29.3	351.5	38.7	2.97	70.6	14.8	92.4	66.6	Fort Union	SCD
BH01051 ^α	N44.16663	W107.83252	202.3	133	14S	3	338.2	57.0	315.6	60.4	2.96	47.4	18.1	173.0	57.7	Fort Union	SCD
BH01052 ^β	N44.16593	W107.83279	209.3	136	10S	3	57.9	59.5	63.1	69.2	2.96	48.5	17.9	307.0	48.7	Fort Union	SCD
BH01053 ^α	N44.16568	W107.83328	216.8	136	10S	3	359.8	46.5	350.6	52.9	2.95	42.3	19.2	109.6	77.1	Fort Union	SCD
BH01054 ^β	N44.16576	W107.83394	224.3	136	10S	3	24.3	62.7	13.4	71.6	2.97	79.5	13.9	282.2	75.2	Fort Union	SCD
BH01055 ^α	N44.16787	W107.83918	240.3	135	8S	3	192.8	-39.7	188.6	-46.3	2.85	13.3	35.2	226.7	-72.1	Fort Union	SCD
BH01056 ^β	N44.16720	W107.84020	267.5	135	8S	3	174.5	-51.5	165.5	-56.1	2.94	31.8	22.2	312.8	-76.7	Fort Union	SCD
BH01057 ^β	N44.16707	W107.84127	282.5	135	8S	3	208.6	-35.8	206.6	-43.4	2.84	12.4	36.6	194.5	-61.4	Fort Union	SCD
BH01061 ^β	N44.16426	W107.84761	369.8	135	8S	3	149.9	-50.3	140.1	-51.7	2.9	20.7	27.8	335.0	-56.9	Fort Union	SCD
BH01064 ^α	N44.35619	W108.06234	18.5	153	24W	3	144.5	-54.0	117.9	-44.7	2.95	37.9	20.3	343.7	-37.6	Willwood	AC-1976
BH01066 ^β	N44.35126	W108.07354	80.6	148	11W	3	123.5	-56.5	110.6	-50.8	2.83	11.8	37.6	353.5	-35.4	Willwood	AC-1976
BH01068 ^β	N44.34382	W108.07634	106.0	148	11W	3	168.6	-38.4	159.7	-41.5	2.69	6.4	53.3	297.6	-		

BH01092 ^α	N44.33749	W108.23267	106.5	0	0	3	43.1	62.7	43.1	62.7	2.8	9.8	41.6	326.8	59.5	Willwood	DC
BH01001 ^β	N44.33812	W108.26951	119.8	0	0	3	167.7	-61.6	167.7	-61.6	2.99	332.4	6.8	336.0	-81.0	Willwood	DC
BH01011 ^β	N44.33149	W108.27371	159.9	0	0	3	189.1	-63.9	189.1	-63.9	2.92	25.1	25.2	147.5	-83.4	Willwood	DC
BH01018 ^β	N44.33100	W108.27370	189.1	0	0	3	200.1	-48.5	200.1	-48.5	2.68	6.3	54.2	198.0	-68.2	Willwood	DC
BH01019 ^β	N44.33100	W108.27370	192.4	0	0	3	173.3	-69.1	173.3	-69.1	2.98	114.7	11.6	46.0	-80.6	Willwood	DC
BH01022 ^α	N44.33000	W108.27000	205.6	0	0	3	350.0	78.1	350.0	78.1	2.97	67.1	15.2	242.0	66.6	Willwood	DC
BH01023 ^α	N44.33000	W108.27000	210.9	0	0	3	333.9	71.8	333.9	71.8	3	508.0	5.5	208.0	69.5	Willwood	DC
BH01101 ^β	N44.27460	W108.31322	5.5	0	0	3	190.1	-45.4	190.1	-45.4	2.87	15.9	32.0	223.3	-70.8	Willwood	ECR
BH02054 ^α	N44.27360	W108.32769	28.4	0	0	3	352.1	67.6	352.1	67.6	2.99	188.1	9.0	213.9	81.8	Willwood	ECR
BH01096 ^α	N44.26779	W108.33661	70.2	0	0	3	357.0	61.5	357.0	61.5	2.95	40.1	19.7	126.0	87.3	Willwood	ECR
BH01097 ^α	N44.26643	W108.33861	88.1	0	0	3	341.3	46.9	341.3	46.9	2.64	5.6	57.8	120.7	68.0	Willwood	ECR
BH02060 ^α	N44.32814	W108.27178	103.8	0	0	3	355.1	70.3	355.1	70.3	2.97	72.7	14.6	236.0	79.4	Willwood	ECR
BH02050 ^α	N44.26535	W108.35116	130.0	0	0	3	352.3	64.9	352.3	64.9	2.97	66.5	15.2	190.1	84.0	Willwood	ECR
BH02051 ^α	N44.26537	W108.35119	130.5	0	0	3	0.6	49.8	0.6	49.8	2.94	34.5	21.3	69.5	76.3	Willwood	ECR

