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Paleomagnetic Investigations in Northeast Greenland and New Data from Devonian(?) and Late Carboniferous Rocks

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THEME 5: The Barents Shelf and the Eastern Greenland Margin: A Comparison

Summary: New palaeomagnetic results from Devonian (?) continental redbed deposits of Kap Kane (Johannes V Jensen Land) and from the Late Carboniferous Foldedal Formation of Peary Land (north to northeast Greenland) are presented in this paper. A remanent component of magnetization was achieved during diagenesis of the sediments. The bedding corrected Kap Kane pole is situated on the Devonian sector of the Apparent Polar Wandering Path (APWP; rotated into European coordinates). Hence, we assume a Devonian age of the redbed deposits of Kap Kane. The latitudinal position of the resulting palaeopol for the Foldedal Formation (Peary Land) is in agreement with other Late Carboniferous pole positions for Europe, but the longitudinal position is displaced from the European APWP by 20°. This is taken as evidence for clockwise rotation of the outcrops of Foldedal from which the samples were collected. This is in accordance with dextral lateral movements along the Trolle Land Fault Zone, which separates different tectonic blocks in the area under investigation.

INTRODUCTION

The object of the CASE-expeditions (Correlation of Alpine Structural Events in Spitsbergen and North Greenland) was to compare the structural evolution of the (Cretaceous to) Early Tertiary fold and thrust belt of West Spitsbergen and the fault structures of Northeast Greenland in the light of their plate tectonic evolution. Our aim was to improve the stratigraphy of Cretaceous rock sequences by magnetostratigraphy.

During the CASE II expedition several hundreds of palaeomagnetic samples were collected in Northeast Greenland (Fig. 1). The primary aim failed due to the thermal overprint of the Cretaceous rocks at Santon Gletscher in Johannes V. Jensen Land and Depot Bugt in Peary Land. In contrast, Late Carboniferous marine redbed samples from Foldedal (Peary Land) were not affected by the thermal overprint. Also continental redbeds at Kap Kane (Johannes V Jansen Land), which are probably of Devonian age, exhibit a shallow magnetic inclination. Hence, this paper deals only with new results of the palaeomagnetism of Devonian to Late Carboniferous sediments.

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REGIONAL GEOLOGY AND STRATIGRAPHIC SETTING

Proterozoic to Late Palaeozoic

Northeast Greenland is built up by three different tectonostratigraphic units:
(1) the Precambrian Craton with a cover of stable shelf sediments,
(2) the Caledonides in the east,
(3) the Ellesmerian fold belt in the north.

Precambrian crystalline rocks are overlain by Middle Proterozoic rift related sediments and volcanic rocks in north Greenland (SURLYK 1991). In east Greenland, the passive margin of the Iapetus Ocean developed in Late Proterozoic times and was closed again during the Ordovician/Silurian Caledonian Orogeny. In northernmost East Greenland, middle Wenlockian turbidites are affected by westward emplaced nappes, such that the main Caledonian diastrophism started in late Wenlock time (ROBERTS 1988). In the north, the Franklinian Basin started to open at the end of the Precambrian leading to facies differentiation between Cambrian to Silurian platform and ramp deposits in the south and deep-water succession in the Franklinian Basin toward the north (HIGGINS et al. 1981). The Proterozoic to mid-Palaeozoic history of northeast Greenland was terminated by the Devonian-Early Carboniferous Ellesmerian Orogeny (HENRIKSEN 1992).

Late Palaeozoic to Mesozoic

Two intracratonic rift basins developed during the Late Palaeozoic (STEMMERIK & HÅKANSSON 1991): The East Greenland Rift Basin between Norway and Greenland and the North Greenland – Svalbard Basin between these two terranes. Both are included in the Middle Carboniferous to Tertiary Wandel Sea Basin (HÅKANSSON & STEMMERIK 1989, HÅKANSSON & PEDERSEN 1982, HÅKANSSON et al. 1994a, b). The depositional history of the East Greenland Rift Basin comprises Early Carboniferous to Early Permian sediments, whereas the Greenland - Svalbard Basin is characterized by (Devonian (?), this paper) Late Carboniferous to Triassic sediments (STEMMERIK & HÅKANSSON 1989).

The (Devonian? to) Late Carboniferous sediments of Eastern Peary Land and northern Johannes V. Jensen Land (Tab. 1), from were our palaeomagnetic samples were collected, belong to the Greenland – Svalbard Basin. According to literature, syn-rift sedimentation started diachronously during Early to

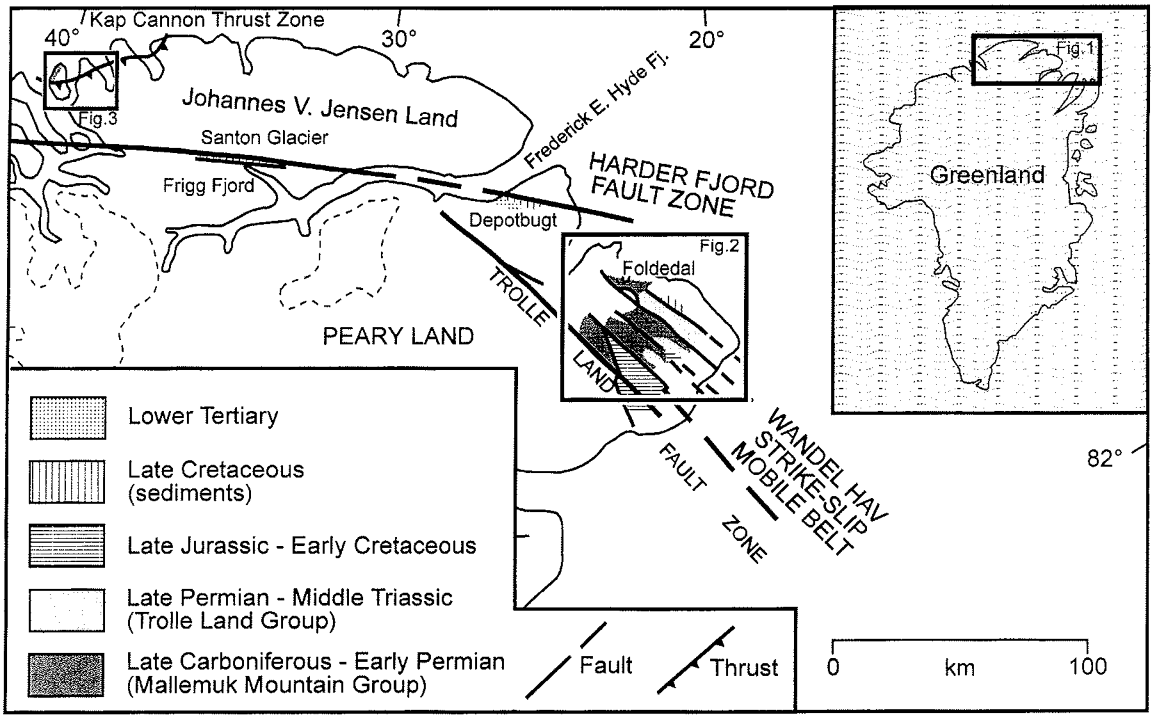

Fig. 1: Simplified sketch map of Northeast Greenland with main structural elements (compiled by von Gosen after HENRIKSEN 1992)

Late Moscovian with the Foldedal Formation (STEMMERIK et al. 1994a and b, RASMUSSEN & HÅKANSSON 1994).

