GSA Data repository Item for:

Hounslow et al. "Bio-magnetostratigraphy of the Vikinghøgda Formation, Svalbard (arctic Norway) and the geomagnetic polarity timescale for the Lower Triassic"

The nature of the overprint magnetisation in the Vikinghøgda Formation.

A lower stability overprint direction (remagnetisation) is often present in the samples from Vikinghøgda, and frequently forms a substantial part of the NRM intensity. This overprint direction was isolated as a linear segment from the demagnetisation data, using the software detailed by Kent et al. (1983). In 32% of specimens this overprint was fitted from the NRM direction, with the remainder of the line-fits from either the first thermal demagnetisation step (often at 200°C), or the initial stages of alternating field demagnetisation. This is a reflection that some 68% of specimens also included a lower stability 'laboratory viscous' magnetisation (which was not analyzed) superimposed on the stronger overprint magnetisation.

The overprint directions from the interpreted Triassic reverse polarity specimens are notably more dispersed than those from the interpreted Triassic normal polarity specimens (Fig. DR2), with Fisher- k values less than 10 for the 'reverse overprint' compared to greater than 10 for the 'normal overprint' specimens (Fig. DR2, Table DR1). The average precision of the principle component (PCA) line-fits for the overprint directions are similar, accept for those from 'normal polarity' specimens in the Lusitaniadalen Member (Table DR1). This suggests that at least for the Deltadalen and Vendomdalen members that the directional scatter evident in Figure DR2 is not related to the precision of the fitted lines. The 'normal polarity' overprints from the Lusitaniadalen Member are anomalous in this respect, since the average precision of the line fits is some half of that in the other units (Table DR1). This is likely a reflection of several features. Firstly, most of these 'normal polarity' specimens come from the upper part of the Lusitaniadalen Member, in which the samples were dominantly collected from early diagenetic calcite concretions. Secondly, most of the calcite concretions have significantly elevated NRM intensity compared to the sandstone and siltstone lithologies in other parts of the sections (Fig. DR3a). Thirdly, the calcite concretions are some twice as

likely to retain only the overprint magnetisation, compared to other types of lithologies (Fig. DR3b). These factors likely account for the greater average precision of the overprint PCA line fits for the 'normal polarity' specimens from the Lusitaniadalen Member.

The mean overprint direction of the 'normal polarity' specimens falls in the NE quadrant, whereas that for the 'reverse-polarity' is notably displaced to the west (Table DR1, Fig. DR2). The 95% confidence interval of the mean direction of each of the three members includes the geocentric axial dipole field (GADF) direction (Fig. DR2). Whereas the 95% confidence interval of the mean overprint direction of the reverse polarity specimens, does not include the GADF direction (Table DR1).

We interpret the overprint as probably a composite magnetisation, consisting mostly of a remagnetisation with a field direction similar to the GADF (Brunhes age?), with the addition of a small (and variable from specimen to specimen) amount of Triassic magnetisation. This interpretation can account for the dispersion and directional bias seen between the interpreted Triassic reverse and normal polarity specimens. It also accords with the great-circle behaviour seen by many specimens during demagnetisation, indicating the strong overlap of the Triassic magnetisation and the Brunhes-age overprint.

REFERENCES

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Kent, J.T., Briden, J.C., and Mardia, K.V., 1983, Linear and planar structure in ordered multivariate data as applied to progressive demagnetisation of palaeomagnetic remanence: Geophysics Journal Royal Astronomical Society, v. 81, p. 75-87.

