Beckmann (1979) presented a case for a Precambrian 30° anti-clockwise rotation of the Hebridean craton in the conventional reconstruction of the Laurentian Shield. Here I give the contrary arguments which suggest that the conventional (Bullard, Everett & Smith 1965) reconstruction is correct subject to minor modification.

Beckmann has adequately summarized the age-evidence relating to the Lewisian and Nagssugtoqidian, but he has incorrectly implied that the predominant high blocking temperature component in the Central Zone of the Lewisian Complex (Piper 1979, A2 in Fig. 1) and the characteristic remanence of the Angmagssalik region of East Greenland are the typical and the only remanence directions present in the ‘Hudsonian’ terrains. This is not so: in fact, a large migration of the geomagnetic field is represented in the Central and Southern Zones of the Lewisian terrain and indicated by mean poles $A_2 + A_5$ in Fig. 1; there is complete overlap with the ‘B’ directions discussed by Beckmann (Smith & Piper, in preparation). As shown in Fig. 1 a similar situation is represented by the Greenland record and there are no grounds for equating the Lewisian $A_2$ remanence (from predominantly amphibolite-facies terrain) and the Nagssugtoqidian granulite poles 11, 15 and 17–19. We could equally well select the Ketilidian poles 23 or the Nagssugtoqidian poles 22, 24 or 25, all of which come from amphibolite facies terrains like the Lewisian data. These data themselves provide no compelling reason for modifying the existing reconstruction because the $A_2$ pole is comparable to Greenland poles 23–25, and the younger Lewisian poles $A_3 - A_5$ agree closely with new data from the Belcher fold belt of Labrador (Schmidt 1980, pole 27, Fig. 1) from rocks linked to late episodes of the Hudsonian mobile activity.

To justify the linking of the magnetizations he considers Beckmann has attempted to assign ages to them using the geochronological data. This is fraught with difficulties because the ages of the magnetizations (and probably isotropic closure) will depend on the rate of uplift (Pullaiah et al. 1975; Dodson & McClelland-Brown 1980): rates in these terrains are simply not known well enough to estimate magnetization ages to better than about $\pm 50$ Ma. Beckmann (1979) also attempted to match the mean strike of the east–west dykes in central Greenland with the Scourie dyke swarm in Scotland. However, the east–west dykes in Greenland cut, and are sometimes cut by, the north-north-east trending Kangâmiut dykes dated $1950 \pm 60$ Ma (Kalsbeek, Bridgewater & Zeck 1978), and it is clear that at least the majority of the two sets are part of a conjugate swarm of comparable age (Escher, Jack & Watterson 1976; Kortsgaard 1979). It has long been clear that intrusion of the Scourie dykes
Figure 1. Summary of palaeomagnetic poles related to late tectonic and uplift stages of the Hudsonian mobile terrains. The immediately preceding part of the path is summarized by Irving & McGlynn (1979) and Piper (1979). Poles with assigned ages in Ma in brackets are: 1, Martin Formation (1930–1635); 2, Et-Then Group (1835–1630); 3, Sparrow dykes (1700); 4, Pearson Formation 'C'; 5, Menihek 'B' magnetizations; 6, Dubawnt Group (1787); 7, Nonacho sediments (> 1700); 8, Seward 'B' magnetizations; 9, Daly Bay 'A' magnetizations (1622); 10, Cape Smith metavolcanics (1650–1460); 11, Itivdleq area dykes; 12, Kahocella secondary; 13, Metamorphosed Kaminak dykes (1892–1615); 14, Flin Flon tertiary (1700–1600); 15, Angmagssalik gneisses (1800–1600); 16, Castignon Complex; 17, Kangamiut dykes (1750); 18, Godthåb gneisses; 19, Nordre Strømfjord basement (1710); 20, Holsteinsborg basement; 21, Retty 'B' magnetizations; 22, Sagdierssuq basement (1620); 23, Ketilidian metavolcanics (1730–1600); 24, West Greenland amphibolite boudins; 25, Sarfangaqauland amphibolites; 26, Wind River dykes (Beartooth Province, Wyoming, 1880–1580); 27, Eskimo Volcanics (1750–1625); 28, Flaherty Volcanics (1690–1640); 29, Haig intrusions (1790–1620); 30, Eskimo Volcanics, secondary; A, → A, are representative poles summarizing the migration of magnetization represented in the Central and Southern Zones of the Lewisian Complex. The oldest reliably dated poles from the Laurentian Shield which post-date the 'Hudsonian' uplift and cooling are: 31, Sherman Granite; 32, Harp Complex (1450); 33, Michikamau anorthosite (1450–1400); 34, St Francois rocks (1370); 35, Croker Island Complex (1440).

predates 2100 Ma and they have recently been dated c. 2400 Ma by the Rb-Sr method (Chapman 1979) they are thus appreciably older than the Greenland dykes. Both dyke swarms were intruded into hot crust at great depth.

