PALEOLATITUDE AND CAUSE OF THE SVECOKARELIAN OROGENY

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Paleomagnetic data suggest a paleolatitude of 22°N for the Fennoscandian protocontinent during the Svecokarelian orogeny. This is lower than that of the Canadian shield during the same period. Precambrian polar wandering curves of the two continents differ, thus indicating independent drifting. Mutual collisions and periods of separation are suggested by the early history of the two shield areas.

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Paleolatitude

Synorogenic gabbro and diorite intrusions are abundant in the Svecofennian territory in Finland and Sweden. Remanent magnetization of some of these intrusives has recently been measured. M. Puranen (1960) demonstrated a distinct magnetic orientation in Ylivieska gabbro in the western part (Pohjanmaa) of Central Finland. Later Stigzelius (1970) showed that the remanence of the Ylivieska gabbro was hard and stable. Cornwell (1968) measured a stable magnetization of Tärändö gabbro in Northern Sweden. Grundström (1967) and R. Puranen (1968) gave magnetic data for Svecofennian (= Svecokarelian, Simonen, 1971) intrusive rocks in Central and Southern Finland. More recently, Pesonen and Stigzelius (1972) have published abundant data concerning the paleomganetism of synorogenic gabbro-diorite intrusions in the Pohjanmaa area.

Additional magnetic data on similar intrusive bodies in SW Finland were collected by the present author and are given in Table 1. There were more samples but many of them were too weak and unstable to yield reliable results. The hardness of the magnetization of the samples listed was tested by AC and heat treatment. These two methods were also used for cleaning, and both of them revealed an equal direction of the hard magnetization. However, since the AC demagnetization was more effective than the heating

TABLE 1

Remanent magnetization of diorite-gabbro intrusions in SW-Finland

	Original NRM				After AC-cleaning (250—350 Oe)						
Sample index	Locality	Decl.	Inclin.	Intensity 10^{-5} EMU	Decl.	Inclin.	R	k	α_{95}	(N)	Intensity 10^{-5} EMU
7206	Moisio, Maaria, Turku ...	—117°	+66°	50.0	—48°	+59°	11.67	34.98	7.4	12	3.6
7207	Kanervamäki, Turku	— 67°	+22°	435.2	—56°	+49°	11.86	10.51	13.4	13	27.2
7209	Jalkala, Aura	— 29°	+30°	3.5	—41°	+20°	10.92	120.7	4.2	11	2.0
7214	Kruuvais, Paimio	— 40°	+65°	108.6	—28°	+19°	10.75	40.06	7.3	11	12.7
7215	Kruuvais, Paimio	— 18°	+58°	50.2	—20°	+13°	11.90	106.2	4.2	12	21.8
7216	Suutarla, Karinainen	+ 18°	+40°	18.0	—27°	+18°	11.71	37.26	7.2	12	7.7
7217	Ojakas, Karinainen	+ 35°	+74°	152.0	—15°	+23°	9.75	8.01	17.2	11	13.2
Average	Long. 22.4 E, Lat. 60.6 N	— 32°	+58°		—31°	+29°	6.57	14.15	16.6	7	
	Pole posit. Long. 117° W, σp = 10° Lat. 40° N, σm = 18°										

TABLE 2

Direction of remanent magnetization and paleomagnetic pole sites of the synorogenic Svecokarelian (1 900 My) gabbro-diorite intrusions after AC demagnetization

Sampling area	Long. (°E)	Lat. (°N)	Decl. (°)	Incl. (°)	α_{95}	Paleomagnetic Pole Long. (°W)	Paleomagnetic Pole Lat. (°N)	Paleomagnetic Pole σp (°)	Paleomagnetic Pole σm (°)	P (°)	L (°N)	References
Tärändö, Sweden	22.5	67.1	—20	+41	14	131.3	44.6	10.3	17.0	66.5	23.5	Cornwall (1968)
Ylivieska, Finland	24.28	64.03	—28.7	+38.2	6.8	117.7	43.3	4.8	8.1	68.5	21.5	Pesonen and Stigzelius (1972)
Pohjanmaa, »	24.55	64.12	—27.7	+29.2	13.4	120.9	37.9	8.2	14.8	74.4	15.6	» » »
Tammela, »	23.68	60.67	—36.2	+50.9	3.6	100.6	52.5	3.3	4.9	58.4	31.6	Grundström (1967)
Mikkeli, »	27.25	61.70	—15.2	+44.6	12.2	129.7	53.1	9.7	15.3	63.8	26.2	» »
Hyvinkää »	24.6	60.6	—30.5	+36.1	7.3	113.8	44.1	4.9	8.5	70.0	20.0	Puranen, R. (1968, 1973)
SW-Finland, »	22.44	60.60	—31.0	+29.0	16.6	117.4	39.7	10.0	18.3	74.5	15.5	This study, Table 2
Average	24.55	62.70	—27.1	+38.6	7.2	118.9	45.1	5.1	8.5	68.2	21.8	Fig. 1

α_{95} = the half-angle of the cone of conficence at a probability of 95 % (by site).

P = distance between sampling site and pole, L = paleolatitude of the sampling site.

(450°C), all the heated specimens were also AC cleaned. The results are given in Table 1.

The gabbro-diorite intrusions mentioned above occupy a tectonically similar, synorogenic position and are considered to be about 1 900 My old (Kouvo, 1966). As demonstrated by Table 2, they all show similar magnetic orientation. Table 2 also lists the paleomagnetic pole positions and the calculated distance from the sampling site to the pole. The paleolatitudes of the sampling sites were calculated assuming that the geomagnetic dipole was parallel to the rotation axis. The paleolongitude of the sites is naturally not determined by the magnetic measurements.