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	Fisher Mean					VGP		PCA
Member (polarity)	**Dec.**	**Inc.**	**k**	**α_{95}**	**Nl**	**Lat.**	**Long.**	**α_{95}**
Vendomdalen Mb (R+N)	296	68	13.8	9.4	19	55	276	10.3
Vendomdalen Mb (N)	303	73	16.2	10.2	15	63	273	10.8
Lusitaniadalen Mb (R)	232	85	9.2	5.8	50	71	353	11.4
Lusitaniadalen Mb (N)	15	84	14.3	4.5	73	87	102	5.1
Deltadalen Mb (R)	329	76	5.8	9	52	73	247	11.8
Deltadalen Mb (N)	57	85	13.4	7.3	31	80	70	11.3
All reverse polarity	306	81	5.6	6.4	107	76	294	-
All normal polarity	15	85	12.2	4.5	89	87	67	-

Table DR1. Summary of the overprint mean directions from the Vikinghøgda Fm, Vikinghøgda (prior to bedding correction). This excludes those specimens which were not assigned a polarity, but are displayed in Fig. DR2. Nl=number of specimens using with fitted lines, used in the determining the mean direction. α95, Fisher 95% cone of confidence. k, Fisher precision parameter. Lat. and Long. are the latitude and longitude of the mean virtual geomagnetic pole. The PCA α_{95} is the average Fisher α_{95} measuring the precision of the line fitted to the overprint direction for each specimen. GADF field inclination is 84°.

Sample level	**Height (m)**	**Dec.**	**Inc.**	**R-bar**	**Nl/Np**	**VGP Latitude**
Botneheia Formation						
VM1	257.0	005	60	0.971	1/1	68
VM2	256.3	**017**	**56**	**0.994**	**2/0**	**72**
VM3	254.5	**057**	**63**	**0.989**	**2/0**	**73**
Vendomdalen Member						
VM4	252.0	044	67	0.987	3/0	83
VM5	249.8				0/1^{+}	
VM6	243.0	048	38		1/0$^{\#}$	59
VM18	240.3	041	83	1.000	0/2	64
VM7	237.3	**058**	**61**	**0.997**	**2/0**	**71**
VM8	234.4	024	72	0.996	1/1	81
VM9	231.4	**065**	**60**	**1.000**	**2/0**	**66**
VM10	224.0	**043**	**67**	**0.993**	**2/0**	**84**
VM11	218.3	**027**	**69**	**0.999**	**2/0**	**86**
VM12	210.8	115	-52	0.998	0/3	-20
VM13	202.6	**044**	**70**	**0.996**	**2/0**	**82**
VM14	188.9	**014**	**70**	**0.994**	**2/0**	**78**
VR49+VM15	186.0	146	-70	0.987	0/3	-50
VR48	181.2	**078**	**61**	**0.989**	**3/0**	**58**
VR47+VM16	178.7	**021**	**62**	**0.997**	**5/0**	**79**
VR46+VM17	173.6	**047**	**64**	**0.979**	**3/0**	**79**
VR45	168.8	**042**	**65**	**0.996**	**3/0**	**83**
VR44	164.3	**039**	**65**	**0.984**	**3/0**	**85**
Lusitaniadalen Member						
VR43	155.8	**359**	**64**	**0.993**	**2/0**	**68**
VR42	155.3	**033**	**65**	**0.999**	**2/0**	**85**
VR40	154.4	**032**	**56**	**1.000**	**2/0**	**75**
VR40	153.3	035	51	0.998	1/2	70
VR39	151.8	072	66	0.997	2/0	64
VR50	149.3				0/1^{+}	
VR52	146.7	359	75	0.999	0/3	70
VR51	145.6	016	57	1.000	0/2	72