^α represents an alpha site and ^β represents a beta site (see text for discussion); Lat, Lon are GPS site coordinates (latitude, longitude) in decimal degrees and referenced to the North American 1927 Continental U.S. datum (NAD 1927 CONUS); Level is the local stratigraphic level in meters; S, D are strike and dip of bedding using right hand rule, N is number of samples from site; D_p , I_g (D_s , I_s) are declination and inclination of average characteristic component in geographic, in situ (stratigraphic, tilt corrected) coordinates; R is length of resultant vector, κ is precision parameter, α_{95} is circle of 95% confidence; ϕ_p , λ_p are longitude and latitude of the site virtual geomagnetic pole. Formation and Section are geological formation and stratigraphic section of site (SCD - Sand Creek Divide, AC-1976 - Antelope Creek, DC - Dorsery Creek, ECR - Elk Creek Rim).

Backstripping - Polecat Bench

Unit	Strat Level	Depth Top (m)	Thickness (m)	Mean Age (Ma)
1	Bio B	0	0.7	54.804
2	P/E	0.7	0.417	56.2325
3	C25n	1.117	0.269	56.9225
4	C25r	1.386	0.319	57.7795
5	C26n	1.705	0.1	58.558
6	C26r	1.805	0.287	60.1935
7	C27n	2.092		

TIME 1 Bring up Unit 6 60.1935 Ma

Unit 4 :		Phi zero	Initial Porosity	0.62
Mean Depth Unit 4	1.9485 km	c	Depth constant	0.43 km ⁻¹
Phi	0.268235			
Phi*	0.559585		Rho water	1000 kg/m ³
S	0.287 km		Rho grains	2650 kg/m ³
S*	0.47686 km		Rho man.	3330 kg/m ³
Rho bar	1726.686 kg/m ³			
y	0.328136 km			

TIME 2 Bring up Unit 5. Push down Unit 6 58.558 Ma

Unit 5 : (Bringing it up)

Mean Depth	1.755 km
Phi	0.291509
Phi*	0.597003
S	0.1
S*	0.175805

Unit 6 : (Pushing it down)

Mean Depth	0.23843
Phi	0.559585 This is initial phi
Phi*	0.522943 Subsequent phi after compaction by unit 5
S	0.47686 Initial uncompacted thickness
S*	0.440234 Thickness after compaction by unit 5

Sum Rho 5 bar	292.7065
Sum Rho 6 bar	786.7609
Rho BAR	1752.271
y	0.417143

TIME 3 Bring up Unit 4. Push down Units 5 and 6. 57.7795 Ma

Unit 4 (Bringing it up)

Mean Depth	1.5455
Phi	0.318988
Phi*	0.557846

S	0.319
S*	0.491329

Unit 5 (Pushing it down)

Mean Depth	0.087903
Phi	0.597003
Phi*	0.487233
S	0.175805
S*	0.13817

Unit 6 (Pushing it down)

Mean Depth	0.395922
Phi	0.522943
Phi*	0.436548
S	0.440234
S*	0.372732

Sum Rho 4 bar	849.7792
Sum Rho 5 bar	255.0712
Sum Rho 6 bar	719.2588
Rho bar	1820.05
y	0.649493

Time 4 Bring up Unit 3, Push down units 4, 5, 6

56.9225 Ma

Unit 3 (Bringing it up)

