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Palaeomagnetic argument for a stationary Spitsbergen relative to the British Isles (Western Europe) since late Devonian and its bearing on North Atlantic reconstruction

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Palaeomagnetic results from the Devonian of Central Spitsbergen (Mimer Valley Formation, Billefjorden) suggest an average palaeofield direction for the late Devonian/early Carboniferous with declination = 227.5°, inclination = −30.6°, corresponding to a relative pole position at lat. = 24°S, long. = 325°E. This magnetization which is post-tectonic is regarded as acquired chemically, linked with the Upper Devonian Svalbardian phase of deformation. This result, together with some recent data from Central Spitsbergen, defines a Devonian polar wander segment that accords extremely well with corresponding British data. We interpret this in terms of no major displacement of Central Spitsbergen as compared with Western Europe since Devonian time; Svalbard and the Barents Sea region have probably formed a fairly stable platform since the early Devonian. On the balance of available geological and palaeomagnetic evidence from Spitsbergen, the British Isles, and Newfoundland, the North Atlantic region does not appear to have been subjected to strike-slip motions in the order of thousands of kilometers in or since the late Devonian.

1. Introduction

The Iapetus Ocean was presumably initiated in late Precambrian time and bounded by passive margins until the early Palaeozoic. Subsequent plate convergence and marginal deformation, forming the Caledonian-Appalachian orogen, is first recognized in the Lower/Middle Ordovician, particularly in the northern Appalachians, British Isles and Scandinavia [1,2]. Accompanying later extensive deformations and continental suturing in the mid-Palaeozoic, late Devonian/Carboniferous mega-shearing and continental re-arrangement, including the shear zones of Spitsbergen, northern Britain and Newfoundland/New England (Fig. 1A), have been proposed [3–8]. Due to suggested Devonian/early Carboniferous palaeomagnetic discordances between the northeastern seaboard of North America (Acadia) and the interior of the continent, Kent and Updyke [9,10] argued that Acadia was originally situated some 1500 km south of the North American craton, and moved into its present relative position during the Carboniferous. Van der Voo and Scotese [6] subsequently postulated a ca. 2000 km early Carboniferous sinistral displacement along the Great Glen Fault (GGF), Scotland, in attempting to explain apparent palaeomagnetic latitudinal discrepancies between Europe and North America in the classical Bullard et al. [11] assemblage. In the latter model Acadia and Britain south of GGF were attached to the European margin of the shear zone, while Scotland north of the GGF was joined to the North American side.

Large-scale crustal displacement hypotheses have a tendency to be favoured and in turn adopted in the literature unless strong evidence is available to the contrary. In the present paper palaeogeographical implications of some new palaeomagnetic data from the Devonian of Spitsbergen are discussed with particular reference to the British Isles. Mega-shear hypotheses as put forward by Harland and co-workers [4,8,12–14] and Van der Voo and Scotese [7] are critically evaluated and discounted.

The almost undeformed Upper Silurian/Devonian red sandstone and siltstone of the Wood

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Bay Formation of Dicksonfjorden, Spitsbergen, have been studied palaeomagnetically by Storetvedt [15] and Løvlie et al. [16]. Based on an overall scattered distribution of stable remanence directions, almost coinciding azimuthal orientation of remanent directions and principal axes of maximum susceptibility, and magnetomineralogical/petrological observations, Løvlie et al. [16] described the magnetization as a detrital one (DRM) carried by haematite. On the other hand, Storetvedt [15], working on beds apparently having a much larger proportion of cation-deficient phases (maghemites), suggested that the complex distribution of remanence directions was due to multicomponent magnetization, brought about by post-depositional chemical changes in a palaeofield of varying polarity.

Along with a recent palaeomagnetic field collection in the Dicksonfjorden area (1982, 1983), sampling was also performed at five locations of the Middle Devonian Mimer Valley Formation (later referred to as the Billefjorden sediments). These sediments, which form the basis of the present discussion, are exposed in a small area immediately to the west of the Billefjorden lineament, and include grey-green sandstones, quartzitic siltstones and mudstones [17].

2. Mid-Palaeozoic tectonic setting of Spitsbergen

The pre-Carboniferous geology of Spitsbergen is basically a distinction between the Upper Silurian/Devonian Old Red Sandstone (ORS) and the Precambrian/Lower Palaeozoic Hecla Hoek Formation. The latter complex constitutes the area of main Caledonian metamorphism and of the late tectonic granite emplacement on Svalbard, for which an age ranging from 390 to 440 Ma [18–21] is suggested based on radiometric data. The Old Red Sandstone was deposited unconformably on the metamorphics of Central Spitsbergen and subsequently affected by late Devonian (Svalbardian) folding and deformation (notable along major fault zones). Spitsbergen includes numerous N–S/NW–SE structural lineaments that presumably played a controlling role in post-Caledonian sedimentation [22].