VR53	144.4	003	79	1.000	0/2	69
VR54	140.6	022	25	1.000	0/2	51
VR33	136.0	034	66	0.995	2/1	86
VR32	131.7	068	66	0.996	1/1	66
VR55	128.4	165	-77	1.000	0/2	-63
VR31	124.3	066	68		1/0#	68
VR37	123.3	151	-80	1.000	0/3	-57
VR38	122.0	060	67		1/0#	72
VR36	121.2				0/1+	
VR35	119.2		only overprints		0/0	
VR30	118.3	038	74		1/0#	81
VR29	115.8	356	74	1.000	0/2	69
VR27	111.9	024	69	0.989	2/0	86
VR28	109.8	083	44	0.949	1/2	43
VR26	108.8	221	-66	1.000	0/2	-83
VR25	107.4	244	-72	0.999	1/2	-71
VR24	105.4	322	-77	1.000	0/2	-38
VR23	104.5	118	-56	0.992	0/3	-26
VR34	102.2		none suitable		0/0	
VR22	100.1	257	-62	0.990	1/2	-58
VR21	99.5	203	-52	0.900	0/3	-70
VR20	97.9				0/1+	
VR19	97.2		'GC trends' unable to fit planes		0/0	
VR18	95.3	078	46		1/0#	48
VR17	93.6	150	-69	1.000	0/2	-53
VR1	92.5	291	72	0.990	0/3	36
VR2	89.1	**215**	**-41**	**0.986**	**3/0**	**-62**
VR3	85.9		none suitable		0/0	
VR4	80.6	205	-72	0.986	0/4	-84
VR5	78.7	201	-26	0.945	1/1	-51
VR6	76.9	200	25	0.985	0/3	-25
VR7	74.3	280	63	1.000	0/2	23
VR8	73.0	008	70	0.657	1/2	76
VR9	72.4		none suitable		0/0	
VR10	68.6	230	-73	0.939	2/2	-77
Deltadalen Member						
VR11	67.4	201	-62	0.993	2/0	-89
VR12	65.7	203	-29	0.935	1/2	-62
VR15+VR13	64.6	199	-46	0.983	2/2	-73
VR16b+VR14b	62.3	358	-35	1.000	0/2	23
DR33	56.8	334	-76	1.000	0/2	-24
DR32	54.7	049	49	0.980	1/1	65
DR31	53.3		only single plane		0/1+	
DR30	52.3	050	53	0.962	2/1	67
DR29	50.8	059	38	1.000	0/2	53
DR28	49.8	68.5	62	0.998	1/1	57
DR25	48.8	184	-74	0.999	0/3	-71
DR24	48.2	227	-80	1.000	0/2	-61
DR23	46.8	234	-22	0.986	0/3	-47
DR22	46.1	193	-53	0.969	1/2	-77
DR21	45.0	177	-76	0.997	0/3	-66
DR20	43.8	147	-57	1.000	0/2	-48
DR19	42.9	**225**	**-45**	**0.967**	**2/0**	**-65**
DR26	40.9	246	-45	1.000	0/3	-51
DR27	38.9	211	-53	0.990	2/1	-78
DR18	36.2	190	-62	0.832	1/1	-81
DR17	34.8	124	-54	0.976	0/3	-31
DR16	33.4	**028**	**62**	**0.995**	**3/0**	**86**
DR15	32.0	010	62	0.951	2/1	81
DR14	30.1	010	53	0.955	2/1	76

DR13	28.4	064	54	0.987	2/0	57
DR12	25.9	**039**	**61**	**0.963**	**3/0**	**78**
DR37	22.3	000	54	0.994	1/1	70
DR36	20.6	**050**	**74**	**1.000**	**2/0**	**67**
DR35	19.3	052	31		1/0[#]	53
DR34	17.4		two of opposite polarity		0/0	
DR11	15.6	331	67	0.999	0/3	55
DR10	14.8	204	-46	0.933	1/2	-73
DR9	14.0	149	-61	0.996	0/3	-51
DR8	13.3	161	-72	0.999	0/3	-61
DR7	12.2	055	68	0.992	1/1	68
DR6	11.3	359	48	0.964	1/1	63
DR5	10.0	176	-63	1.000	0/3	-71
DR4	1.8	143	-51	1.000	0/3	-42
DR3	0.3	096	-64	0.976	0/3	-21
DR2	-1.2	332	-74	1.000	0/2	-22
DR1	-5.0	182	-51	0.901	2/1	-69

