ON SOME NORITIC DIKES FROM ØRSDALEN

By
Paul Antun

When the writer, some years ago, mapped the swarm of young, WNW-striking dolerite dikes which dissect the Precambrian igneous complex of the Egersund region (SW-Norway), the question arose how far these extend into the gneisses bordering the stiff anorthosite masses in the interior of the country. In this connexion, two days of field work were devoted to a reconnaissance of Ørsdalsvatn, a 16 km long lake running in a straight line from Bjerkrem towards NE and of the Ørsdalen valley, a 10 km long extension of the same narrow trough, cut by the glaciers deep down into the peneplain.

Whereas no dolerites belonging to the Egersund swarm could be detected, neither in place nor as pebbles in the rivers, the attention of the writer was called to several, hitherto unrecognized, noritic dikes, which deserve a short description.

As already explained in this journal by K. Heier (1955, pp. 69—85) the Precambrian of Ørsdalen is formed by strongly foliated granodioritic gneisses with norito-amphibolitic bands, developed in the charnockite and in the high-amphibolite mineral facies. If we except some wide-spaced fault-zones, such as that on which the lake and valley are located, the rocks are unaffected by postcristalline deformations. The strike is N 45°W, parallel to the border of the Egersund igneous complex, and the general dip at the Ørsdalen W-Mo-mine, some 20 km from this border, is 70°NE. Isoclinal folds with NW-pitching axes have been observed. This series is cut at the upper end of the lake by two subvertical, E-W-striking dikes, formed by a massive, fine-grained, mesocratic rock. They are several meters thick and can be seen from Vassbø in the SE scarp of Bergaslottknuten. Another steep, N70°E-striking dike of similar appearance had, at the time of my visit, already been noticed at the Ørsdal mine by MM. K. HEIER and P. SANDBERG, who kindly directed my attention to it. The dike, about 5 meters thick, is cut and somewhat displaced by the fault running through the valley. That still other old dikes may occur in this region is indicated by the find of fine-grained, feldsparphyric, granoblastic olivine-dolerites among the pebbles of the Ørsdalen river deposits.

As mentioned, the dikes dissect all the primary structures of the gneisses and they display knife-sharp contacts against the country-rock. Contrary, however, to the younger Egersund dolerites, which may have glassy selvages, their margins are never aphanitic and their grain-size increases only a small amount from the borders towards the centers. The fracture has always a saccharoid appearance. The grain measures on the average 0,15 mm in the Ørsdalen dike, which carries some vitreous, dark-blue plagioclase phenocrysts, up to 2 cm in length. It is about double this size in the Vassbø dikes.

It will be shown below that the dikes are Precambrian norites, most probably connected with the last igneous activity of the Egersund complex, which were emplaced at great depth, under P-T-conditions not very different from those which governed the recrystallisation of the surrounding gneisses. In the norites a granoblastic fabric developed, superimposed on their magmatic texture.

Description

TABLE 1

MODES (in volume %)

Components	a.		b.	c.	
	Border	Center	Center	Border	Center
Plagioclase	69	64,3	66	73,6	67,3
Hypersthene	25	} 20,4	} 24	22,2	} 21,9
Diopside	none			none	
Hornblende	none	4,1	none	none	none
Biotite	none	6,1	5,5	none	7,6
Ore	6	5,1	4,5	4,2	3,2

Rem.: Hypersthene and diopside are grouped together as they could not be always distinguished in random sections.
a. = Ørsdalen dike at the W-Mo-mine.
b. = idem on the NW-scarp of Ørsdalen valley.
c. = Vassbø dike nr 1 at Bergaslottknuten.

The Ørsdalen and the Vassbø dikes have a similar mineralogical composition and they show a systematic compositional (and textural) variation from the margins towards the centers, where diopside and biotite (+ hornblende) appear at the expense of hypersthene, the only ferromagnesian silicate present in the border zones. This is clearly expressed by the modes (see table no. 1).

1° *The Ørsdalen dike.*

Close to the contact, the rock has a typical granoblastic fabric and is composed of independent, regularly interspersed, polygonal, equant grains of plagioclase (0,1—0,2 mm), hypersthene (0,06—0,08 mm) and black ore (0,01—0,06 mm). (See Plate I, Fig.1).