Palaeomobilistic models on the evolution of Svalbard include at least three major late Devonian transcurrent fault zones (Fig. 1B). The

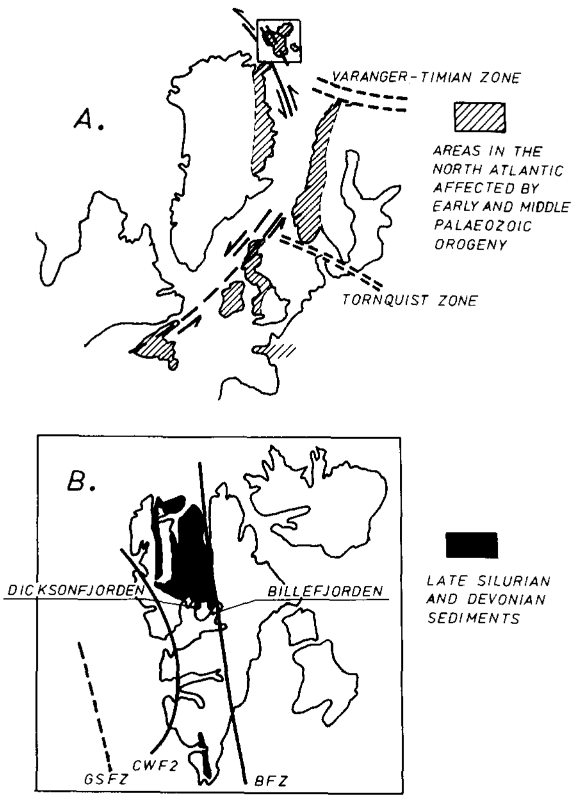

Fig. 1. A. Sketch map of the North Atlantic bordering regions affected by the early and middle Palaeozoic orogenies, including suggested major fracture zones. Simplified after Harland [8] and Harland and Wright [13]. Diagram B shows the distribution of the Old Red Sandstone graben of Central Spitsbergen bounded by the Billefjorden Fault Zone (*BFZ*) to the east. *GSFZ*: Greenland-Svalbard Fault Zone (postulated); *CWFZ*: Central-West Fault Zone (postulated).

Central-West and Billefjorden Fault Zones (CWFZ and BFZ) are considered to define provincial boundaries within Spitsbergen, and based on comparative facies analysis between Spitsbergen and other margins circumscribing the northern North Atlantic (Greenland, Arctic Ganada), they have been thought to involve considerable strike-slip movement [4,8,12–14]. Harland et al. [14] contend that left-lateral movements along the Billefjorden lineament occurred between East Spitsbergen and Greenland from Ordovician to Permian, and that the major part of the integral motion took place in two stages: (1) a late Devonian (Svalbardian) event of ca. 500 km, and (2) a mid-Carboniferous (late Mississippian) phase of ca. 1000 km or more. This would imply that the eastern province of Spitsbergen was originally situated south of Central Spitsbergen and later united by sinistral faulting. On the other hand, and in sharp contrast to the model of Harland and co-workers, recent structural mapping of rock formations adjacent to the Billefjorden Fault Zone does not tend to support large-scale lateral movements (D. Douglas, personal communication, 1984).

3. Palaeomagnetic results from the Spitsbergen Old Red Sandstone

Measurements of anisotropy of magnetic susceptibility (AMS) in the Billefjorden sediments reveal bedding-parallel, steeply inclined magnetic foliation planes striking NNE-SSW, giving both prolate and oblate magnetic ellipsoids (Fig. 2). Total anisotropy (K_{max}/K_{min}) is typically around 5%. The fairly good grouping of K_{max} (lineation: fold axis oriented) may be an original feature, but is more likely to have been imposed during deformation and folding (pencil cleavage). The magnetic fabric data is consistent with structural field evidence suggesting WNW-ESE compression.

Curie temperatures (T_c) around 680°C and the mode of isothermal remanent (IRM) acquisition versus increasing magnetizing field, suggest that haematite dominates the bulk magnetic properties (Fig. 3). A secondary phase with T_c around 560–580°C (probably magnetite) is readily produced during heating above 600°C. Magnetite production on thermal treatment is also suggested by a 2–3 times increase in bulk susceptibility, and by a general increase in low-coercivity material and total IRM intensity.