Mean Depth	1.2515
Phi	0.361975
Phi*	0.569114
S	0.269
S*	0.398316

Unit 4 (Pushing it down)

Mean Depth	0.245664
Phi	0.557846
Phi*	0.477715
S	0.491329
S*	0.415947

Unit 5 (Pushing it down)

Mean Depth	0.560414
Phi	0.487233
Phi*	0.425419
S	0.13817
S*	0.123306

Unit 6 (Pushing it down)

Mean Depth	0.815865
Phi	0.436548
Phi*	0.384964
S	0.372732
S*	0.34147

Sum Rho 3 bar	681.5039
Sum Rho 4 bar	774.3974
Sum Rho 5 bar	240.2069
Sum Rho 6 bar	687.9972
Rho bar	1863.982
y	0.804762

Time 5 Bring up Unit 2, Push down units 3,4, 5, 6

56.2325 Ma

Unit 2 (Bringing it up)

Mean Depth	0.9085
Phi	0.4195
Phi*	0.552
S	0.417
S*	0.540331

Unit 3 (Pushing it down)

Mean Depth	0.199158
Phi	0.569114
Phi*	0.459052
S	0.398316
S*	0.317274

Unit 4 (Pushing it down)

Mean Depth	0.60629
Phi	0.477715
Phi*	0.396832
S	0.415947
S*	0.360169

Unit 5 (Pushing it down)

Mean Depth	0.875916
Phi	0.425419
Phi*	0.358642
S	0.123306
S*	0.110467

Unit 6 (Pushing it down)

Mean Depth	1.108304
Phi	0.384964
Phi*	0.327482
S	0.34147
S*	0.312284

Sum Rho 2 bar	939.744
Sum Rho 3 bar	600.4615
Sum Rho 4 bar	718.62
Sum Rho 5 bar	227.3685
Sum Rho 6 Bar	658.8112
Rho bar	1917.071
y	0.994827

TIME 4 Bring up Unit 1. Push down Units 2,3,4,5,6 (ie all units end up in present position)
54.804 Ma

Unit 1 :
Mean Depth 0.35
Phi* 0.533372
Sum Rho 1 bar 1238.955

Unit 2 :
Mean Depth 0.9085
Phi* 0.4195
Sum Rho 2 bar 816.4128

Unit 3 :
Mean Depth 1.2515
Phi* 0.361975
Sum Rho 3 bar 552.1875

Unit 4 :
Mean Depth 1.5455
Phi* 0.318988
Sum Rho 4 bar 677.4505

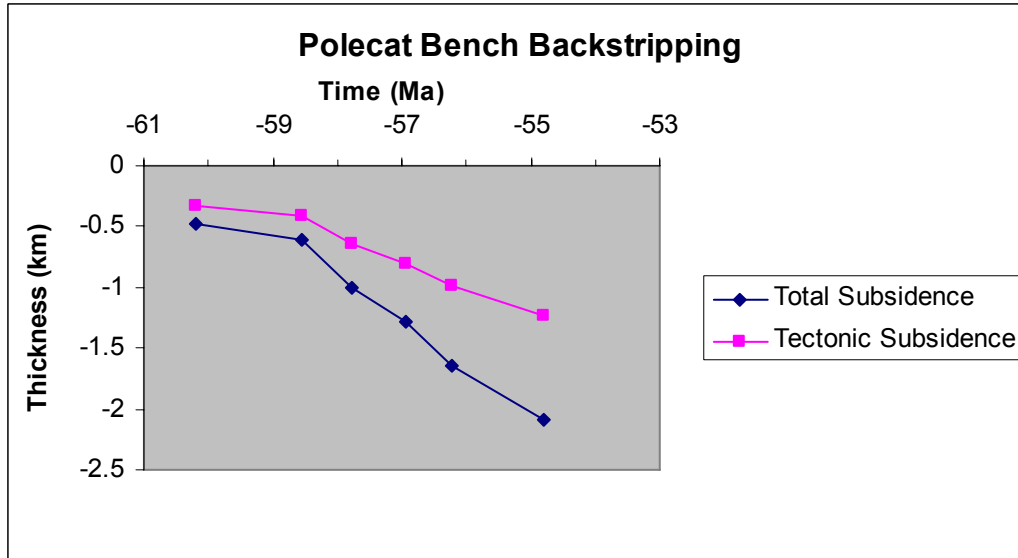
Unit 5 :
Mean Depth 1.755
Phi* 0.318988
Sum Rho 4 bar 212.3669