Fig. 1 illustrates the paleolatitude of the area of the Fennoscandian (Baltic) shield 1 900 My ago. According to this the Svecokarelian orogenic zone lay between latitudes 18°—28° north of the equator. It has to be noted, however, that only a small part of the shield had formed as a solid continental block by that time. The southwestern part of the present shield was occupied by geosynclinal sediments and volcanics cut by intrusive bodies. They were all younger than the basement in the NE part of the area with an age of about 2 500 My (Sakko, 1972).

The svecokarelian sediments met with in Southern and Western Finland and in Sweden are of geosynclinal type and tell very little or nothing at all about the climatic conditions during the period of accumulation. Sediments of the continental margin, *e.g.* Jatulian quartzites and conglomerates exhibit clear signs of arid and hot or warm climate (Väyrynen, 1928 p. 36—38, Eskola, 1963, Ojakangas, 1965 p. 50). These rocks are older (2 150 My, Sakko, 1972) than the synorogenic intrusive rocks. On the other hand, the younger Jotnian sandstone indicates a warm climatic environment (*e.g.* Simonen and Kouvo, 1950 and Marttila, 1969). Consequently, the paleolatitude obtained from the magnetic measurements of the synorogenic intrusions is in good agreement with the paleoclimate prevailing during the 1 900 My orogeny in Fennoscandia.

The Huronian rock sequence in North America resembles the early Svecokarelian rocks in many respects (*e.g.* James, 1955, Church and Young, 1972) and the ages of these rocks are similar. The epicontinental Huronian rock sequence is known to be rich in glacial deposites (*e.g.* in the Gowganda formation, Lindsey, 1969). This indicates accumulation under conditions more polar than those of the Jatulian rocks in Fennoscandia. Paleomagnetic measurements demonstrate that the paleolatitude of the Huronian deposition must have been much higher (about 60°) than that in Fennoscandia (Spall, 1971). However, a considerable change

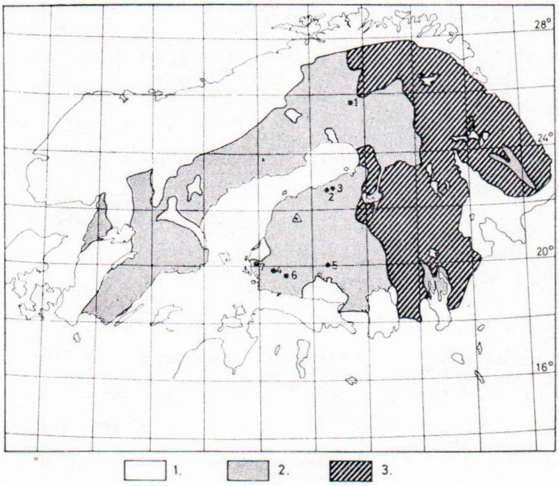

Fig. 1. Paleolatitude of the Fennoscandian (Baltic) shield during the Svecokarelian orogeny (1 900 My).

1) Young areas, 2) Svecokarelian zone, 3) Presvecokarelian area (= Sariola continent).

towards a lower latitude is revealed by track 4 on the polar curve of Canada (Irving and Park, 1972).

Drifting speculations

The apparent polar wandering path found for North America (Robertson and Fahring, 1971, Spall, 1971 and Irving and Park, 1972) and that suggested for Northern Europe (Neuvonen, 1970, 1973 and Spall, 1973) indicate that both blocks were drifting towards the paleoequator between 1 900 My and 1 300 My. The shape of the paths is quite different and gives rise to speculation.

Donaldson *et al.* (1973) have recently made a reconstruction based on Precambrian paleomagnetic data from the Canadian and Fennoscandian shields. The reconstruction shows that the Grenville and Gothide fronts are roughly colinear. The interpretation is only tentative, but, as the authors point out, there are several interesting features to be considered. The age, geological set up and magnetic orientation of the corresponding rock units are very similar in both areas. The similarities are hardly arbitrary and can only be explained by a close spatial connection. The reconstruction shows that the distance between the Canadian and Fennoscandian blocks was not very different from that of the present day. The polar wandering curves of North America (Irving and Park, 1972) and Europe (Neuvonen, 1970) on which the reconstruction was based were calculated assuming a geocentric magnetic dipole. This was certainly not the case and error can be tens of degrees. Consequently, it is quite possible that the two blocks concerned were actually much closer together. On the other hand, old Precambrian parts of Greenland separated the two main blocks from each other. As interpreted by Irving and Park (1972), the hairpins on the polar curve mark large changes in the lateral motion of the Canadian shield and therefore indicate kinematic events. Such loops are not known in the polar curve of Precambrian Fennoscandia (preliminary unpublished data concerning the period from 2 150 to 1 900 My collected by the author suggest that the movement of this block was relatively slight). The differences observed in the polar wandering curves can be interpreted to suggest independent drifting of the two continents before 1 900 My and after 1 300 My and rigid intimate connection during the intervening period. A similar close connection has been suggested by Roy (1972) for the Upper Paleozoic, since the paleolatitudes of Eastern North America and Western Europe were almost identical and co-linear during that time. This indicates that the two continents could twice been parts of a single plate, once during the Middle Precambrian (1 900—1 300 My) and once from the Silurian to the Triassic (McElhinny, 1973).

Further studies will throw more light on the problem but as a working hypothesis one could assume that (2 200 My) the two landmasses were widely separated prior to the Svecokarelian orogeny, as is indicated by the differences in climatical conditions and paleomagnetic orientation, but that they were forced together during the Penokean-Svecokarelian (1 900 My) movements. This intimate connection might have lasted a considerable length of time (about 600 My) and terminated during the Jotnian-Mackenzie episode. After a separation of about 600—700 My, a new collision took place giving birth to the Caledonian mountain chain.

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