Foldedal

The Foldedal Formation (Fig. 2) rests unconformably with a transgressive contact on Precambrian to Silurian basement rocks which were slightly tilted during the Caledonian and/or Ellesmerian events. The formation consists of a redbed sequence composed of fanglomerates, conglomerates, sandstones, and siltstones which are overlain by limestones. The onset of sedimentation varies from place to place. At the CO-Section (Fig. 2), Silurian limestones exhibit a karstic surface which is covered by more than 50 metres of continental fanglomerates. At the FD-Section (Fig. 2), Precambrian quartzites are overlain by an up to metre-thick breccia composed of up to 1 m-sized poorly rounded quarzite blocks. This breccia is followed by conglomerates and cross-bedded coarse-grained calcareous sandstones with large ripples. Brachiopods prove marine environment a few metres above the base of the section. The overlying conglomerates, calcareous sandstones, and sandy limestones are rich in marine fossils indicating nearshore deposition in a shallow sea. 36 Palaeomagnetic samples were collected from the lower part of the section (Fig. 2).

Early Permian	Asselian – Kungurian	Kim Fjelde Formation	Mallemuk Mountain Group
Late Carboniferous	Late Moscovian – Gzehlian	Foldedal Formation	
	Early Moscvian		

Tab. 1: Stratigraphy of Late Paleozoic rocks in the Foldedal area.

Kap Kane

At Lockwood Ø and Kap Kane (Fig. 3), the sedimentary sequence is cross-cut by several thrusts of the Kap Cannon Thrust Zone and by mafic dykes and sills. Nevertheless, the stratigraphy can approximately be reconstructed. Strongly deformed Lower Cambrian basement rocks are overlain by conglomerates, sandstones, cherty limestones and dolomites of the Permo-Carboniferous Mallemuk Mountain Group (HÅKANSSON et al. 1981, STEMMERIK & HÅKANSSON 1989). These Late Palaeozoic rocks are overlain by Late Cretaceous volcanic and sedimentary rocks of the Kap Washington Group (although a sedimentary contact is not exposed).

A sequence of redbeds, quartzites, conglomerates, and limestones with intercalated mafic sills is exposed at an unnamed ridge at Kap Kane (Fig. 3). Ascending the ridge from the south, the following rocks can be found: >200 m of volcanic

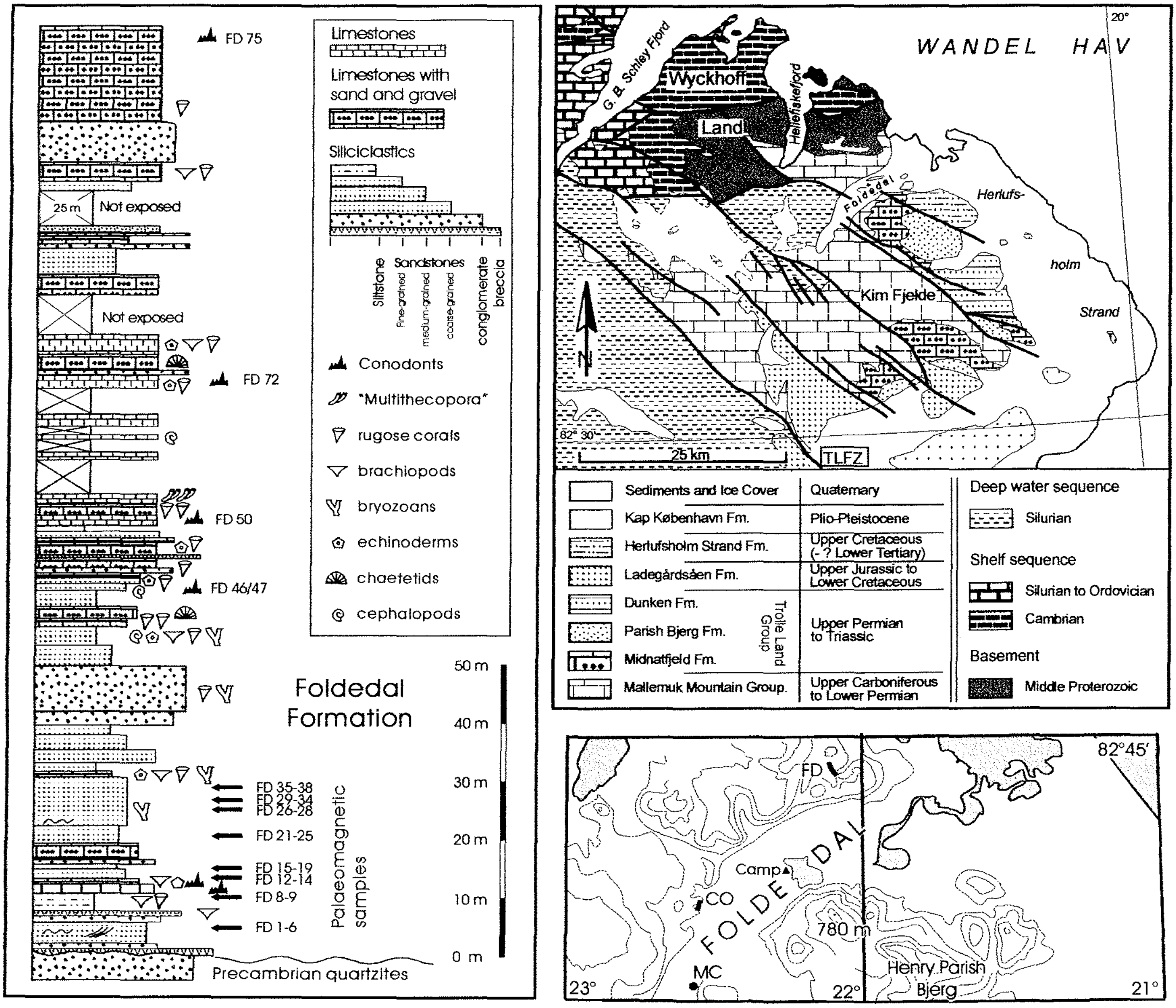

Fig. 2: Geological map of the Wandel Hav Mobil Belt in Herulf Trolle Land (compiled by von Gosen after BENGAARD & HENRIKSEN 1984. TLFZ = Trolle Land Fault Zone). Sketch map of the sampled sections at Foldedal and the measured FD-Section.

rocks are overlain by about 70 m of predominantly red siltstones with some conglomerates and sandstones. Pedogenic carbonates within the siltstones prove a terrestrial depositional environment for these rocks. The redbeds are followed by white quartzitic sandstones which were intruded by mafic sills. Quartzites and sills are together about 65 m thick. The upper part of the section is made up by white and upwards gray and red conglomerates which pass into marine sandy fossiliferous limestones. The sequence is interrupted by several faults. It is therefore unclear, whether it represents a stratigraphic succession or is composed of different stratigraphic units. The uppermost part clearly resembles the basal part of the Mallemuk Mountain Group of the Foldedal area. The stratigraphic position of the quartzitic sandstones is a matter of debate. In the field, E. Håkansson supposed that these rocks belong to the Early Palaeozoic basement, whereas W. Buggisch assumed that they are part of the Late Palaeozoic succession. Assuming a disturbed but in general preserved stratigraphic sequence, the redbeds in the lower part of the section are the oldest post-Ellesmerian sediments which may represent the base of the Permo-Carboniferous Mallemuk Mountain Group or even older deposits (Devonian?). 17 palaeomagnetic samples were collected from these redbeds.