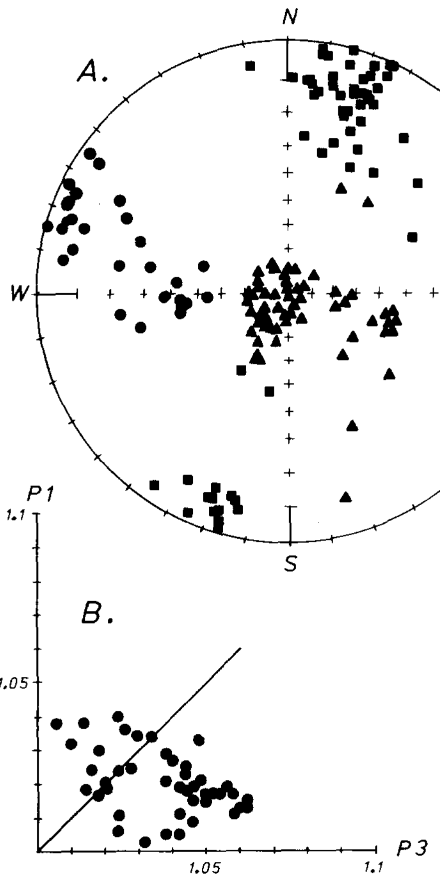

Fig. 2. A. Stereographic presentation of principal axes of maximum (squares), intermediate (triangles) and minimum (circles) susceptibility for the investigated Billefjorden sediments. Axial ratios are shown in a Flinn diagram (B) in which P1 is lineation and P3 foliation. Stereoplot conventions throughout this paper are closed (open) symbols for downward (upward) pointing inclinations.

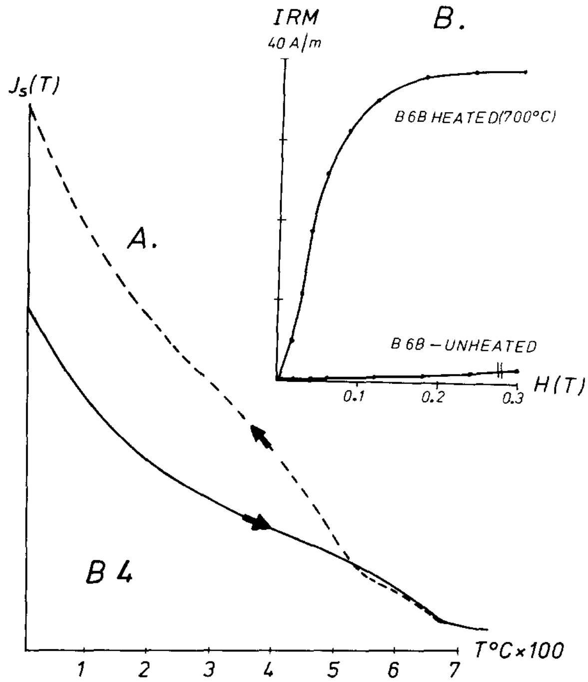

Fig. 3. Example of "saturation" magnetization versus temperature (diagram A) showing formation of a new magnetic phase ("magnetite") after heat treatment to ca. 700°C (cf. cooling curve). Diagram B gives an example of IRM acquisition versus increasing field. Note the huge difference between the unheated and heated rock sample, demonstrating the production of a secondary spinel phase.

A major part of the rock collection had natural remanent magnetizations (NRM) lower than the instrumental noise level (ca. 0.5 mA/m), hence, only 18 samples were subjected to thermal demagnetization (NRM intensities typically in the 2–4 mA/m range). Stepwise thermal demagnetization has only uncovered one component of magnetization as evidenced from optimal vector projections (Fig. 4). Though a fair proportion of the magnetic moment frequently remains after demagnetization to 600°C, it proved impossible to obtain sensible results at higher temperatures. This erratic stage is attributed to the formation of secondary magnetite as discussed above. In the NRM–600°C range, however, all tested samples designate linear trajectories towards the origin of the vector plots. From a total of 18 tested samples (those having NRM intensities above the instrument noise level) 14 samples form a very well-defined grouping of remanence directions, having southwest declinations and upward (negative) inclinations of around 30° prior to structural unfolding (Fig. 5A). Bedding correction (Fig. 5B) yields almost similar declinations but downward-dipping inclinations. Unfortunately, the area concerned has a fairly uniform orientation of bedding so that a fold test, to differentiate between post(/syn)- and pre-folding origin of magnetization, cannot be accomplished.

The Dicksonfjorden Old Red Sandstone succession (Wood Bay Formation), located towards the central part of the ORS graben of Spitsbergen, in general shows scattered directions of stable remanent magnetization [15,16]. For the investigated beds Løvlie et al. [16] ascribe the scatter primarily to randomizing effects from high-energy environments acting during accumulation (including detrital haematite). However, three rock sections show reasonably grouped directions of magnetization

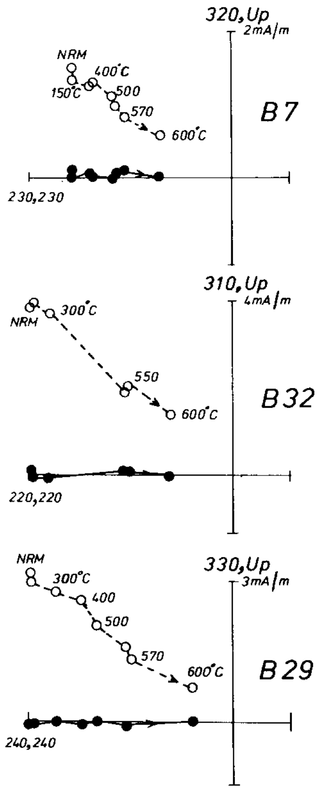

Fig. 4. Orthogonal vector diagrams showing examples of remanence behaviour on thermal demagnetization. The plots are optimal versions, and open (closed) symbols denote projections on the vertical (horizontal) plane. Note that the characteristic components of magnetization are not significantly different from the direction of natural remanent magnetization (NRM).