Unit 6 :
Mean Depth 1.9485
Phi* 0.318988
Sum Rho 4 bar 609.4931

Rho BAR 1963.129
y 1.227251

Summary F of Results

Age	S*	y
-54.804	-2.092	-1.227251
-56.2325	-1.640526	-0.994827
-56.9225	-1.279039	-0.804762
-57.7795	-1.00223	-0.649493
-58.558	-0.616039	-0.417143
-60.1935	-0.47686	-0.328136



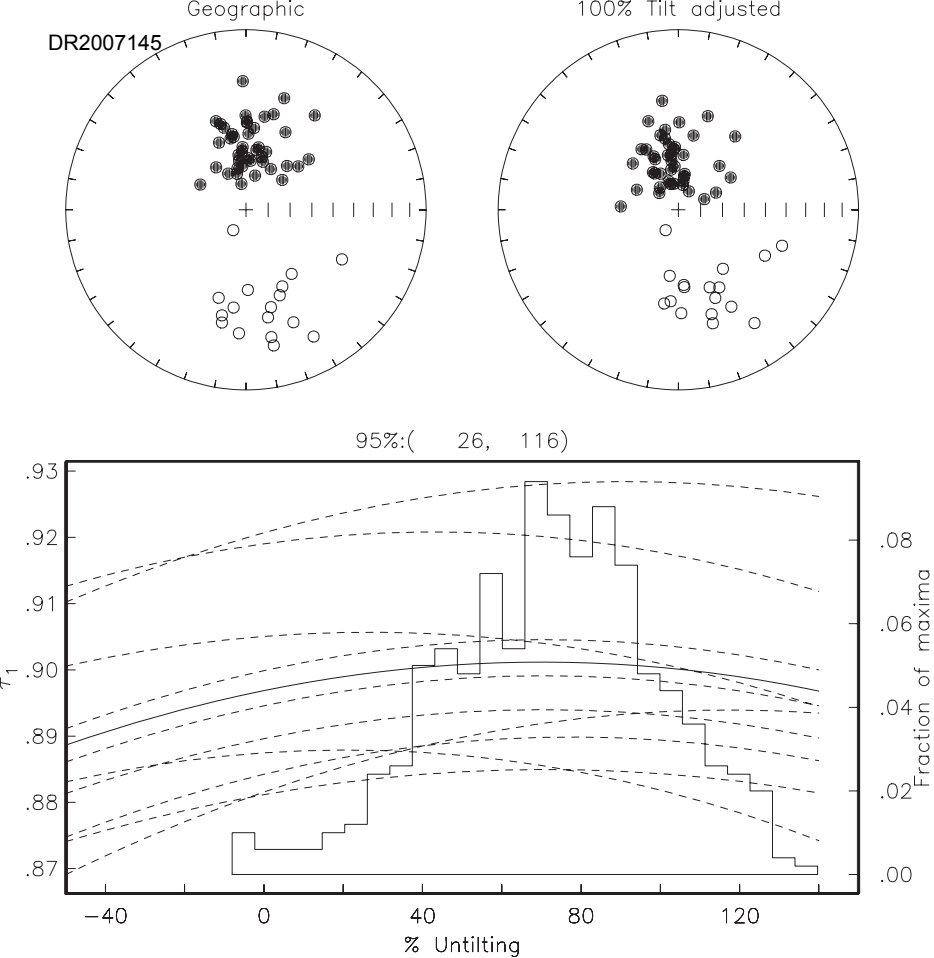


Figure DR1. Parametric bootstrap fold test of Tauxe and Watson (1994) showing maximum clustering of characteristic directions occurring near 100% unfolding and a 95% confidence interval that excludes 0% unfolding, ruling out a post-folding magnetization. The fold test is poorly constrained due to the gentle tilt of the beds.