TECTONICS

Several Late Mesozoic to Early Cenozoic large-scale structures are known in Northeast Greenland (Fig. 1).

The Wandel Hav Strike-Slip Mobil Belt

The Wandel Sea Basin is bordered by the Trolle Land Fault

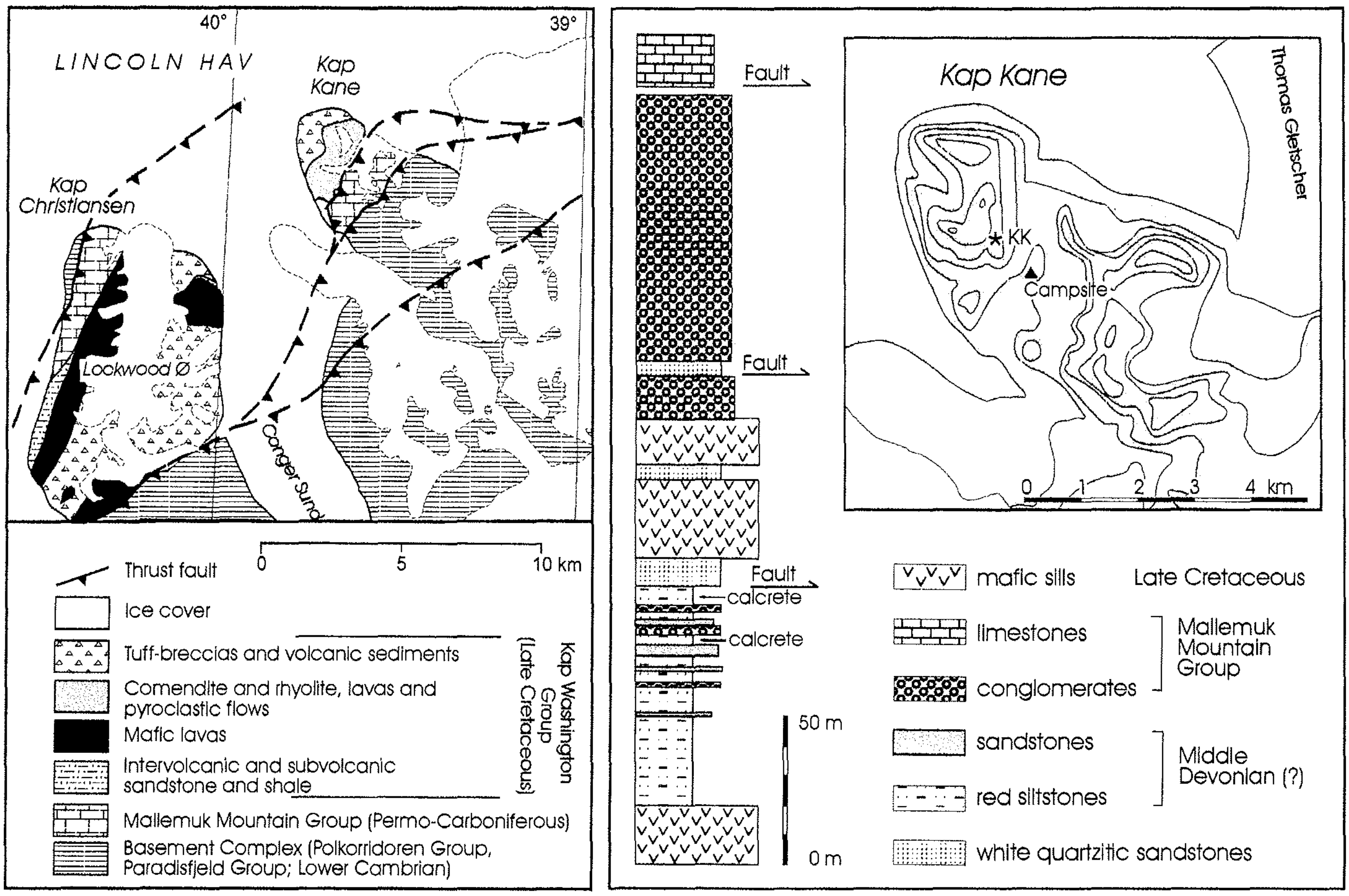

Fig. 3: Geological skech map of Lockwood Ø and Kap Kane (after VON GOSEN & PIEPJOHN 2001). Stratigraphic column of the measured and sampled section and position of the section (Topography after topographic map. 1:100000, Folio 83 Ø3 S Ø, Grønlands Geologiske Undersøgelse 1984. Contour interval 100 m).

Zone (TLFZ) in the Kim Fjelde region of eastern Peary Land (ZINCK-JØRGENSEN 1994, VON GOSEN & PIEPJOHN, unpublished data). Numerous NW-SE trending faults characterize the Wandel Hav Mobil Belt (Figs. 1, 2). Synsedimentary fault tectonics controled the deposition of Late Palaeozoic strata (HÅKANSSON & STEMMERIK 1984, STEMMERIK & HÅKANSSON 1991, ZINCK-JØRGENSEN 1994, HÅKANSSON et al. 1994b). Mesozoic pull-apart basins are related to mid-Jurassic transtension of the "Ingeborg Event" and Late Cretaceous dextral strike-slip deformation of the "Kilen Event" (PEDERSEN 1988, HÅKANSSON & STEMMERIK 1984, HÅKANSSON et al.1991). Latest Cretaceous - earliest Tertiary compressive deformation under a dextral strike-slip regime led to the formation of the Wandel Hav Strike-Slip Mobil Belt. Folds and reverse faults are related to this transpressive event (VON GOSEN & PIEPJOHN unpubl. data, HÅKANSSON & PEDERSEN 1982).

The Harder Fjord Fault Zone

This fault zone cuts through the Ellesmerian fold belt and separates it from the Wandel Hav Mobil Belt in the southeast. Folding, reverse and thrust faulting along the Harder Fjord Fault Zone occured also during the latest Cretaceous-earliest Tertiary compressive deformation (HÅKANSSON & PEDERSEN 1982).