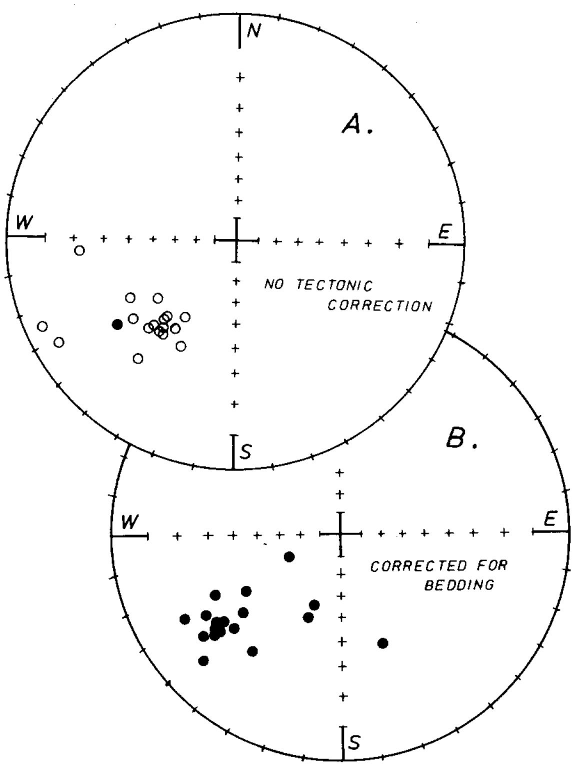

Fig. 5. Distribution of stable remanence directions for all tested samples of the Billefjorden sediments, before (A) and after (B) structural unfolding.

TABLE 1

Overall palaeomagnetic results from the Billefjorden Old Red Sandstone (present study) along with re-calculated/selected results from the Dicksonfjorden ORS [16]

Formation	D (°)	I (°)	N	α_{95} (°)	K	Pole	dp/dm
Mimer Valley Fm. Billefjorden; without tect. corr.	227.5	−30.6	18	8.7	16.8	24°S,325°E	5/10
Mimer Valley Fm. Billefjorden; tect. corrected	227.4	+29.8	18	8.7	16.8	8°N,331°E	5/10
Wood Bay Fm., Dicksonfjorden							
Group 1	231	+22	21	12	6.5	4°N,325°E	7/13
Group 2	049	+15	13	16.3	5.7	15°S,325°E	9/17
Group 3	239	+6	9	10.6	19.8	3°S,317°E	5/11

D = mean declination, I = mean inclination, N = number of specimens, and α_{95} and K are the semi-angle of the 95% confidence cone around the mean direction and the precision parameter, respectively [54]. dp and dm are the semi-axis of the oval of 95% confidence around mean pole position, along the palaeomeridian and perpendicular to it, respectively.

(cf. [16, fig. 11]). The corresponding mean directions (Table 1), excluding some aberrant specimen directions, are plotted in Fig. 6 along with the average Billefjorden results, i.e. before (B-UC) and after (B-TC) correction. It is noted that all these results define the same palaeomeridian, but the Dicksonfjorden magnetizations have inclinations between the two Billefjorden directions (B-TC and B-UC).

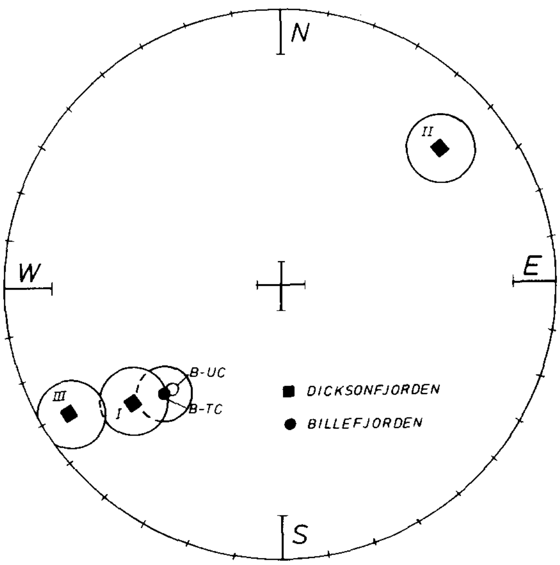

Fig. 6. Stereoplot showing the Billefjorden mean direction, before (B-UC) and after (B-TC) tectonic correction, in conjunction with directions for the most well-grouped populations of the Dicksonfjorden ORS sediments, groups DI–III.