The reconstruction of the Hebridean craton can be derived from the Upper Proterozoic palaeomagnetic data from the Torridonian sediments. The magnetization of these latter rocks was acquired during, or soon after, deposition and largely prior to local slumping (Irving 1957; Stewart & Irving 1974; Smith, Stearn & Piper, in preparation). Thermal and chemical demagnetization studies identify a subordinate secondary component which demagnetization studies and opposing polarities in the Aultbea Formation (Stewart & Irving 1974; Stearn 1978; Smith et al., in preparation) suggest is the resultant of Caledonian and Tertiary/Recent components. Since these have high blocking temperature spectra overlapping with the primary depositional remanence it is not possible to isolate the latter entirely, but the behaviour of vectors with opposing polarities implies that the cleaned directions and pole positions (Fig. 2) are within a few degrees of the Primary Upper Proterozoic directions and pole positions. The stratigraphic sequence of poles 1–5 from the Stoe Group (Fig. 1) and from the Upper Torridonian (Diabag Formation 6, Applecross Formation 7–10, and Aultbea Formation 11–12) define apw motions and trends which match the 1100–850 Ma apw path from the Laurentian Shield on the conventional North Atlantic
Figure 2. APW path for the Laurentian Shield from c. 1150 to 820 Myr. Palaeomagnetic poles from the Shield (small numbers) with assigned ages in brackets are: 1, Baraga County dykes (i); 2, Ilmaaussaq Syenite (1144); 3, Lower Alona Bay lavas; 4, Baraga County dykes (ii); 5, Mamainse Lavas (R, 1070); 6, Lower Cape Gargantua Volcanics; 7, Marquette County dykes; 8, Osler lavas (1115); 9, North Shore Volcanics (1110); 10, Duluth Complex (i), (1115); 11, North Shore Volcanics (1105); 12, Keweenawan intrusive (1120); 13, Beaver Bay Complex (1090); 14, Upper Gargantua Volcanics (1090); 15, Portage Lake lavas (1100); 16, Freda Sandstone; 17, Duluth Complex (ii); 18, Michipicoten Island lavas (952); 19, Copper Harbour lavas (1080); 20, Pikes Peak Granite (1040); 21, Isle Royale lavas; 22, Nonesuch shale (1060); 23, Basalt dykes, Minnesota; 24, Nankoweap Formation (1000); 25, Cardenas lavas (1090); 26, Logan dykes (1050); 27, Mamainse lavas (N, 1076); 28, Fond du Lac Formation; 29, Kearsage rhyolite (1007). Symbols plotted as • are poles J, and JIB-JISA are from the Jacobsville Formation, and mean uplift poles from the Grenville Mobile Belt (A – F) are calculated from thermochron zones defined by the K-Ar mineral ages indicated; individual pole determinations from the Province are indicated by small squares. Hb, and Hb3 are dated Haliburton magnetizations. FD, and FD3 are mean poles from the Franklin diabase (c. 675 – 625 Myr). The c. 1000 Ma Torridonian poles are plotted on the conventional reconstruction as small open circles and after the minor local rotation suggested in the text as open triangles with 95 per cent confidence ovals; the arrows indicate the stratigraphic sequence of poles; the location of the Torridonian studies in the Precambrian foreland of north-west Scotland is shown in (b) where the Lewisian (metamorphic) outcrop is shaded and the Torridonian outcrop is stippled; (c) is a generalized stratigraphic succession.
reconstructions of Bullard et al. (1965). The match is in fact slightly improved by an 8° clockwise rotation (Stewart & Irving 1974, fig. 1, suggest a 12° clockwise rotation), but a 30° anticlockwise rotation as proposed by Beckmann completely removes the Torridonian poles from the Laurentian Upper Proterozoic apw path. (The larger clockwise estimate of Stearn (1978) used in my paper was based on a comparison with the Hadrynian Track of Morris & Roy (1977), and it is now clear that the Torridonian poles must predate the other poles used by these latter authors to define their loop; in addition the apw trends identified from the Torridonian do not match the Hadrynian loop (Fig. 2).)

Although the conventional reconstruction is demonstrably correct for Upper Proterozoic times, it need not, of course, necessarily be true for Middle Proterozoic times; however, a contrasting configuration for earlier times is unlikely both for the reasons given above (and Fig. 1), and because the Lewisian magnetizations are post-tectonic and related to uplift of the already stabilized Hudsonian mobile terrains. Beckmann's case for an anti-clockwise rotation is based on the matching of two well-defined but poorly dated metamorphic magnetizations to the exclusion of other considerations. Since it fails to accommodate the Upper Proterozoic data it cannot be used to explain Palaeozoic discrepancies between Scotland and Europe (Storetvedt 1974) which do not, in any case, appear to be typical of this period (Briden, Morris & Piper 1973; Turner et al. 1976).

References
