THE ORIGIN OF FELDSPAR INCLUSIONS IN THE LAMPROPHYRES OFF KRISTIANSAND, SOUTH NORWAY

A preliminary note

BY

HARALD CARSTENS

T. BARTH (1944) some years ago called attention to associated lamprophyric and diabasic dikes west of Kristiansand on the coast of Norway.

The lamprophyres occur as a rule as flatlying, slightly undulating dikes ranging up to 2 m in width. More steeply dipping sill-like intrusions are, however, not unusual.

A marginal banding is sometimes very conspicuous in the broader dikes. The banding is due to the presence of internal, chilled contacts, symmetrically disposed on each side of the dikes, fig. 1. The width of the bands varies as shown in the figure.

The narrow dikes may contain a thin central band sharply limited from the margins, fig. 2. These bands have a glassy groundmass in which abundant phenocrysts of hornblende occur. P. ESKOLA (1954) has described a similar band in a narrow lamprophyre dike at Helsinki.

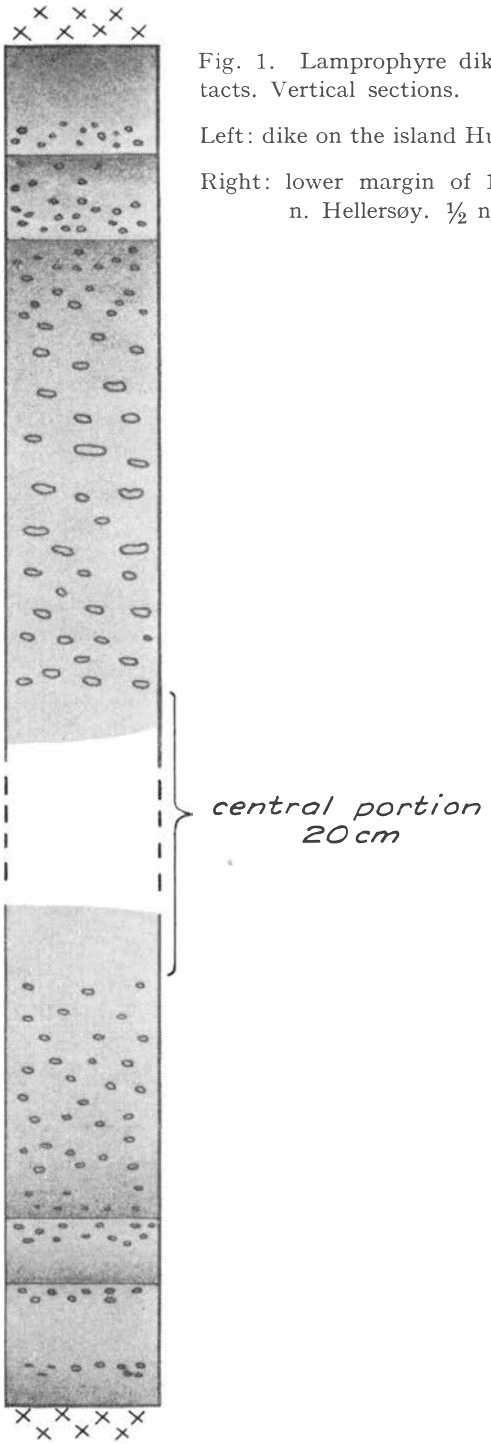
The chilled contacts suggest that the lamprophyric magma was repeatedly injected into the opening fissures. According to J. H. HAFF (1939) the relations between the successive dike intrusions are intrasectate, as the younger dikes lie within the older ones. Similar intrasectate multiple dikes occur in the Arendal region, some 60 km east of Kristiansand.