4. Comparison with British results

In Europe the British palaeomagnetic data define the most coherent apparent polar wander (APW) path for the Palaeozoic, though details in the polar pattern are interpretated differently by various authors. From palaeomagnetic data, minor left-lateral displacement has been suggested along the Great Glen Fault [29], but at least to a first approximation it is fair to say that the polar paths north and south of the Great Glen Fault (GGF) show no significant differences [23]. Also, recent palaeomagnetic data from the ca. 400–430 Ma "newer granites" [24–26], situated on both sides of the GGF, are shown to be consistent, thus disputing the large-scale post-Devonian movement advocated by Van der Voo and Scotese [6]. From at least post-Silurian palaeomagnetic data Scotland north of GGF is clearly "European", and the fault cannot seriously be considered as a megashear of say > 500 km in the mid-Palaeozoic, in agreement with geological evidences [28].

The Lower Devonian lavas, Middle/Upper Devonian sediments and volcanics (all three Scottish rocks), and British Permo-Carboniferous lavas and dykes reveal internally consistent data, suggesting rapid APW in this periode. Data from continental Europe are in general agreement with the British results, but the data, notably the Devonian ones, are more scattered and are clearly in need of laboratory re-examination. The equatorial VGP position held by the Lower Devonian lavas from Scotland is generally absent in investigated Lower

ORS sediments from Europe. This variation is most likely due to differences in the ability to retain the original Lower Devonian field component: the lavas probably acquired a stable Lower Devonian magnetization through an early stage of extensive oxidation (partly of deuteric origin) while the sediments in most cases have undergone a long-lasting magnetization history, including diagenetic processes, continuing in many cases perhaps throughout the Devonian. Furthermore, late Caledonian and younger magnetic overprinting are of importance in central Europe, and e.g. within the Armorican Massif, no Devonian palaeomagnetic data are available [30].

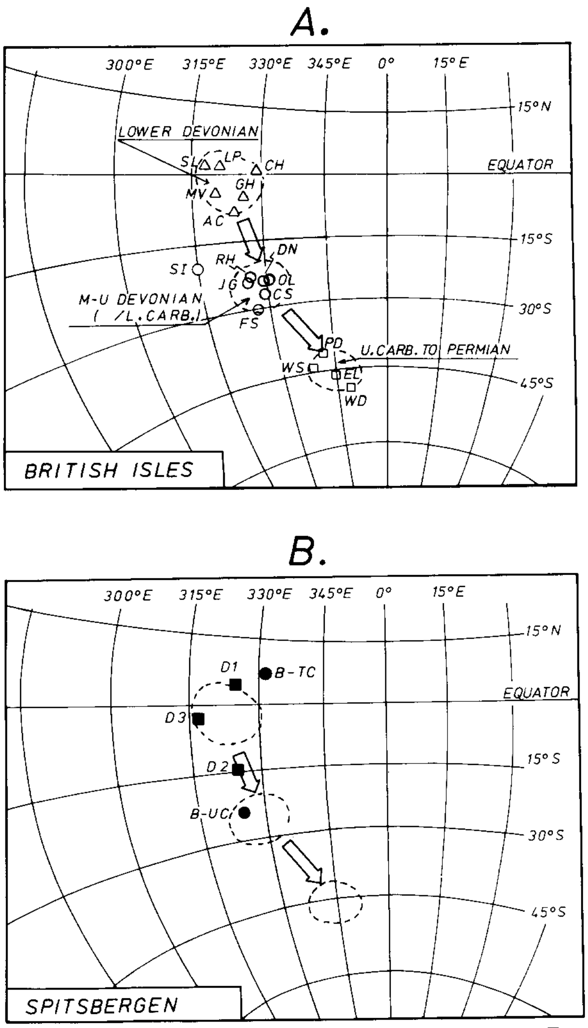

Fig. 7. The relative polar path for the British Isles. A. Devonian to Permian time. Lower Devonian: open triangles; Middle/Upper Devonian: open circles; Upper Carboniferous/Permian: open squares. See Table 2 for formation codes. B. Spitsbergen poles in the framework of the British mid-late Palaeozoic APW path. Poles B-UC and B-TC are based on the Billefjorden ORS sediments, before and after tilt correction, respectively. Poles D1–3 represent the Devonian strata of Dicksonfjorden. Further details in Table 1 and in the text.

Fig. 7B despict the Spitsbergen Devonian data in the framework of the British Middle/Upper Palaeozoic (Devonian/Permian) results (Table 2). From this comparison the Billefjorden magnetization has two possible age alternatives: (1) the magnetization is pre-folding (initial) and of Lower Devonian age (cf. pole B-TC), or (2) the magnetization is post-tectonic (pole B-UC), i.e. remagnetized at around Upper Devonian time (Svalbardian).