Table DR2. Summary of the horizon mean directions (in stratigraphic coordinates) for the Vikinghøgda sections. Nl/Np= number of ChRM planes/number of great circle planes. Those horizons which contained only specimens with suitable line-fit ChRM directions were averaged using Fisher statistics (marked in bold), whereas others containing specimens with fitted great-circles were averaged using the method of McFadden & McElhinney (1988). R-bar is the mean resultant length [R/(Nl+Np)] as a measure of the dispersion (since Fisher k or a confidence cone is of dubious value for such low numbers of specimens at each level). [#] single suitable specimen with ChRM line-fit; [+] single suitable specimen with fitted great circle. Note that a mean using two planes will always give an R-bar of 1.0, since the direction given is the intersection point of the two planes. Horizon VGP latitudes based on mean directions for each respective member that the level belong to. Deltadalen Mb mean: 022.4, 62.7, k=11.5, α_{95}=7.2, n=38, reversal test=Rc; Lusitaniadalen Mb mean: 031.2, 68.3, k=16.4, α_{95}=4.9, n=54, reversal; test=Rb; Vendomdalen Mb + Botneheia Fm: 033.1, 67.5, k=23.6, α_{95}=6.9, n=20, reversal test not possible).

Captions

Fig. DR1. Boundary interval details of the three members of the Vikinghøgda Fm. A) The basal sandstone of the Deltadalen Mb, with the two stratigraphically lowest sampling points in the Deltadalen Mb indicated with arrows. B) and C) the boundary interval between the Deltadalen and Lusitaniadalen members, with marker levels indicated in metres, and magnetostratigraphic sampling points (see Table DR2) shown in C). The dotted line is the base of the Lusitaniadalen Mb. D) and E) the boundary interval of the Lusitaniadalen and Vendomdalen members, with heights indicated in D). The arrows in D) and dotted line in E) indicate the base of the Vendomdalen Mb at the 156 m level in the section. Note the shale interbedded in the sandstone in the upper-most part of the Lusitaniadalen Mb in D).

Fig. DR2. Overprint directions extracted from each specimen (*in situ* coordinates), separated into the three members, interpreted Triassic polarity and interpreted polarity quality. The data for the Deltadalen Member includes 3 specimens from the Kapp Starostin Fm. The data for the Vendomdalen Member includes 6 specimens from the Botneheia Fm. The Fisher mean and α_{95} are indicated for each plot. GADF= geocentric axial dipole field for the present-day.

Fig. DR3. a). NRM intensity and susceptibility properties of the Vikinghøgda Fm, sub-divided according to lithology. B) Percentage subdivision of specimen magnetisation characteristics for the Vikinghøgda Fm, sub-divided according to member, and type of sample lithology. 'Line-fits'= conventional principle components, fitted-line ChRM data (i.e. S-class data in main text). 'Great circle fits'= polarity interpreted according to great circle (remagnetisation circle) trends (i.e. T-class in main text). N=number of specimen data for each of the lithological categories. These plots also include data from the Vendomdalen Member at Milne Edwardsfjellet detailed by Hounslow et al. (2008).