The plagioclase occurs as macrophenocrysts, microphenocrysts and granoblastic ground-mass feldspar, all of about the same composition, An 45 to An 41, devoid of any zoning and without any strain. When fresh, the macrophenocrysts are vitreous and deep blue. Frequently, however, they show opaque white spots caused by a local development of very fine-grained saussurite. The microphenocrysts, only slightly greater than the groundmass feldspar, are characterized by an elongated shape parallel to (OIO) and by the presence of Karlsbad twins in addition to albite- and pericline-twinning. In the marginal rocks, they are oriented parallel to the contacts but this fluidal texture fades away towards the center of the dike. The groundmass-feldspar is wholly allotriomorphic. Karlsbad-twinning is not often developed, but albite and pericline lamellae are well-formed and of constant thickness straight through the grains. Though equant, the grains are crystallographically well oriented in the marginal rocks, the side pinacoid being subparallel to the contact, as indicated by the observation that the lower refractive index is subparallel to the contact. This orientation too disappears towards the interior portions of the dike.

The hypersthene has optical properties corresponding to a content of about 35 mol-% $FeSiO_3$. Close to the contacts, it is the only ferromagnesian mineral present and it occurs in small independent grains of polygonal and somewhat convex outlines. In the center of the dike, its aspect is reminiscent of ophitic augite, several neighbouring grains, connected or not, showing an optical orientation identical or very close to one another. In the latter case, it may be seen that the different grains form a broken arc of strain-free subindividuals which are obviously derived from an originally bent monocrystal which has undergone a recrystallisation. The same observation can also be made on some plagioclase microphenocrysts and on hornblende.

The clinopyroxene, which is associated with the hypersthene in the interior parts of the dike, is a green diopside which frequently shows small grains of unmixed ilmenite. It has, in many cases, a homoaxial position towards neighbouring hypersthene. Adjacent grains of hypersthene and diopside may then be simply contiguous or may show a coarse, irregular, myrmekite-like interpenetration along their contact.

The brown hornblende seems to be a phase inherited from the magmatic mineralogy, for it displays here and there a habit resembling that of the bent and recrystallized ophitoidic hypersthene.

The biotite, a uniaxial reddish-brown variety, forms idiomorphic tablets. The ore is mostly ilmenite in rounded to amoeboid grains. (For the texture of the dike-center see Plate I, Fig.2.)

On the northwestern flanc of the Ørsdalen valley, the dike lacks hornblende and shows a better orientation of the feldspar and of the biotite, but here too, the very central portion has no orientated texture. (Plate I, Fig. 3).

2°. *The Vassbø dikes.*

Although more feldspathic than the Ørsdalen rocks, the Vassbø norites are not porphyritic, Their grain is a little coarser and hornblende has not been found, but otherwise, the composition and the texture as well as their variations from the margins towards the center are similar to those of the Ørsdalen dike and need no further comment. (Plate I, Fig. 4).

Interpretation

It is obvious that the norites here described have invaded open fissures in the already deformed charnockitic gneisses and that, since then, they have undergone no deformation.

This geological evidence is confirmed by such internal characters as the occurrence of several generations of feldspar, the originally ophitic behaviour of the ferromagnesian silicates, the fluidal texture displayed by the marginal rocks and the systematic, though limited increase in grain-size towards the centers of the dikes.

On the other hand, the Ørsdalen norites show clear metamorphic features. Such are the homogenous nature of the plagioclase, the purity of the associated metasilicate phases, hypersthene and diopside, the recrystallization of originally bent crystals into subindividuals with neighbouring orientation, the granoblastic texture, particularly that of the formerly fine-grained marginal rocks.

That a granoblastic fabric can be superimposed on an original magmatic texture through static recrystallization in contact-metamorphic aureoles is a well-known fact. In the Ørsdalen, however, as well as in the Egersund area where identical norites are more frequent, there is no indication of a rise of temperature, neither on a local nor on a regional stage, posterior to the intrusion. One must therefore admit that after solidificaton, which had imparted to the minerals such crystal forms as stable in contact with a liquid, the rocks were held for a long time at a temperature high enough to permit strong diffusion (as indicated by the homogeneisation of the feldspar, the recrystallization of bent individuals) and the development of mutual contacts such as stable in the solid state between adjacent crystals of different surface tension. During this recrystallization, the magmatic mineralogy remained almost unaltered. Therefore the regional temperture must have been high and similar to that which governed the mineral paragenesis of the surrounding gneisses, i.e., the Ørsdalen norites have recrystallized at great depth.

As these dikes share their mineralogical and textural characters with the noritic dikes dissecting the Egersund igneous complex, they can be safely considered to represent offshots of the latter. They prove thus that noritic magmas were still available in the Egersund region after the principal folding had taken place.

