Schematic 3-D model of a dyke in the Faeroese Basalt Plateau

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By combining a large number of individual observations of Faeroese dykes intruded in lameller zones it is attempted to visualies a dyke as a schematic three-dimensional intrusive body in the Faeroese basalt plateau.

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Dykes are usually defined as sheet-like, discordant, intrusive bodies, thin in relation to their length, cutting more or less vertically through the bedding planes of the surrounding rocks. Without departing from this definition, it is tempting to visualise a dyke as a three-dimensional intrusive body, not only that which concerns its well-defined central part that can be indicated as a line on a geological map, but also its peripheral parts, both in its horizontal and vertical extension. It is difficult to collect field evidence that makes it possible to depict a single dyke of normal size as a spatial whole, but by combining a large number of individual observations of both the central and peripheral parts of different dykes it should be possible to build up a generalised model of 'the dyke body'.

Lamellar zones and dykes

A lamellar zone is a jointed and fissured zone formed in response to tensional stresses and repeated reworking in consequence of instability or subsidence in the substratum (Peacock 1928, Noe-Nygaard 1940). Lamellar zones occur in exceedingly large numbers in the Faeroese basalt plateau, where they are often eroded and weathered into deep clefts (Faeroese: gjógv, pl. gjáir). A lamellar zone encompasses a number of plane-parallel basalt lamellae, centimetres to metres in breadth, separated by intermediate zones consisting of more or less hydrotermally altered breccia material. The lamellar zones vary from fractions of a metre to many metres in breadth; during tunnelling, lamellar zones up to 40 m in breadth have been encountered. Lamellar zones can often be followed over long distances as depressions in the terrain (faeroese: gil). The formation of the lamellar zones partly preceded the dyke intrusions and partly succeeded the dyking. The youngest lamellar zones affect dykes of the same trend (Noe-Nygaard 1940) or cause horizontal offset where they intersect dykes.

During the geological mapping of the Faeroe Islands (Rasmussen & Noe-Nygaard 1969), 845 exposures of dykes were observed and recorded from all the islands. These exposures are not evenly distributed. By far the greatest number, about 75 % of the total, occur in a ca 20 km wide belt running approximately SW-NE across the islands from Vágar to Fugloy. In this belt, the majority of the Faeroese lamellar zones are also found. By tracing individual dykes it has been possible in many cases to find dyke lenghts of up to 10 km – 20 km, and even in a few cases to more than 20 km. Since in every case only one of the distal terminations of a given dyke has been observed, these distances are all minimum figures. Within the mentioned dyke-cut belt exposures are distributed at all altitudes and stratigraphic levels, from the bottom of the lowest basalt series to the top of the uppermost basalt series, i.e. over a total thickness of about 3000 m.

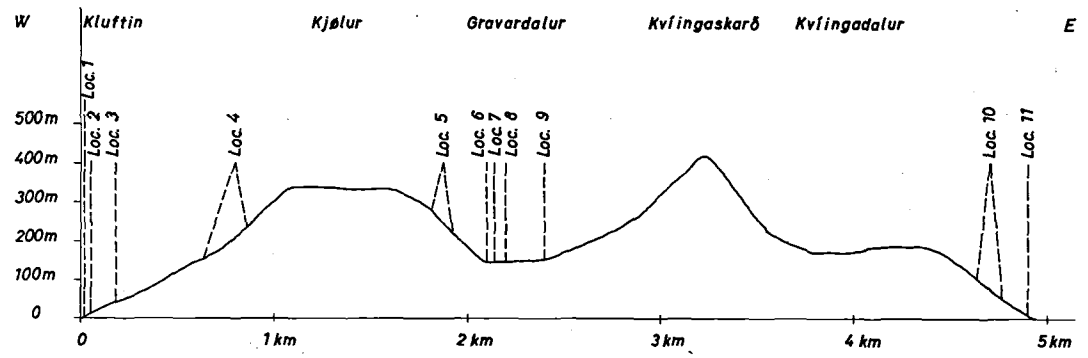

Fig. 1. Profile along the lamellar zone Kluftin – Kvíingadalur.