The fairly extensive tectonic deformation (including pronounced cleavage) of the investigated Billefjorden rocks, and the fact that these rocks are most likely Middle Devonian in age clearly favour the remagnetization alternative. Although the Billefjorden data represent a relatively small number of tested samples, they all exhibit high-quality single-component magnetizations compared with

TABLE 2

Relevant Palaeozoic palaeomagnetic poles from the British Isles used in an APW master curve for comparison with other regions

	Pole	Ref.	Notation in Fig. 7A
Lower Devonian			
Lorne Plateau Lavas	2°N, 321°E	[31]	LP
Garabal Hill-Glen Fyne	5°S, 326°E	[32]	GH
Arrochar Complex	8°S, 324°E	[32]	AC
Midland Valley lavas/sed.	4°S, 320°E	[33]	MV
Midland Valley lavas	2°N, 318°E	[34]	SL
Cheviot Hill lavas/granites	1°N, 329°E	[35]	CH
Middle/Upper Devonian			
Orkney lavas	24°S, 330°E	[36]	OL
Hoy lavas	23°S, 326°E	[37]	RH
Caithness sst.	27°S, 329°E	[38]	CS
Duncansby Neck	24°S, 329°E	[39]	DN
John O'Groats sst.	24°S, 325°E	[40]	JG
Foyers ORS sed.	30°S, 327°E	[41]	FS
Shetland ignimbrites	20°S, 315°E	[27]	SI
Upper Carboniferous/Permian			
Exeter lavas	46°S, 345°E	[42]	EL
Wackerfield dyke	49°S, 349°E	[43]	WD
Whin Sill	44°S, 339°E	[44]	WS
Peterhead dyke	41°S, 342°E	[26]	PD

the Dicksonfjorden sediments [16]. The Svalbardian thermal and chemical environments were probably at their maximum in rocks adjacent to the Billefjorden lineament. Thus, the rocks of the present study (sampled close to the fault) appear to have a single-component magnetization due to complete magnetic resetting in Svalbardian time. The Dicksonfjorden results referred to here (D1–D3) are most likely of depositional origin and must therefore be older than the Billefjorden remanence. Poles D1 and D3 are seen to match the Lower Devonian pole for Britain extremely well. The suggested inclination error in the Dicksonfjorden beds [16] may in fact be negligible due to the apparent equatorial latitudes of Central Spitsbergen in the Lower Devonian. The low palaeolatitude of Spitsbergen in the Devonian is also supported by palaeoclimatic [22] evidence (Fig. 8).

Thus, with reference to Fig. 7B, available Palaeozoic palaeomagnetic data from Central Spitsbergen may tentatively be interpreted as follows: (1) Dicksonfjorden sediments (poles D1–D3) record Lower Devonian compatible poles (depositional age; magnetization probably unbiased by later orogenic episodes), and (2) Billefjorden sediments (pole B-UC) are considered to have late Devonian or possible early Carboniferous magnetic ages. However, we *emphasize* that the polar pattern pattern as outlined here is preliminary and actual magnetic ages are uncertain. Of the poles concerned, the inferred late Devonian ones seem to be most reliable. Nevertheless, the presently available results from Central Spitsbergen are remarkably consistent with corresponding British data, suggesting a fairly coherent tectonic relationship in late/post-Devonian times.

5. Palaeozoic latitudinal discordances between Europe (Acadia) and North America?

The proposed Carboniferous (Mississippian) phase of strike-slip (ca. 1000 km) motion within Spitsbergen [14] is exclusively based on mega-shear models from elsewhere in the North Atlantic region, where palaeomagnetic data have been used

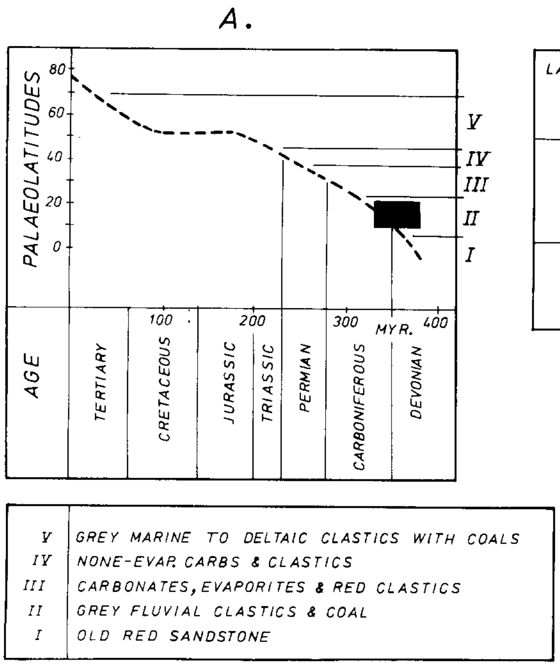

Fig. 8. The palaeolatitude/palaeoclimatic migration of Svalbard (A), redrawn from Steel and Worsley [22], in conjunction with the palaeomagnetically based latitudinal configuration (for Central Spitsbergen, Scandinavia and the British Isles) in Middle Devonian/early Carboniferous (B). The palaeolatitude of Central Spitsbergen is based on the inferred Middle Devonian age Billefjorden magnetization. Note the good correspondence between the palaeoclimatically and palaeomagnetically based latitudes.