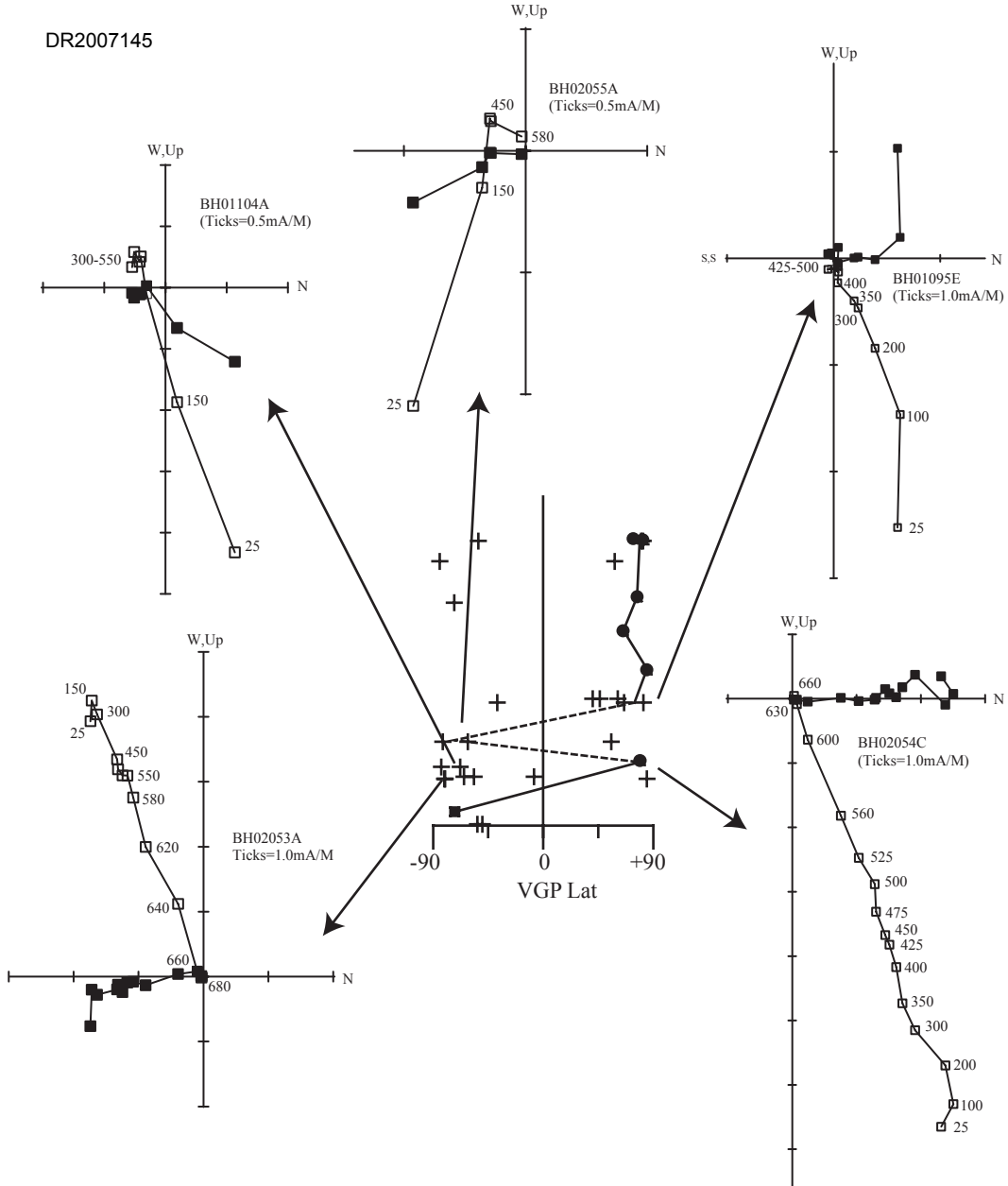


Figure DR2. Vector endpoint diagrams showing demagnetization data for representative samples from the Elk Creek Rim section across the polarity reversal observed in that section. Notice the 30 meter interval of mixed polarity that complicates determining a precise placement for the reversal.