As for the systematic internal differentiation of the here-examined dikes (see modes table no. 1) we may imagine that it has been caused by a loss of volatiles, suffered by the marginal magma-portion, as schematically indicated by the following expression:

Dike-Border		*Dike-Center*
1 biot. + 4 diop.	=	3 hyp. + 1 magnet. + 2 anorthite + (H_2O + K_2O) lost by diffusion.

Manuscript received March 20, 1962.

Printed September 1962.

EXPLANATION OF PLATE I

Magnification 27 x. Ordinary light.

Fig. 1. *Border-rock of Ørsdalen dike at the W-Mo-mine.*
Fine- and even-grained norite formed of andesine (white), hypersthene (grey) and ilmenite (black). The field shows tree elongated andesine laths parallel to its long side (= magmatic microphenocrysts with fluidal arrangment) and the granoblastic fabric of the recrystallized groundmass.

Fig. 2. *Central rock of Ørsdalen dike at the W-Mo-mine.*
Recrystallized norite formed of andesine (white with grey saussurite spots), ilmenite (black), hypersthene (light grey, heavily cleaved grains), diopside (flatter relief) and hornblende + biotite (medium grey). The ferromagnesian components occur in aggregates reminiscent of magmatic, ophitic pyroxene.

Fig. 3. *Intermediate rock of Ørsdalen dike opposite W-Mo-mine.*
Granoblastic norite formed of andesine (white), ilmenite (black), hypersthene and diopside (light grey, heavily cleaved) and oriented biotite flakes (medium grey).

Fig. 4. *Central rock of Vassabø dike no. 1.*
Granoblastic norite formed of andesine (white with grey-black saussurite spots), hypersthene (light grey, strong relief), diopside (light grey, flatter relief), biotite (medium grey) and ilmenite (black).

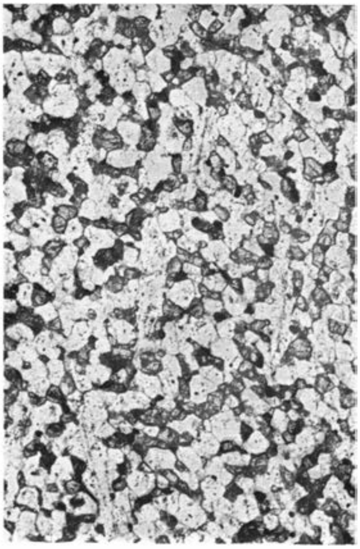

Fig. 1

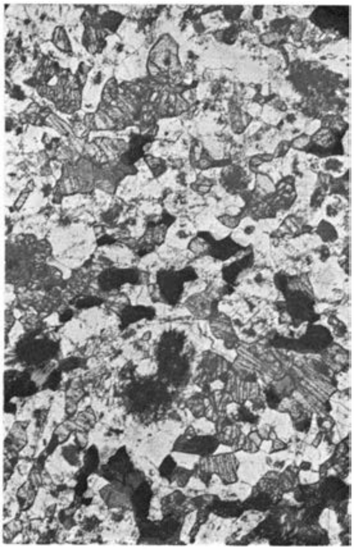

Fig. 2

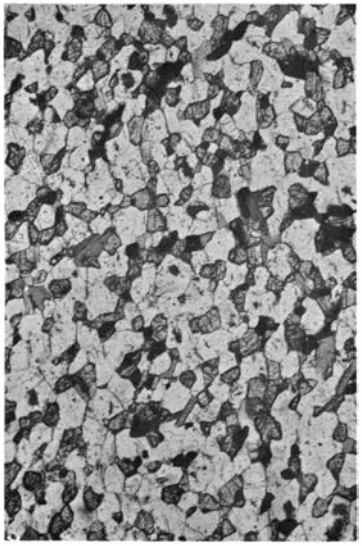

Fig. 3

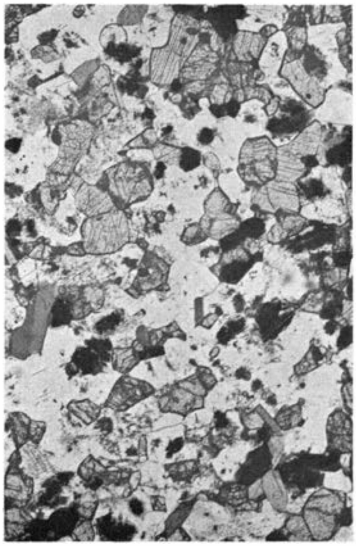

Fig. 4