The nature of the intrusions

In order to illustrate the course of a dyke in a lamellar zone we have chosen an example of a 5 km long dyke-intruded lamellar zone that runs through a landscape with such great variations in altitude that it has been possible to observe changes in the intrusive features of the dyke both horizontally and vertically. The lamellar zone starts on the coast in a small gorge, Kluftin, north of Klaksvík, then runs SE across the mountain of Kjølur, down into the Gravardalur valley, across the Kvíingaskarð pass, and down to the coast at Kvíingadalur. Although the landscape is covered by vegetation over most of this area, the existing exposures still permit the vertical variations in thickness and the course of intrusion of the dyke to be observed.

Fig. 1 shows a profile along the lamellar zone (Kluftin – Kvíingadatur) with the localities at which observations can be made:

Loc.1. The lamellar zone cuts the coast line in the little gorge Kluftin, on the north side of Klaksvík. At the high water mark it is about 7 m wide. The basaltic rock is strongly lamellated near the side walls of the gorge and near the middle, where it is also strongly brecciated, with mineralizations (zeolites and calcite) in the fissures between the lamellae. Due to the strong weathering, it is not possible to establish with certainty whether or not the lamellar zone is intruded by a dyke, but no apophyses were found in the side walls and no traces of contact metamorphism could be seen.

Loc. 2. Immediately above the road, about 20 m above sea level, the lamellar zone is exposed for a distance of about 1 m. No dyke intrusions.

Loc.3. The lamellar zone is exposed at a height of 40 – 50 m. No dyke intrusions.

Loc. 4. A deep gully 170–240 m a.s.l. runs up towards the mountain of Kjølur in continuation of loc. 1–3. The gully is about 10 m wide. Most of its floor is covered by fallen stones and sparse vegetation. Where the lamellar zone is exposed, no traces of dyke rocks, apophyses or even boulders of dyke material have been found.

Loc. 5. In the cleft of Líðargjógv on the east side of Kjølur there is a dyke intrusion at about 280 – 230 m a.s.l. The dyke is about 4 m wide, but varies somewhat in width.

Loc.6. At the first ford in Gravará at the foot of Líðargjógv, dyke contact traces are found at a height of about 150 m.

Loc. 7. At the second ford in Gravará, about 140 m a.s.l., the dyke is about 80 cm wide. Faint lamellar-jointing of the wall rock, not of the dyke.

Loc.8. At the third ford in Gravará, about 140 m a.s.l., two thin (10–30 cm) dykes run irregularly parallel about 3.5 m apart. Faint lamellar-jointing of the wall rock.

Fig. 2. Dyke in a cleft at Kvíingadalur (fig. 1, loc. 10). G = dyke, M = median lamella. The dyke to the left is about 1 m in width. The dyke to the right (partly concealed by vegetation) is about 2 m wide. The median lamella, of coarse-grained feldspar lava, is about 3 m wide.

Loc.9. At the southern stream in Gravardalur, about 155 m a.s.l., the dyke is about 3 m wide. Both dyke and wall rock are lamellar-jointed.

Loc.10. An intrusive dyke may be seen in Kvíingadalur in a cleft extending from about 100 – 50 m a.s.l. At a height of about 90 m the dyke varies about 1 m in width at the south side of the cleft, and is about 2 m wide at the north side; in the middle of the cleft the northern and southern parts of the dyke are separated by a ca. 3 m wide median 'lamella' consisting of coarse-grained feldspar lava, fig. 2. At a height of about 70 m the dyke is 3–4 m wide. At 55 m the dyke was only partially exposed, about 1 m wide.

Loc.11. From the upper edge of the coastal cliff and down to the shoreline in Kvíingadalur the dyke is exposed for about 20 m. Here it is about 5 m wide, but narrows rapidly down towards the shoreline, where in a little gully it is scarcely 1 m wide.

The above profile indicates that dyking has not taken place along the entire length of the lamellar zone, and that the width of the dyke varies considerably both vertically and laterally. On first thoughts one would think that a dyke gradually becomes thinner upwards over its entire length, but this is not the case with the Faeroese dykes. They are often thinner low down in the valleys (e. g. fig. 1, loc. 5). This must imply that the dyke tapers away in tongues upwards through the lava pile.