The Kap Cannon Thrust Zone

In the north, the "North Greenland Fold Belt" is bounded by the Kap Cannon Thrust Zone (Figs. 1, 3) which can be traced from Cap Cannon across Kap Washington and Kap Kane to Lockwood Ø. According to von GOSEN & PIEPJOHN (2001), the post-Ellesmerian structural history can be summarized as follows: During Late Cretaceous times, the Basement and Late Carboniferous to Early Permian clastics and carbonates were injected by mafic sills and dykes under a extensional regime. This also led to the formation of the Late Cretaceous volcanic rocks and clastic sediments (Kap Washington Group). Under ductile and final brittle conditions the basement rocks were thrust from south to north into a higher crustal level. In the footwall of the main thrust zone, cover sediments are thrust and imbricated with N- to NW-directed transport of the hangingwall units during post-Late Cretaceous times.

THERMAL HISTORY

Along the Harder Fjord Fault Zone (Fig. 1), vitrinite reflectances are in the range of 2.6 % to 3.6 % Rm and 3.5 % to 4.6 % Rmax at Santon Gletscher which correspond to the coal rank of anthracite and temperatures of about 250 °C during burial and tectonism assuming heating times of 1 to 10 Ma

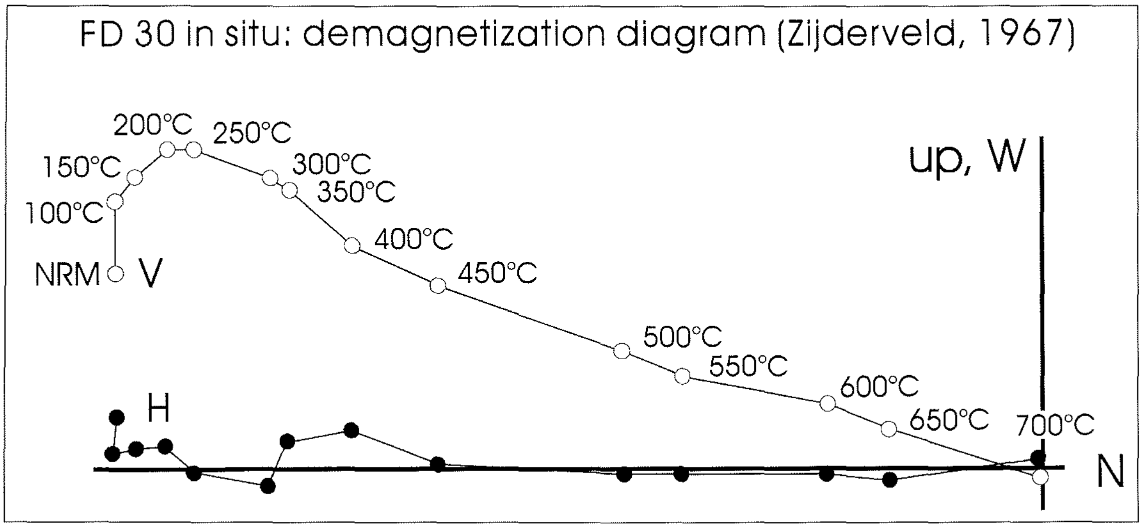

Fig. 4: Orthogonal thermal demagnetization diagram for FD 30 of the Foldedal Formation.

(coal rank and temperature ranges according to the compilation of TEICHMÜLLER 1987). At Depot Bugt vitrinite reflectance is about 2 % Rm and 2.6 % Rmax which indicates temperatures of 200 to 250 °C. Therefore, all gray or green samples of Cretaceous rocks along the Harder Fjord Fault Zone with magnetite as main carrier of the NRM, were remagnetized or at least overprinted during the latest Cretaceous to early Tertiary interval.

Also along the Trolle Land Fault Zone, peak temperatures were probably up to 200 °C as evidenced by vitrinite reflecance of 1.2 % to 2.0 % Rm and 2 % to 2.5 % Rmax of Cretaceous sediments southeast of Foldedal. Obviously, these temperatures were sufficient to remagnetize the Cretaceous gray sandstones and siltstones containing magnetite. This very-low grade metamorphism may be related to a short term intense increase in heat flow as evidenced by quartz veins in northern Kronprins Christian Land (HÅKANSSON et al. 1981, HÅKANSSON et al. 1994c) and/or to the dextral transpression (PEDERSEN 1988).

Late Carboniferous conodonts of the Foldedal Formation in blocks between fault lines exhibit colour alteration indexes (CAI) of 1.5 to 2 which are compatible with temperatures of <100 °C (EPSTEIN et al. 1977). The NRM of hematite in these Late Carbonifeous samples was not affected by this weak thermal overprint.

Data on coal rank are not available from Kap Kane; vitrinite reflectance values of Cretaceous rocks of the adjacent Kap Washington area are between 2.04 to 5.35 % Rm and 2.3 to 7.37 % Rmax which exhibit a strong, but differing thermal overprint during the Late Cretaceous/Early Tertiary break-up of Greenland and Svalbard. Obviously, the Late Palaeozoic NRM of the redbeds of Kap Kane, which exhibit a shallow magnetic inclination, were not completely overprinted by this event.

PALAEOMAGNETIC SAMPLING AND LABORATORY PROCEDURES

A total of 76 oriented drill cores were sampled during the CASE-2-Expedition at two different locations at Foldedal (FD and MC in Fig. 2) and at Kap Kane (KK in Fig. 3). Samples were drilled in the field using a petrol-driven portable rock drill and oriented using a standard magnetic compass. In order to test the amount of local declination, sun compass measurements were made. The mean magnetic deviation was calculated as 38° for FD, 37° for MC, and 47° for KK sample sites. All specimens, cut to a standard size (10 ccm) from individual samples, were analyzed in the Palaeomagnetism Laboratory at Munich University. Measurements of the direction and intensity of the Natural Remanent Magnetization (NRM) were carried out using a three-axis 2G cryogenic SQUID magnetometer, housed in a magnetically shielded room. Two Schonstedt furnaces, also housed in the shielded room, were used for stepwise thermal demagnetization experiments. The results of the demagnetization experiments were plotted on standard orthogonal demagnetization diagrams (ZIJDERVELD 1967). Linear segments of the demagnetization trajectories were identified visually and subjected to the standard three dimensional principal component analysis (KIRSCHVINK 1980). Results of this procedure have been judged significant if the resulting component of magnetization was defined by three or more successive data points with a mean angular deviation (MAD) value (KIRSCHVINK 1980) of less than 15 degrees. Site mean and formation mean directions were computed after FISHER (1953).

PALAEOMAGNETIC RESULTS

Initial intensities of the NRM of the rocks studied are moderate (between 0.1 to 6 mA/m). Detailed thermal demagnetization experiments on sandstones and siltstones revealed a consistent behaviour of magnetization.