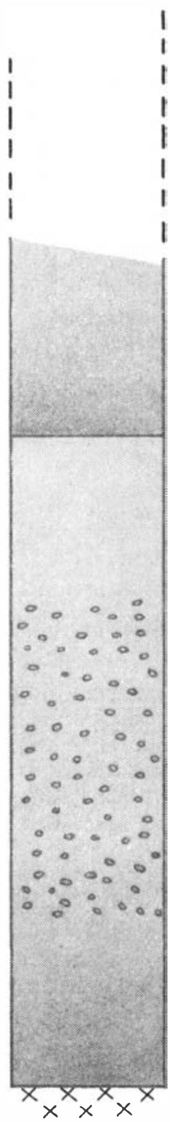
The lamprophyres are characterized by red vesicular inclusions containing predominantly red anorthoclase, fig. 3. The feldspar is

Fig. 1. Lamprophyre dikes with internal chilled contacts. Vertical sections.

Left: dike on the island Hundsøy. ½ nat. size.

Right: lower margin of 1,70 wide dike on the island n. Hellersøy. ½ nat. size.





heavily clouded with a brown pigment. Needles of brown hornblende may protrude from the groundmass into the large vesicles, the lower part of which, however, commonly is devoid of hornblende, fig. 4. The hornblende-bearing vesicles have a composition analogous to larger irregular patches of leucocratic lamprophyre. The vesicles are commonly filled with a core of calcite and fibrous, radiating chlorite. Pyrite is frequently present. The lath-shaped feldspar indiviuals are frequently arranged in fan-like groups, fig. 5. The flattening of the vesicles is as a rule parallel to the walls.

The distribution of the feldspar inclusions is rather interesting, fig. 1. They are concentrated towards the marginal portions of the dikes, and only a few scattered vesicles occur in the central parts. The size of the vesicular inclusions always decreases towards the chilled contacts. It is also worthy of notice that the vesicles are largest in size near the hanging wall, commonly exceeding 5 mm in length.

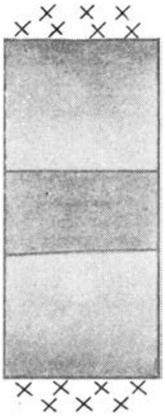


Fig. 2. Narrow lamprophyre sill with central glassy band on the island Skarvøy. Vertical section. Nat. size.

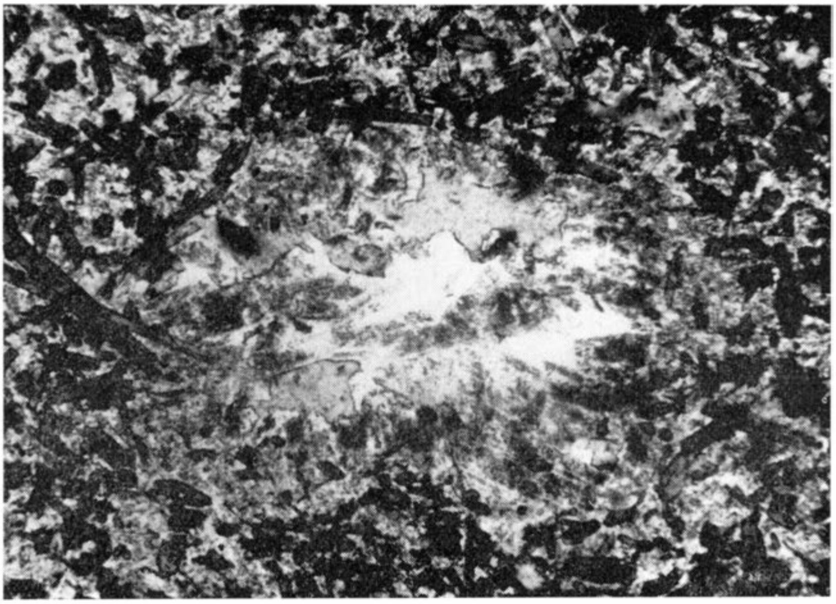


Fig. 3. Feldspar inclusion (ocelli) in the lamprophyre dike on the island Tjamsøy. 64 x.

Fig. 4. Left: Vesicular inclusions containing hornblende (2 x nat. size). Right: Irregular patch of leucocratic lamprophyre with circular feldspar ocelli.