Fig. Dr1

DR2008106

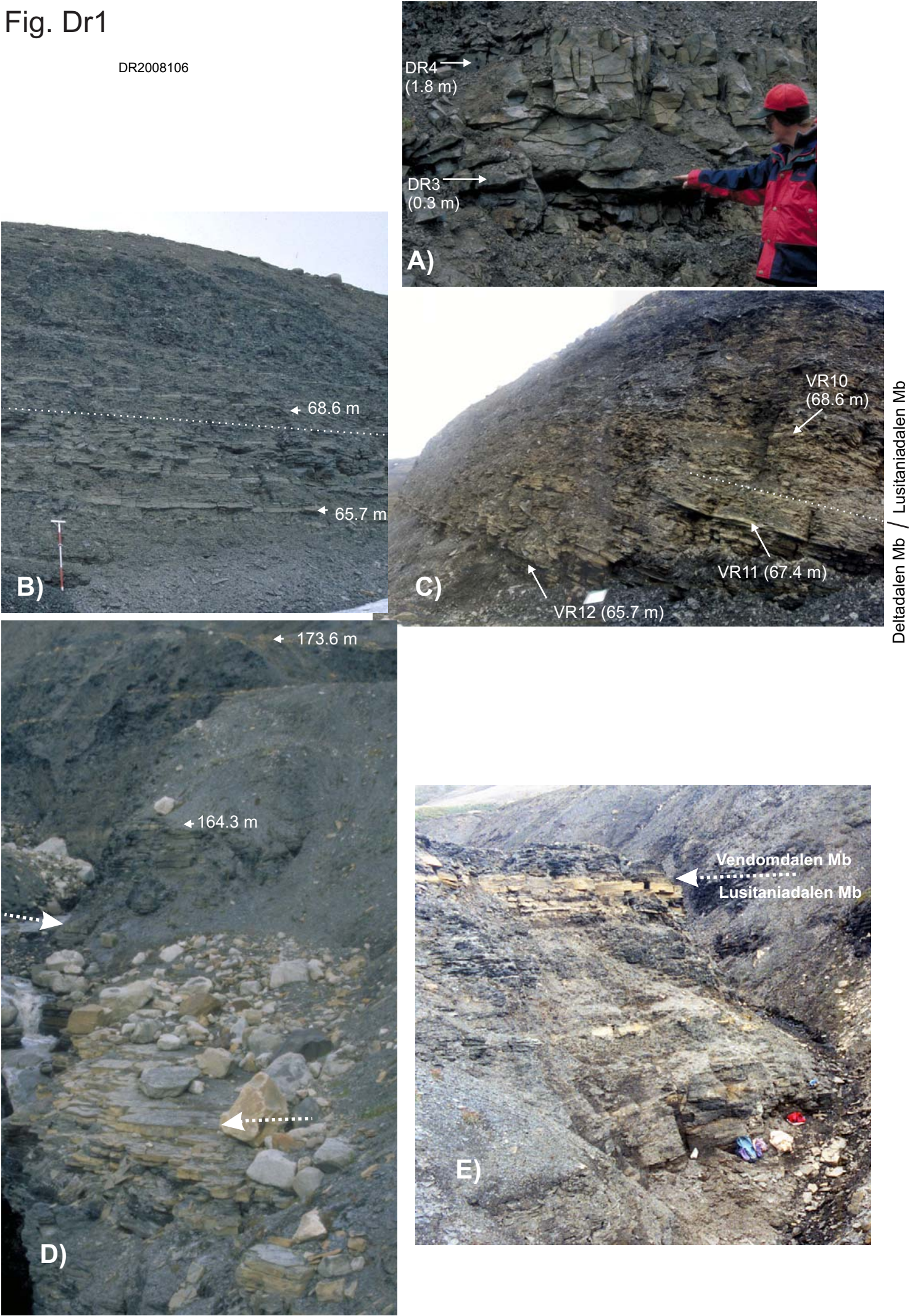


Fig. Dr2

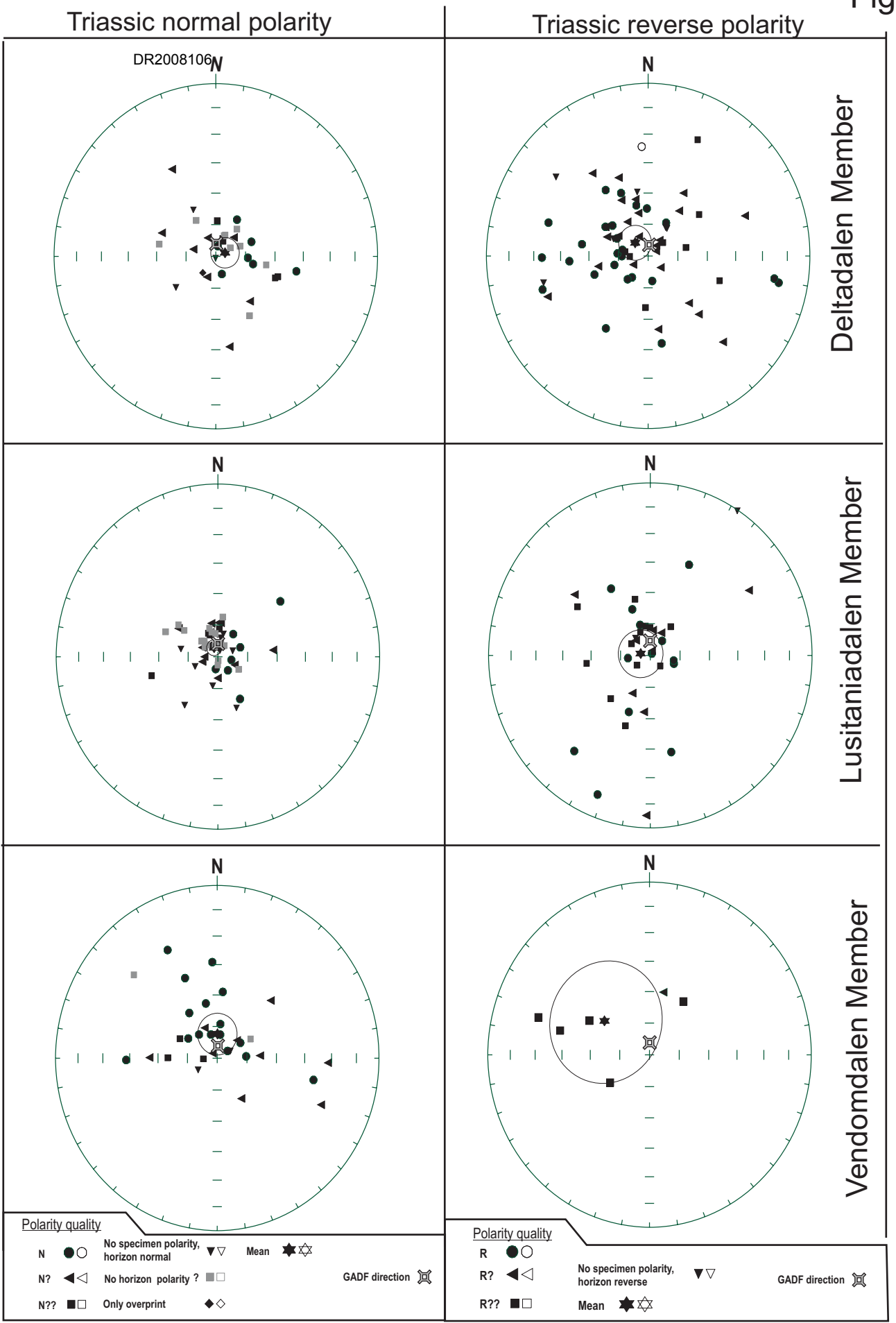
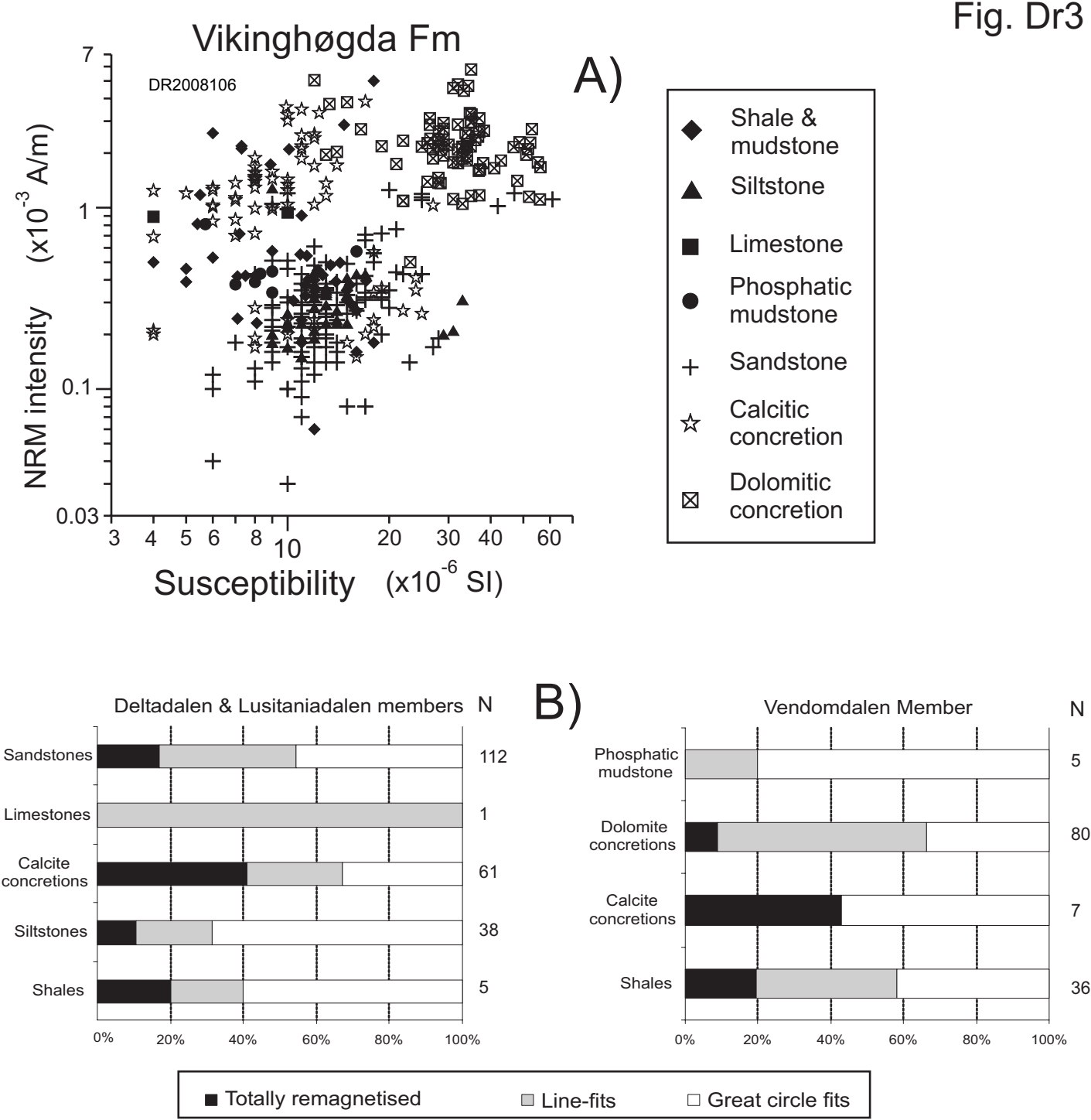

Triassic normal polarity
Triassic reverse polarity
DR2008106
N
Deltadalen Member
Lusitaniadalen Member
Vendomdalen Member
Polarity quality
N
N?
N??
No specimen polarity, horizon normal
No horizon polarity ?
Only overprint
Mean
GADF direction
R
R?
R??
No specimen polarity, horizon reverse
Mean
GADF direction

Fig. Dr3


Vikinghøgda Fm
DR2008106
A)
NRM intensity (x10^{-3} A/m)
7
1
0.1
0.03
3
4
5
6
8
10
20
30
40
60
Susceptibility (x10^{-6} SI)
Shale & mudstone
Siltstone
Limestone
Phosphatic mudstone
Sandstone
Calcitic concretion
Dolomitic concretion
B)
Deltadalen & Lusitaniadalen members
N
Sandstones
112
Limestones
1
Calcite concretions
61
Siltstones
38
Shales
5
0%
20%
40%
60%
80%
100%
Vendomdalen Member
N
Phosphatic mudstone
5
Dolomite concretions
80
Calcite concretions
7
Shales
36
0%
20%
40%
60%
80%
100%
Totally remagnetised
Line-fits
Great circle fits