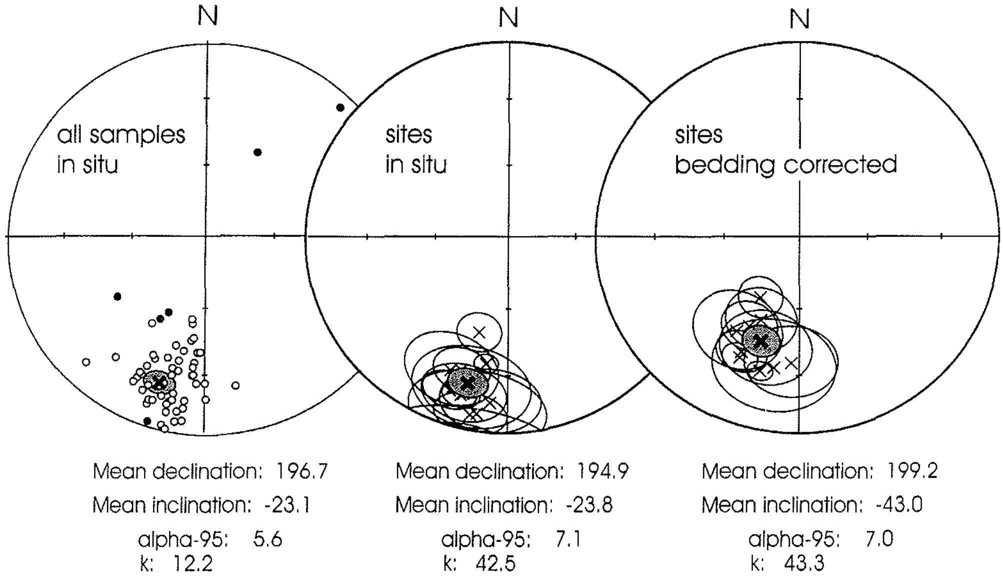

Fig. 5: Characteristic directions of magnetization for specimens and sites of the FD and MC section and resulting mean directions.

(A) Foldedal

Orthogonal demagnetization diagrams (Fig. 4) for the red-coloured sediments of the Foldedal Formation show the presence of at least two components of magnetization in this material. Heating at temperatures of up to 150 °C results in the removal of a component of magnetization with steep positive inclinations, similar to the direction of the present day magnetic field in the sampling area. Such magnetization is therefore assumed to reflect a magnetic overprint of recent age. During heating in the 150-700 °C temperature range, a characteristic magnetization with South to Southwesterly declinations and shallow inclinations (*in situ* coordinates) is removed, usually displaying linear decay to the origin. Maximum unblocking temperatures well above 600 °C are indicative for haematite being the carrier of this component of magnetization. The characteristic directions of magnetization for specimens from the two sections studied and the resulting site mean directions are shown in Figure 5 and listed in Table 2. Due to the similar shallow dip of bedding planes it was not possible to subject the sites to an incremental fold test (McFadden 1990).

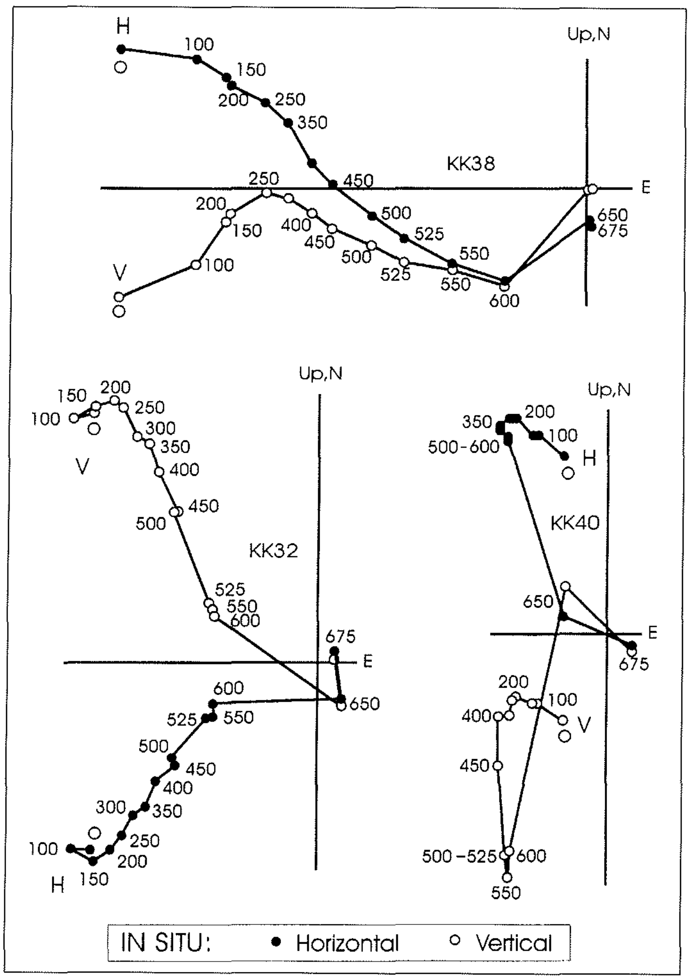

Fig. 6: Orthogonal thermal demagnetization diagrams for samples from Kap Kane.

(B) Kap Kane

Samples taken at Kap Kane display a more complex behaviour during stepwise thermal demagnetization. Heating at temperatures of up to 250 °C succesfully removes a component of viscous origin. A second component of magnetization, directed to the Northwest (Southwest) with intermediate negative (positive) inclinations (in situ), is removed in the 250-600 °C temperature range. Upon heating above 600 °C the directional behaviour of the samples from Kap Kane becomes erratic and no stable component of magnetization can be identified. Although there is no direct proof, it can be argued that this is caused by chemical alteration and formation of a new, highly viscous, magnetic phase. However, the intermediate component (250-600 °C) can be clearly identified as linear segments in the Zijderveld diagrams (Fig. 6) and passes the fold test on the 95 % probabilty level (McFadden 1990). Additional great circle analysis (McFadden & McElhinny 1988) confirms this result, yielding a well defined intersection very similar to the mean direction based on the analysis of

		in situ				Bedding corrected			
Site	N/n	Dec.	Inc.	k	α_{95}	Dec.	Inc.	k	α_{95}
FD 1-6	6/6	196.5	-48.3	62.3	8.6	211.5	-60.3	62.3	8.6
FD 8-14	7/6	198.8	-29.4	43.8	10.2	208.1	-47.7	40,8	10.6
FD 15-19	5/5	196.2	-17.5	145.5	6.4	205.1	-32.6	145.5	6.4
FD 21-25	5/5	200.3	-18.0	68.9	9.3	205.5	-35.3	68.9	9.3
FD 26-28	3/3	202.8	-27.5	53.9	17.0	212.2	-42.6	53.9	17.0
FD 29-34	6/5	193.3	-21.4	15.1	15.1	196.0	-40.3	21.6	16.8
MC 1-12	12/10	189.4	-35.1	119.4	4.4	195.5	-29.7	119.5	4.4
MC 13-15	3/3	185.8	-16.3	56.0	16.6	183.4	-35.7	56.0	16.6
MC 16-17	2/2	191.6	-8.5	-	-	195.3	-37.3	-	-
MC 18-23	6/6	195.4	-18.4	22.7	14.4	203.7	-51.7	25.2	13.6
Mean Directions						Dec.	Inc.	k	α_{95}
All samples in situ						196.7	-23.1	12.2	5.6
Sites in situ						194.9	-23.8	42.5	7.1
Sites bedding corrected						199.2	-43.0	43.3	7.0
Resulting Paleopole position						Lat. [°N]	Long. [°E]		
In Greenland coordinates, in situ						-20	322		
bedding corrected						-32	317		
In European Coordinates in situ						-25	342		
bedding corrected						-37	335		