The uppermost tongue-shaped parts of a dyke will tend to branch into dykelets, since the magma, owing to its reduced pressure, intrudes existing lamellae fissures instead of opening the main dyke fissure further. The setting where two narrow dykes are separated by an intermediate wall rock lamella may well have been produced in this way. Small rafts from such intermediate lamellae are also commonly encountered, fig. 2.

Without entering the discussion on whether or not dykes acted as feeders lo lavas (Tyrell 1937), it should be mentioned that dykes passing into lava flows have never been observed in the Faeroese basalt plateau, even if there are numerous instances of dykes that cut through the entire basalt series; in quite a number of cases they are seen in vertical sections to taper away as they ascend in the vertical cliff walls (Rasmussen & Noe-Nygaard 1969).

In places where dykes cut successive lava flows small lateral sill-like apophyses may extend into the tuff beds or scoriaceous horizons that separate the flows. Geikie (1880) described such lateral outgrowths with a breadth of 3–5 inches and Noe-Nygaard (1945) mentioned that intruding dyke magma that was unable to penetrate overlying basalt flows, has spread out to both sides in horizontal apophyses of 10–20 m length, either in tuff horizons or in zeolite or scoriaceous zones. Noe-Nygaard ads that in profile these apophyses often appear as thin, 10–20 cm thick 'sills' that can reach lengths of up to 25–30 m; in other cases they occur as lenses 2–6 m long and up to 0.5 m thick. Lateral apophyses of this order of size are found very frequently, and therefore only one additional example will be mentioned here of a lateral apophysis of considerably larger dimensions. To the

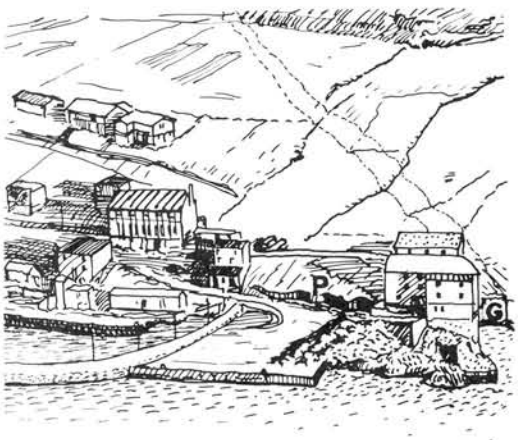

Fig. 3. View of Sandavágur. North to the left, south to the right of the picture. G = dyke. The dyke runs from the coast in an approx. ENE direction. The lateral apophysis (P) can be seen on the section above the road.

east of Sandavágur, a dyke up to 10 m wide runs from the coast with a roughly ENE direction. Immediately northwest of the dyke on a slope above the road, a section is seen through a lateral apophysis given off this dyke (figs. 3 & 4). The apophysis is lense-shaped, but its northerly extremity is now truncated due to blasting and house construction. The original length before the northerly part of the section was blasted away was 22 m, while the remaining part now has a length of about 15 m. The apophysis tapers to the north and south. Its maximum thickness is 1.2 m; the overlying strata have been lifted up by the intrusion and now dip gently to the north and south. Both the underlying and overlying flows consist of highly vesicular basalt with zeolite amygdules. Small apophyses 2–8 cm in length extend into the underlying flow. The distance from the dyke at the coast to the south limit of the section is about 35 m.