for arguments that the coastal Canadian Maritime–New England region [9,10] and later including the Avalon Platform, East Newfoundland [47], was originally situated some 15–20° farther south, the present juxtaposition of the coastal region (Acadia) and cratonic North America being brought about by mega-shearing in mid-late Carboniferous. Van der Voo and Scotese [6] have extended this idea, proposing left-lateral displacement in the order of 2000 km between cratonic North America and Europe. Van der Voo and Scotese [6] suggested that the Great Glen fault, Scotland, to be the appropriate candidate for such a major crustal translation, but it has subsequently been pointed out [24,25,27,38] that palaeomagnetically northern Scotland is clearly European in post-Silurian time, and the available data are totally incompatible with the proposed mega-scale transcurrence.

Compared with the British Isles, palaeomagnetic data from the North American craton [7,46] show almost no APW in Devonian/Permian time (Fig. 9B). This may be taken as evidence for severe magnetic resetting in the Hercynian [45,46,55–57]. Furthermore, Irving and Strong [48,49] have shown that results from the early Carboniferous of western and eastern Newfoundland are very close (Fig. 9A), implying that no large-scale strike-slip motion has occurred between Acadia and cratonic North America since early Carboniferous. The latter authors have also demonstrated the widespread late Palaeozoic magnetic overprinting in Newfoundland, an observation that accords completely with the palaeomagnetic evidence from northern Scotland [24,37,39,40,50,51]. In fact, it was the

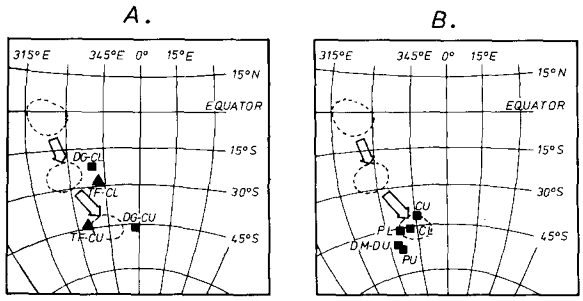

Fig. 9. Middle/Upper Palaeozoic palaeomagnetic poles from Newfoundland (A) and cratonic North America (B). The poles have been rotated according to the Bullard et al. [11] continental configuration for comparison with the British (European) apparent polar wander path (open arrows). Lower Carboniferous rocks from both western Newfoundland, DG [49], and eastern Newfoundland, TF [47], are characterized by Upper Carboniferous/Permian magnetic overprinting (DG-CU and TF-CU, respectively). Poles DG-CL and TF-CL are thought to represent the original magnetization of these rocks. B. Mean poles [7] for the Devonian (DM-DU), Carboniferous (CL, CU) and Permian (PL, PU) respectively. Note the lack of systematic polar migration for cratonic North America as compared with that for the British Isles.