Tab. 2: Palaeomagnetic data of the Foldedal Formation. N=number of samples measured, n = number of samples used for calculating mean directions; Rotation from Greenland to Europe after Bullard (1985): 73/096.5 W/ 22.0

subtracted vectors (Fig. 7). The characteristic directions of magnetization for specimens from Kap Kane are shown in Figure 7 and listed in Table 3.

INTERPRETATION AND CONCLUSION

Figure 8 shows the resulting palaeopole position for the Foldedal Formation of Peary Land (in situ [A] and bedding corrected [B]) and for the redbed deposits of Kap Kane (in situ [C] and bedding corrected [D]) the together with the Baltica APWP plotted in European COORDINATES (MACNIOCALL & SMETHURST 1994).

(A) Foldedal

The Foldedal Formation, from which the palaeomagnetic samples were collected, is of Moscovian (Middle Carboniferous) age according to conodonts and other fossils. Despite the fact that there is no positive fold test, the shallow inclination clearly ties the age of magnetization to the time of Late Carboniferous deposition (or shortly after). Based on this inclination, the Foldedal area was situated at about 23.5 °N during Late Carboniferous times. The resulting pole position for the Foldedal Formation (B in Fig. 8) is significantly displaced from the APWP. Whilst the latitudes of the Foldedal Pole and the apparent Late Carboniferous pole are well matched, deviate the longitudes by about 20°. The deviation in declination is interpreted as the result of a clockwise block rotation during Early Tertiary dextral transcurrent fault movements.

(B) Kap Kane

The age of the redbed deposits at Kap Kane is unknown. They are injected by Late Cretaceous mafic sills and were sandwiched between sediments of the Late Carboniferous Mallemuk Group and Lower Cambrian basement rocks during Early Tertiary compression. Based on field evidence, the redbeds postdate the Ellesmerian deformation and low grade metamorphism. They probably represent the base of the Late Carboniferous Mallemuk Group or are even older.

The palaeomagnetic investigation has revealed a characteristic shallow inclination (mean declination / inclination is 205° / 0.5°, tilt corrected) that passes local fold test. Thus the age of the magnetization can be bracketed as post-Ellesmerian (Orogeny) and pre-Tertiary. The shallow magnetic inclination clearly ties the age of magnetization to Palaeozoic times.

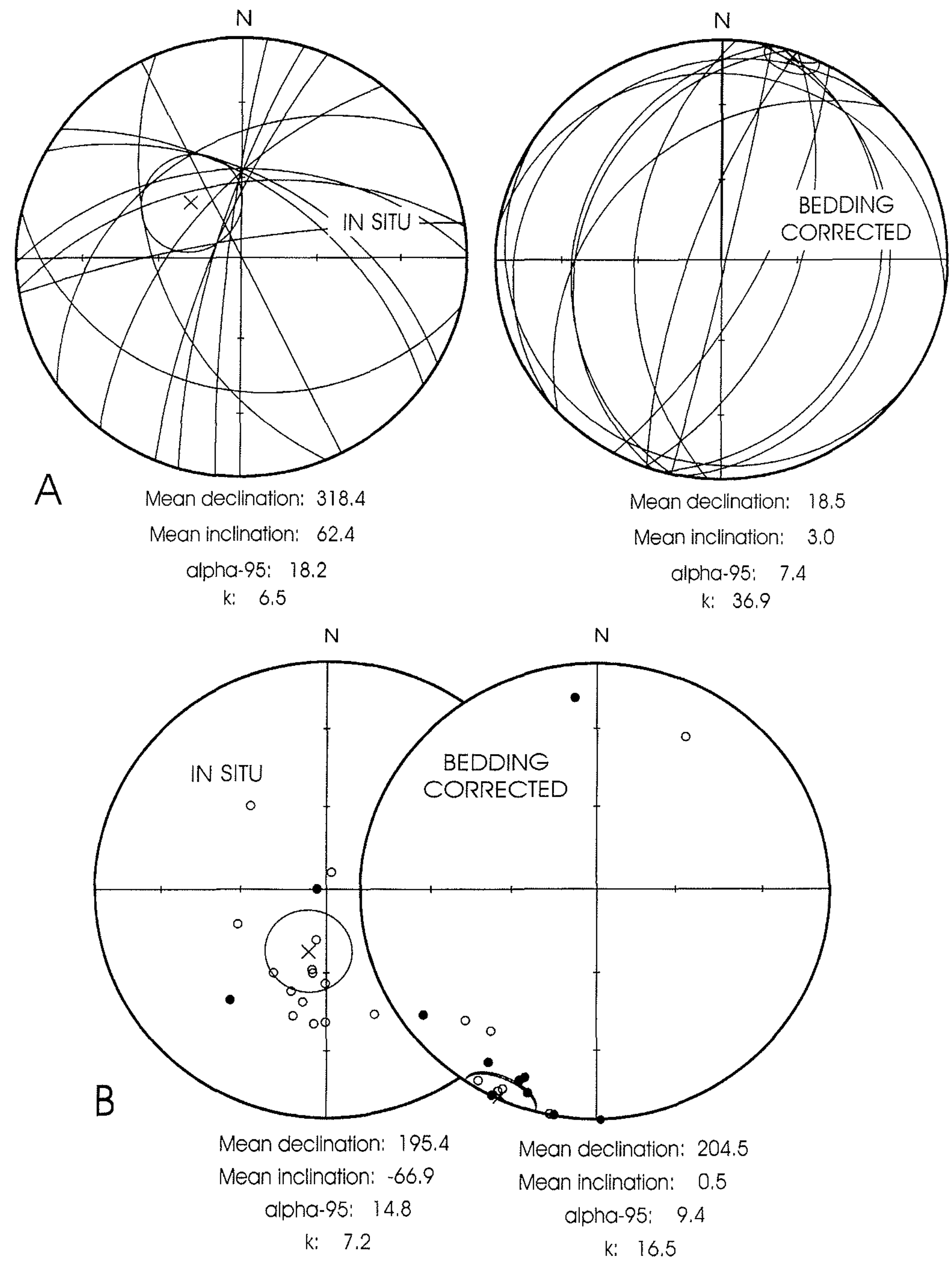

Fig. 7: Characteristic directions of magnetization for specimens of Kap Kane and resulting mean direction.