The shape taken by a dyke where it terminates depends, like its propagation upwards through the plateau, on the extent to which the magma pressure has been able to overcome the resistance exerted by the lamellar zone. In cases where it has been possible to observe how a dyke terminates, it is often seen to taper or branch out over a rather short distance; in the section (Fig. 1, loc. 11) the dyke tapers from about 5 m in width to about 1 m over a distance of 20 metres. Dykes may often ramify into terminal apophyses. The dyke at Marknagjógv (Rasmussen & Noe-Nygaard 1969) is about 5 m wide at a height of 160 m; it can be followed upwards, and at 205 m only a few dyke intrusions remain in the interstices between the lamellae. The about 5 m wide dyke at Ravnagjógv (Rasmussen & Noe-Nygaard 1969) can be followed 9 km with a WNW trend along a lamellar zone to Egilsnes south of Vestmanna. To the ESE it continues up into an almost inaccessible cleft in the mountain of Trantur; here it decreases in width and at the same time its course becomes very irregular. At a height of about 365 m no dyke is found, only the lamellar zone, while at about 400 m the dyke is seen to break up through the lamellar zone over a short distance (fig. 5). Further to the east-southeast and at 550 m the dyke intrusion is sometimes seen only on the west side of the cleft, and sometimes only on the eastside, where it penetrates the lamellar zone, forming thin apophyses in places. On the ridge above the cleft at a height of 600 m both the lamellar zone and dyke intrusions have disappeared, and do not reappear further eastwards. The 2 m wide dyke near Grananes on the north side of Vestmanna (Rasmussen & Noe-Nygaard 1969) follows a lamellar zone running approx. WNW-ESE. On the south side of the bay, at Fiskinakulla, all that observed is a broad

Fig. 4. The southern part of the lateral apophysis, with a somewhat irregular columnar structure. Greatest thickness 1.20 m. To the right the somewhat tilted overlying flows may be seen. The intrusion has followed the surface of the underlying basalt flow.

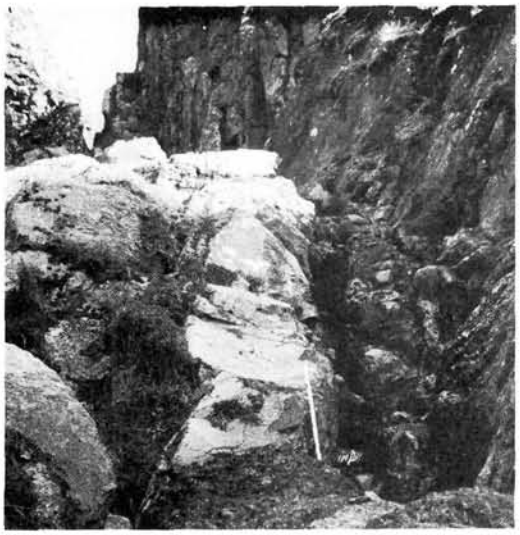

Fig. 5. The dyke in the cleft on the mountain of Trantur, at a height of about 400 m. Here the dyke breaks through the lamellar zone. The scale in the centre of the picture is 0.5 m; above the scale is the dyke, about 1 m. Below the scale the lamellar zone, of coarse-grained feldspar lava, which here has not been penetrated by the dyke. Just below the scale an irregular apophysis from the dyke, 10–30 cm, may be seen.

lamellar zone with a 50–80 cm dyke on its north side and thinner, irregular apophyses a little further to the south.

A schematic 3-D model

The deeply dissected Faeroese landscape permits observations to be made of lamellar zones and dykes in many different sections and at many different geological levels. There are thus innumerable vertical sections in the exposed mountain walls (particularly in the northern and western isles), oblique sections up along the mountain slopes, and sections along the flanks of dykes in landscapes where the wall rock has been eroded away. Exposures of dyke contacts also occur where lamellar zones and dykes have been eroded into deep clefts.

By combining these great many observations into a generalized three-dimensional model of a dyke body intruding into a lamellar zone, the picture shown in fig. 6 is arrived at. This "Faeroese