Almost identical feldspar inclusions in Swedish lamprophyres (kullaites) have been described by S. HJELMQVIST (1930 and 1939). Hjelmqvist who first considered the inclusions as amygdales, in his last paper abandoned this hypothesis, and assumed them to represent fragments of country rock syenitized by the enclosing magma. T. BARTH (1944) suggested a similar origin for the red inclusions of the Kristiansand lamprophyres.

Amygdaloidal and ocellar structures are rather common in the associated diabases of the Kristiansand region. The chlorite- and calcite-filled amygdales decrease in size towards the chilled selvages, and sometimes they are arranged in parallel rows. The more complex ocelli, fig. 6, usually have a kernel of calcite, chlorite and feldspar spherulites, which is surrounded by a zone of lamprophyric composition. It is important to note that the feldspar around the ocelli is tangentially arranged, showing that the ocelli were formed before the enclosing magma was completely solidified. Similar feldspar-rich ocelli are found in the aforementioned Arendal dike.

So many points of resemblance are found between the feldspar inclusions of the lamprophyres and the ocelli just described, that they naturally must be attributed to a similar mode of origin.

Reviewing the lamprophyre literature it becomes evident that analogous ocelli and feldspar vesicles are very common in lamprophyres. Very similar ocelli have lately been described and pictured by E. A. VINCENT (1953), and E. SÆTHER (1947) has shown that related vesicles occur in lamprophyres of the Oslo region. I will also refer to the recent papers by A. KNOPF (1935), H. W. JAFFE (1953) and J. G. RAMSAY (1955).

D. L. REYNOLDS (1935) has proposed that ocellar structures in lamprophyric rocks in general may be due to the transfusion of quartzitic inclusions. The vesicular feldspar inclusions and the ocelli of lamprophyre or diabase are different, however, from inclusions of granitic country rock, epixenolithic in character, which likewise occur in lamprophyres and diabases. These xenoliths are not very abundant, they vary in size, and seem to have suffered no alteration by their immersion in the magma. The lamprophyres are commonly chilled against the xenoliths. A xenolithic origin of the feldspar inclusions appears to be more likely if it be assumed that they represent inclusions which have travelled with the magma for a long distance.

The resemblance to ordinary calcite- and chlorite-filled amygdales, on the contrary, ties the formation of the feldspar inclusions and the ocelli to the magmatic stage. In fact, the only difference of some

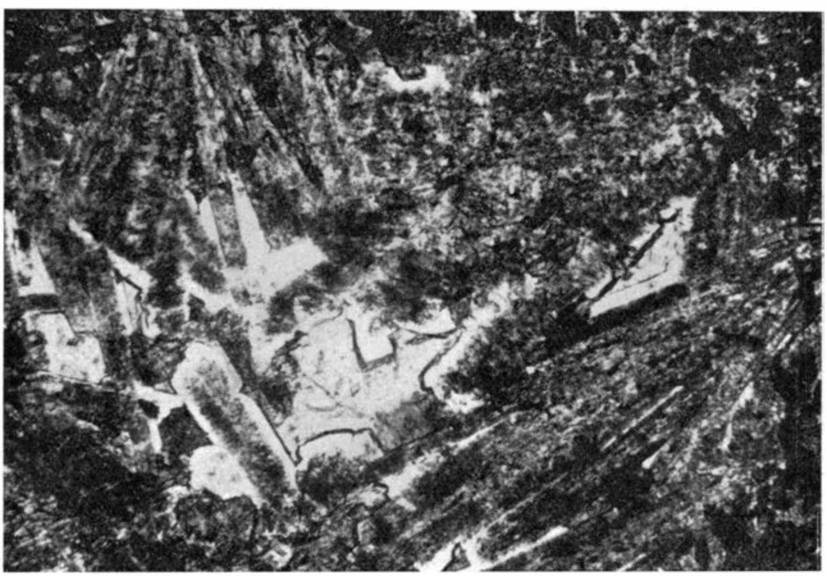


Fig. 5. Feldspar inclusion (ocelli) in the lamprophyre dike on the island Tjamsøy. Fan-shaped arrangement of the feldspar. Calcite in the center. 64 x.