Based on the inclination, the Kap Kane area was situated at the equator during deposition of the redbeds. The corresponding palaeopole (rotated into European coordinates) is situated on the Middle Devonian sector of the Apparent Polar Wandering Path for Baltica (MacNiocall & Smethurst 1994). Therefore we assume that the redbeds were deposited during Middle Devonian times.

This result is in contradiction to the assumed Late Devonian to Early Carboniferous age of the Ellesmerian Orogeny which is based on palaeomagnetic and radiometric data. The youngest sediments involved in the Ellesmerian Orogeny are of Ludlow to Pridoli age (see Henriksen 1992). Stearns & Van der Voo (1989) presented palaeomagnetic data of Cambro-Ordovician rocks from the Franklinian Basin in the North Greenland Fold Belt. A negative breccia test and a positive fold test bracketed the age of magnetization as post-depositional and pre-Ellesmerian. They interpreted their new palaeopole as Late Silurian to Early Devonian in age. Rb-Sr analyses of clay fractions and whole rock samples of metamorphic shales and slates gave ages of 437 ±77 Ma and 350 ±8 Ma (Springer 1981). Springer & Friedrichsen (1994) published 4 isochrons ages on clay fractions and carbonate cements within the range of 318-346 Ma. These results were interpreted as reflecting the time of uplift and cooling below the threshold temperature for diffusion of Rb and Sr in white mica. It is open to question whether these "ages" reflect a late compressional event of the Ellesmerian Orogeny or are associated with crustal thinning and rifting which led to the formation of the Wandel Sea Basin.

		in situ					Bedding corrected			
Site	N/n	Dec.	Inc.	k	α_{95}		Dec.	Inc.	k	α_{95}
KK	17/15	195.4	-66.9	7.2	14.8		204.5	0.5	16.5	9.4
Resulting Paleopole position							Lat. [°N]	Long. [°E]		
In Greenland Coordinates in situ							-56	302		
Bedding corrected							-6	296		
In European Coordinates in situ							-59	315		
Bedding corrected							-9	316		

Tab. 3: Palaeomagnetic data of redbed deposits from Kap Kane; N = number of samples measured, n=number of samples used for calculating mean directions, Rotation from Greenland to Europe after Bullard (1985): 73/096.5 W/ 22.0

Regarding the youngest sediments involved in the orogeny and the palaeomagnetic results of STEARN & VAN DER VOO (1989), the lower age limit for the Ellesmerian Orogeny in the North Greenland Fold Belt is Late Silurian to Early Devonian. In Svalbard, which is supposed to have been situated adjacent to North Greenland before the opening of the Atlantic Ocean, post-Caledonian Early to Middle Devonian redbed sediments are common. Therefore, we propose that the Ellesmerian Orogeny of the North Greenland Fold Belt is of Late Silurian to Early Devonian age at least in the Kap Kane area, where folded and metamorphosed Early Palaeozoic strata are overlain by post-orogenetic Middle Devonian redbed deposits.

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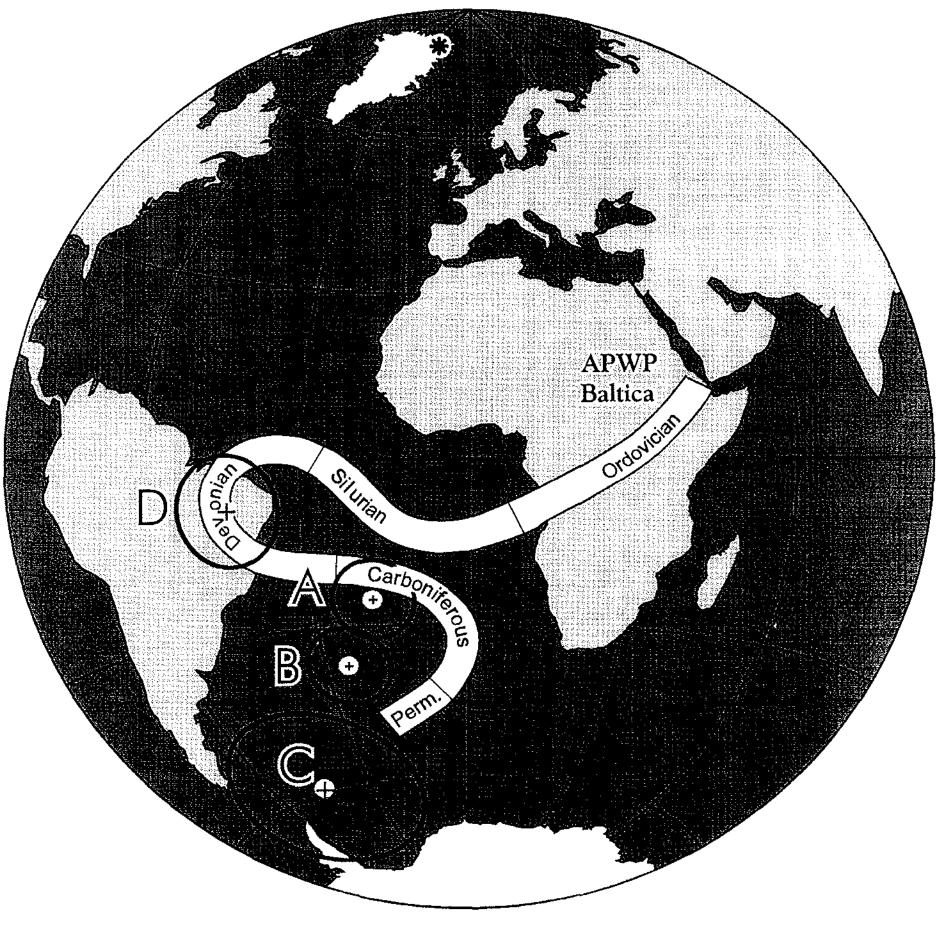

Fig. 8: Resulting palaeopole positions for the Foldedal (A. in situ; B: bedding corrected) and for Kap Kane (C: in situ; D: bedding corrected) plotted in European coordinates together with the APWP of Baltica (MACNIOCALL & SMETHURST 1994).

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References

Bengaard, H.J.& Henriksen, N. (1984): Geological map of Greenland 1 : 500,000, sheet 8, Peary Land.- Grønlands Geol. Unders. Bull. / Geol. Surv. Greenland.

Bullard, E. C., Everett, J.E. & Smith, A.G. (1965): The Fit of the continents around the Atlantic.- In: P.M.S. BLACKETT, E.C. BULLARD & K.S. RUNCORN (eds.), A Symposium on Continental Drift, London. 258: 41-51.

Epstein, A.G., Epstein, J.B. & Harris, L.D.(1977): Conodont color alteration – an index to organic metamorphism.- Geol. Surv. Prof. Paper 995: 1-27.