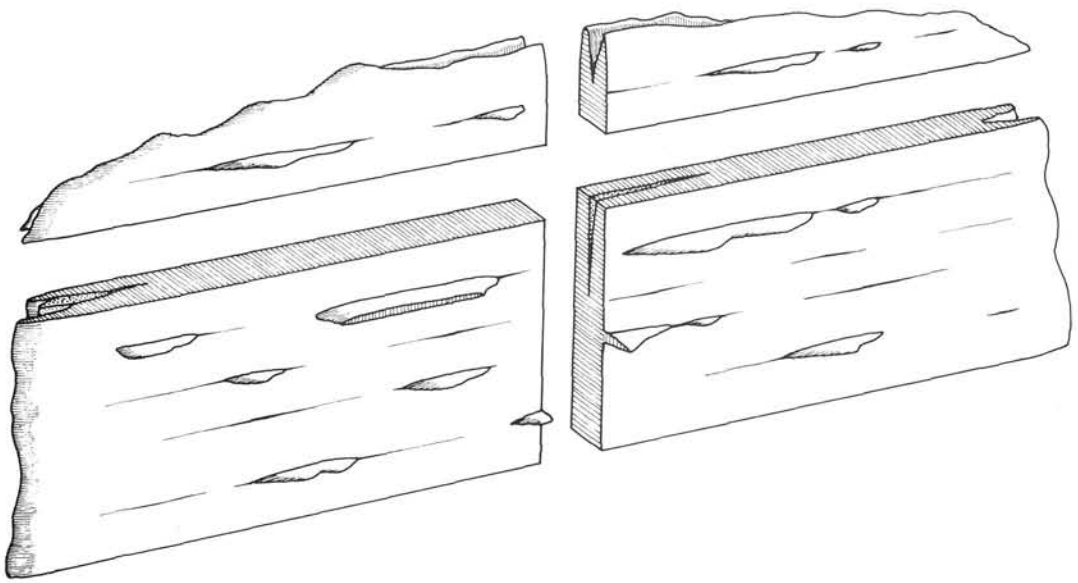

Fig. 6. Schematic model of a dyke that has intruded into a lamellar zone with terminal branching and tapering away. Lateral apophyses at the sides of the dyke. Stippled area: traces of rock of the lamellar zone (median lamella).

dyke" shows a rather irregular, at times bifurcating or branching periphery. It must be pointed out, however, that this model is not drawn true to scale. The peripheral parts of the dyke have been exaggerated in the figure for the sake of clarity, and it is also assumed that the dyke does not penetrate the entire lava pile. As already mentioned, it will depend on the shape of the lamellar zone and its resistance to the magma pressure in its different parts – resistant lamellae, lamella interstices, and brecciated zones – whether the termination of the dyke simply tapers away or consists of branching, irregular apophyses. This is the case both in a horizontal direction within the lamellar zone and in the vertical direction. The size of the lateral apophyses given off from the main dyke body (also exaggerated in the fig. 6) will depend not on the nature of the lamellar zone, but on the nature of the interbasaltic tuff layers and scoriaceous zones in the wall rock that limits the dyke laterally.

Acknowledgements

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Dansk sammendrag

Under den geologiske kartering af Færøerne blev der iagttaget og registreret 845 gangblotninger fordelt over alle øerne. Gangene er intruderet i lamelzoner, hvis dannelse i tid dels ligger forud for gangintrusionerne – dels efter disse. Da gangene er intruderet i lamelzoner, vil deres morfologiske udformning være afhængig af lamelzonernes natur. Der er nævnt en række eksempler på gangforløbet i lamelzoner, og ved sammenstykning af et stort antal enkelte gangiagttagelser i forskellige snit og i forskelligt niveau både af gangens centrale og perifere dele er der gjort forsøg på at opstille en skematisk tredimensional model af en gang i det færøske basaltplateau.

References

Geikie, J. 1880: On the Geology of the Faröe Islands. *Trans. Roy. Soc. Edinb.* XXX, 217–269.

Noe-Nygaard, A. 1940: Om gjógv-Systemernes Alder paa Færøerne. *Meddr Dansk geol. Foren.* 9: 542–547.

Noe-Nygaard, A. 1945: Om Intrusionsforholdet hos nogle færøske Gange. *Meddr Dansk geol Foren.* 10: 546–547.

Peacock, M.A. 1928: Recent lines of fracture in the Faeroes in relation to the theories of fjord formations in northern basaltic plateaux. *Trans. geol. Soc. Glasgow,* 18: (1) 1927–28.

Rasmussen, J. 1956: Nøkur orð um gjáir i Føroyum – uppruna teirra og aldur (Notes on Origin and Age of Goes). *Fróðskaparrit* (Annal. societ. scient. Færoensis) 4: 108–124.

Rasmussen, J. and Noe-Nygaard, A. 1969: Beskrivelse til Geologisk Kort over Færøerne. *Danm. Geol. Unders.* (1) 24: 1–370.

Tyrrell, G.W. 1937: Flood basalts and fissure eruption. *Bull. volc.* 2 (1): 89–111.