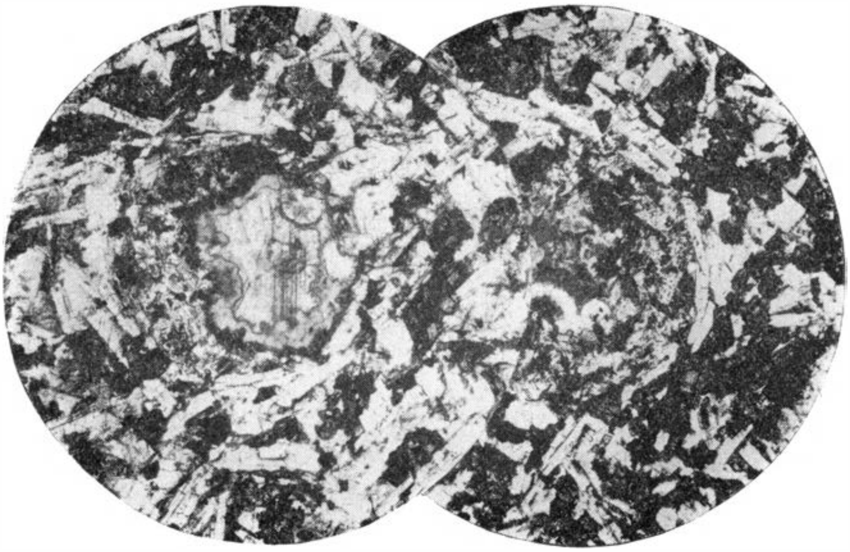


Fig. 6. Ocellar structures in diabase on the island Tjamsøy. 29 x.
Left: kernel of chlorite and feldspar.
Right: kernel of calcite and chlorite.

importance between the feldspar inclusions (or the ocelli) and the amygdales are their mineralogical composition. The presence of feldspar in the ocelli show that they were formed at a higher temperature than the amygdales. That the ocelli were formed earlier than the amygdales was also demonstrated by the tangential orientation of the feldspar around the ocelli. The leuco-lamprophyric patches in the normal lamprophyre furthermore form a link between the lamprophyre and the feldspar inclusions.

The authors referred to above (VINCENT, SÆTHER, KNOPF, JAFFE and RAMSAY) agree in a late magmatic origin of the ocelli described by them.

The claim that the red feldspar inclusions were formed at the magmatic stage, does not disprove a hybrid origin of the lamprophyres in question, though I believe that it weakens the theory of hybridization. Furthermore, the fact that potash predominates in the granitic country rocks, whereas the lamprophyres characteristically are soda-rich, also goes against hybridism.

It seems to be an indisputable fact that true xenoliths are remarkably common in lamprophyres. In some cases, however, I believe that magmatic ocelli or late-stage leucocratic segregations wrongly have been taken for xenoliths. For example REYNOLDS' description (REYNOLDS 1938) of "quartz xenoliths with feldspatic replacement rims" may well represent quartz-filled ocelli of the type described by H. VON ECKERMANN (1928).

However, it is also true that lamprophyres with no traces of xenoliths whatsoever, occur as well, commonly in association with diabases. The finding of VINCENT (1953) of lamprophyric ocelli in the diabases associated with the Skaergaarden lamprophyres (analogous to the ocelli in the Kristiansand diabases) is highly suggestive of a basaltic parentage.

Certainly, no single solution to the "lamprophyre puzzle" can be offered, see for example CHR. OFTEDAHL (1957). Hybridism, fractional crystallization of basaltic magmas and simple heteromorphism are all possible causes for the development of lamprophyric rocks.

The manuscript was critically read by prof. T. BARTH.

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Manuscript received November 11, 1957.

Printed August 1958.