Fisher, R.A. (1953): Dispersion on a sphere.- Proc. R. Soc., A 217: 295-305.

von Gosen, W. & Piepjohn, K. (2001): The Kap Cannon Thrust Zone in North Greenland.- Polarforschung 69:

Håkansson, E., Heinberg, C..& Pedersen, S.A.S. (1994a): Geology of Kilen: Wandel Sea Basin.- Basin Analysis, EFP-91, Project No. 0012, Competion Report of the Ministry of Energy, Scientific Report, #.16, p. 1-13.

Håkansson, E., Heinberg, C. & Stemmerik, L. (1981): The Wandel Sea Basin from Holm Land to Lockwood Ø, eastern North Greenland.- Grønlands Geol. Unders. Rap. 106: 47-63.

Håkansson, E., Heinberg, C., & Stemmerick, L. (1991): Mesozoic and Cenozoic history of the Wandel Sea Basin, North Greenland.- Grønlands Geol. Unders. Bull. / Geol. Surv. Greenland Bull. 160: 153-164.

Håkansson, E. & Pedersen, S.A.S. (1982): Late Paleozoic to Tertiary tectonic evolution of the continental margin in North Greenland.- Can. Soc. Petrol. Geol. Mem. 8: 331-348.

Håkansson, E., Pedersen, S.A.S. & Zinck-Jørgensen, K. (1994b): Tectonics of the Wandel Hav Strike-Slip Mobile Belt, eastern North Greenland: Wandel Sea Basin.- Basin Analysis, EFP-91, Project No. 0012, Competion Report of the Ministry of Energy, Scientific Report, #.22, v. Scientific report #. 17, p. 1-4.

Håkansson, E., Piasecki, S., Konnerup-Madsen, J., Springer, N. & Thomsen, E. (1994c): A late, thermal event in the Wandel Sea Basin; eastern North Greenland: Wandel Sea Basin.- Basin Analysis, EFP-91, Project No. 0012, Competion Report of the Ministry of Energy, Scientific Report 22: 1-9.

Håkansson, E. & Stemmerik, L. (1984): Wandel Sea Basin - The North Greenland equivalent to Svalbard and the Barents Shelf.- In: NORWEG. PETROL. SOC. (ed.), Petroleum Geology of the North European Margin, 97-107.

Håkansson, E. & Stemmerik, L. (1989): Wandel Sea Basin - A new synthesis of the late Paleozoic to Tertiary accumulation in North Greenland.- Geology 17: 683-686.

Henriksen, N. (1992): Geological Map of Greenland 1 : 500 000; Nyboe Land, Sheet 7; Peary Land, Sheet 8. Grønlands Geol. Unders.

Higgins, K.A., Fridrichsen, J.D. & Soper, N.J. (1981): The North Greenland fold belt between central Johannes V. Jensen Land and eastern Nansen Land.- Grønlands Geol. Unders. Rap. 106: 35-45.

Kirschvink J. L. (1980): The least-squares line and plane and the analysis of paleomagnetic data.- Geophys. J. R. Astronom. Soc. 62: 699B718.

MacNiocall, C. & Smethurst, M. (1994): Palaeozoic palaeogeography of Laurentia and its margins: a reassessment of palaeomagnetic data.- Geophys. J. Int. 116: 715-725.

McFadden P. (1990): A new fold test for palaeomagnetic studies.- Geophys. J. Int. 103: 163-169.

McFadden, P. & McElhinny, M. (1988): The combined analysis of remagnetization circles and direct observations in palaeomagnetism.- Earth Planet. Sci. Letter 87: 161-172.

Pedersen, S.A.S. (1988): Model of structural events in the Late Mesozoic platform break up between Greenland and Svalbard.- Norsk Polarinstitutt Rapportser. 46: 99-100.

Rasmussen, J.A. & Håkansson, E. (1994): First report of Permo-Carboniferous conodonts from North Greenland. Wandel Sea Basin.- Basin analysis - Project summary: Wandel Sea Basin : Basin Analysis, EFP-91, Project No. 0012, Competion Report of the Ministry of Energy, Scientific Report, #. 5, p.1-18.

Roberts, D. (1988): Timing of Silurian to middle Devonian deformation in the Caledonides of Scandinavia, Svalbard and E Greenland.- In: A.L. HARRIS & D.J. FETTES (eds.), The Caledonian-Appalachian Orogen, Geol. Soc. Spec. Publ. 38: 429-435.

Springer, N. (1981): Preliminary Rb-Sr age determinations from the North Greenland Fold Belt, Johannes V. Jensen Land, with comments on the metamorphic grade.- *Grønlands Geol. Unders. Rap. 106: 77-84.*

Springer, N. & Friedrichsen, J.D. (1994): Age of low-grade regional metamorphism in the North Greenland Fold Belt: mineralogical and Rb-Sr-isotope evidence from pelitic metasediments.- Can. J. Earth Sci. 31: 358-368.

Stearns, C. & Van der Voo, R. (1989): A new Siluro-Devonian paleopole from early Paleozoic rocks of the Franklinian Basin, North Greenland Fold Belt.- J. Geophys. Res. 94: 10669-10683.

Stemmerik, L. & Håkansson, E. (1989): Stratigraphy and depositional history of the Upper Palaeozoic and Triassic sediments in the Wandel Sea basin, central and eastern North Greenland.- Grønlands Geol. Unders. Rap. 143: 1-45.

Stemmerick, L. & Håkansson, E. (1991): Carboniferous and Permian history of the Wandel Sea Basin, North Greenland.- Grønlands Geol. Unders. Bull. / Geol. Surv. Greenland Bull. 160: 141-151.

Stemmerick, L., Håkansson, E., Madsen, L., Nilsson, I., Piasecki, S., Pinard, S. & Rasmussen, J.A. (1994a): Stratigraphy and depositional evolution of the Upper Paleozoic sedimentary succession in eastern Peary Land, North Greenland: Wandel Sea Basin.- Basin Analysis, EFP-91, Project No. 0012, Competion Report of the Ministry of Energy, Scientific Report 4: 1-22.

Stemmerik, L., Nilsson, I. & Elvebakk, G. (1994b): Gzelian-Asselian depositional sequences in the western Barents Sea and North Greenland: Wandel Sea Basin.- Basin Analysis, EFP-91, Project No. 0012, Competion Report of the Ministry of Energy, Scientific Report, 8: 1-25.

Surlyk, F. (1991): Tectonostratigraphy of North Greenland.- Grønlands Geol. Unders. Bull. / Geol. Surv. Greenland Bull. 160: 25-47.

Teichmüller M. (1987): Organic material and very low-grade metamorphism.- In: M. FREY (ed.), Low Temperature Metamorphism, Blackie, 114-161.

Zijderveld J.A.D. (1967): AC demagnetization of rocks: Analysis of results.- In: D.W. COLLINSON, K.M. CREER & S. RUNCORN (eds.), Methods in Palaeomagnetism, Elsevier, 254-286.

Zinck-Jørgensen, K. (1994): The Trolle Land fault system, Kim Fjelde, eastern Peary Land: Wandel Sea Basin.- Basin Analysis, EFP-91, Project No. 0012, Competion Report of the Ministry of Energy, Scientific Report 18: 1-9.