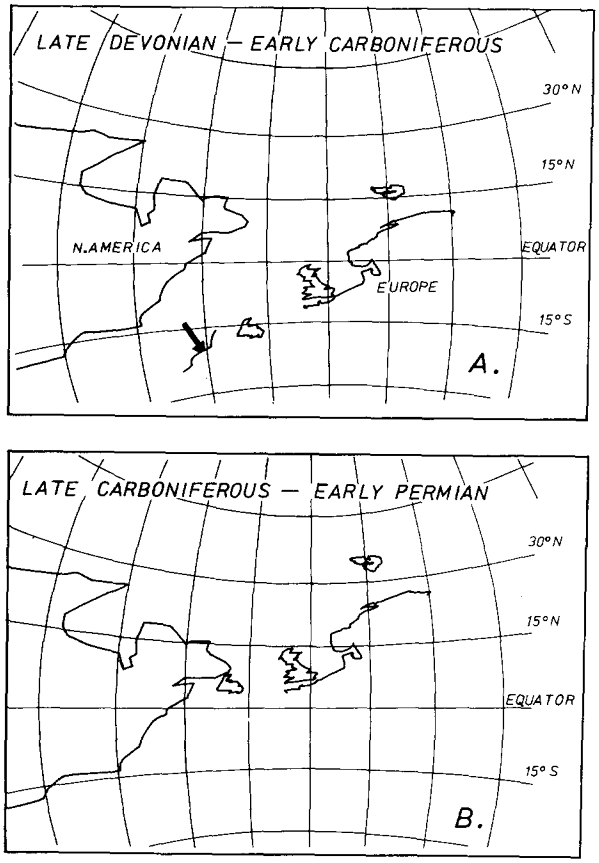

Fig. 10. Late Devonian/early Carboniferous (A) and late Carboniferous/Permian (B) reconfiguration in the North Atlantic based on presently available palaeomagnetic data. Longitudinal positioning which for diagram B is according to the Bullard et al. [11] fit is only optional. Reference poles for latitudinal positioning are according to Figs. 8 and 9. Scandinavia/coast-line Central Europe, and Spitsbergen in the late Carboniferous/Permian, is with reference to British data (assuming no relative movements). The northerly position of the North American craton in late Devonian/early Carboniferous time is thought to be incorrect, reflecting substantial magnetic resetting of mid-Palaeozoic rocks during the Hercynian orogeny. The arrow indicates the assumed true position of cratonic North America relative to Acadia/Newfoundland.

strong"Permian" overprint that Van der Voo and Scotese erroneously accepted as the original magnetization in Orcadian basin rocks, which led to their artificial tectonic interpretation.

Two palaeo-reconstructions, revealing the controversial transition between late Devonian/early Carboniferous and late Carboniferous/early Permian, are outlined in Fig. 10A and B. These reconstructions are strictly latitudinal. They are tentatively corrected for opening of the North Atlantic using the classical Bullard et al. [11] assemblage (apart from cratonic North America in Fig. 10A for which longitude versus Acadia/ Newfoundland is optional), and they summarize the present status in the North Atlantic transcurrence debate. In Fig. 10A the North American craton (based on present palaeomagnetic data) is positioned north of Acadia and Europe. Newfoundland forms one single unit, and the whole of Scotland is seen as part of Europe. However, there are reasons to believe that the relative latitude of the North American craton in late Devonian/early Carboniferous is incorrect, caused by Permian magnetic resetting. Thus, Irving and Strong [48] argue that regions of the craton, apparently free from Kiaman overprinting, should reveal palaeolatitudes that accord with those of Acadia and Europe. Consequently, the late Devonian/early Carboniferous configuration of cratonic North America and Europe was apparently similar to the one for late Carboniferous/early Permian (Fig. 10B), and mega-shearing is not required. If so, a Mississippian phase of strike-slip motion within Spitsbergen [14] is not supported by palaeomagnetic data outside the Arctic Caledeonides.

6. Conclusion

Palaeomagnetic results from the Devonian Billefjorden sediments (Mimer Valley Formation) define a magnetic meridian compatible with recent results from the Dicksonfjorden Old Red Sandstone. The investigated rocks have suffered later deformation and folding, and well-defined remanence directions similar to data from the mid-late Devonian of the British Isles suggest remagnetization linked with a late Devonian (Svalbardian) phase of deformation. The Dicksonfjorden ORS was probably not significantly affected by the Svalbardian orogenic disturbance. However, the palaeomagnetic reliability of the Dicksonfjorden is uncertain (inclination error), though it is not unlikely that the magnetization is fairly accurate and records a stable depositional period in the Lower Devonian.

In Middle/late Devonian (/early Carboniferous) the British Isles and southern Norway were apparently in equatorial areas (Fig. 8B), while Central Spitsbergen was confined to a ca. 15° northerly latitude, a conclusion which is sustained by palaeoclimatic evidence from Spitsbergen (Fig. 8A). Palaeomobilistic views given by Harland [8] and Harland and Wright [13], separating Spitsbergen by several major shear zones, cannot be fully tested by the available palaeomagnetic data, but it seems likely that at least Central Spitsbergen has not been involved in major displacement as compared with Europe, which in turn may reflect the fact that Svalbard and the Barents Sea region have formed a stable platform since late Devonian/early Carboniferous time. If one accepts the Dicksonfjorden results, it implies, in fact, that Central Spitsbergen has remained fixed relative to Europe since Lower Devonian.

The mega-shear argument has been employed to explain differences in the various tectonic zones of Newfoundland, though recent palaeomagnetic data conclusively show that eastern and western Newfoundland were attached to each other and to the North American craton (due to its lithotectonic relationship with western Newfoundland) prior to early Carboniferous [49], and presumably since the Acadian orogeny in Middle Devonian. The proposal of Van der Voo and Scotese [6] of a mega-shear along the Great Glen fault can similarly be discounted. We submit, that on balance of both geological and palaeomagnetic evidence from Spitsbergen, the British Isles, and Newfoundland, that mega-scale transcurrence in the North Atlantic region during the mid-late Palaeozoic is not proven and indeed must be regarded as highly *suspect.* Strike-slip controlled Old Red Sandstone basins within the Caledonian Fold Belt may certainly have occurred locally [3,22,53], but *do not imply or prove* mega-shear in the order of thousands of kilometers.

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