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Mesozoic Hypabyssic Mafic Intrusions and Basalt Flows in the Heimefrontfjella (East Antarctica)

by Gerhard Spaeth[1]

Abstract: Mesozoic mafic dykes, sills and lava flows are not very common in Heimefrontfjella, most occurrences are restricted to the NE part of the range. Geochemically these basalts are different from contemporaneous mafic igneous rocks in Antarctica, they are characterized as Fe-rich, low-Si continental tholeiites. Only few K-Ar ages confirm a Middle Jurassic igneous activity, related to initial Gondwana break-up.

Zusammenfassung: Mesozoische mafische Gänge, Sills und Lavaflüsse sind nicht sehr häufig in der Heimefrontfjella. Die meisten Vorkommen sind auf den NE-Teil der Gebirgskette beschränkt. Geochemisch unterscheiden sich diese Basalte deutlich von gleichzeitig auftretenden Basalten in anderen Regionen Antarktikas. Sie lassen sich als Fe-reiche, Si-arme kontinentale Tholeiite charakterisieren. Nur wenige K-Ar-Alter wurden bisher publiziert, sie belegen ein mitteljurassisches Alter der magmatischen Aktivität, die als Beleg für das beginnende Auseinanderbrechen Gondwanas interpretiert wird.

INTRODUCTION

Mesozoic, or more precisely, Middle Jurassic hypabyssic mafic intrusions are common in western Dronning Maud Land (SPAETH & SCHÜLL 1987). However, their relative abundance in ice-free areas, i.e. nunataks and mountain ranges, is unevenly distributed. In the Heimefrontfjella, they are relatively sparse in contrast to weakly to highly metamorphosed pre-Mesozoic dykes (BAUER et al. 2003, 2009). Mesozoic intrusions occur as dykes or sills, in total 15 dykes and only three sills were recorded (Fig. 1). In the neighbouring nunatak group of Mannefallknausane further west, six dykes and four relatively thick sills have been mapped.

Jurassic dolerites are known from few localities in Heimefrontfjella. They are mainly concentrated on the northeastern part of the range. In the field, Jurassic dykes can be distinguished from older, greenschist-facies dykes by the well preserved columnar jointing, chilled margins and their dark colour. On joints or weathered surfaces, they show characteristic reddish staining by iron oxides.

REGIONAL OCCURRENCE

At Kottasberge (Milorgfjella), the most prominent outcrop with Jurassic dolerites was mapped on sheet Vikenegga, where a ~10 m thick sill within the Permian sedimentary rocks can be traced over nearly 3 km around the Schivestolen massif. Usually, the sill is concordant, keeping a position 30 m above the base of the sediments. At one locality, a small branch, intruding discordantly into the overlying sediments for some 10 m, was observed (Fig. 2). JUCKES (1972) has already noted this locality and shown it on Plate VIIId. One subvertical dyke of 2-6 m thickness intrudes the nunatak Rieber-Mohnnosa (sheet Hanssonhorna); a second dyke in the eastern part of Krogh-Johanssenberga is not shown on this sheet, its position was yet published by BAUER (1995).

In XU-Fjella, a pile of at least 130 m thick lava flows is exposed in the nunatak group of Bjørnnutane (sheet Bjørnnutane), which is probably genetically linked to the dolerite intrusions. It should be noted, that no dykes were found in the metamorphic basement itself.

In Sivorgfjella, the central part of Heimefrontfjella, 13 dykes were mapped, all of them are located on sheet Norumnuten. One dyke is exposed in a ridge 2 km south of Bieringmulen, another dyke 2 km southeast of Bieringmulen. In an unnamed ridge west of the Paalnibba massif, a subvertical dyke is exposed, and a 2 m thick sill crops out in the central part of the ridge over a long distance. In the Norumnuten massif itself and in the ridge SW of Norumnuten, eight subvertical dykes of approximately the same orientation were recorded. They strike NE-SW, and the thickness varies between 0.6-2 m. They form a small dyke swarm, but it is possible that, due to an offset on hidden strike-slip faults or lateral splitting of single dykes, this number is too high. Two additional small dykes at the western footwall of Bieringmulen are not shown on this sheet.

In Tottanfjella, the southernmost part of Heimefrontfjella, WORSFOLD (1967) already recognized an approximately 4 m thick dolerite sill. The sill can be easily traced over more than one kilometre in the northern cliffs of Johnsonhogna (sheet Juckeskammen). It intruded a Neoproterozoic granite, dissimilar to the sill at Vikenegga, which intruded parallel to the bedding of Permian sandstones. Discordant dykes are not known from the Tottanfjella region. With the exception of the mentioned sill in the Permian sandstone at Vikenegga, all other dykes and sills intruded the Precambrian basement, which is obvious, taking into account the limited preservation of the sedimentary cover.

PETROLOGY AND GEOCHEMISTRY

In the crystalline basement, the Jurassic mafic dykes are easily recognizable due to their colour contrast and their negative morphology (gaps in ridges). Fresh rocks show a homogeneous grey to blackish-grey colour, the weathered crusts, however, show colours ranging from reddish brown to greyish brown. All signs of hydrothermal or metamorphic alteration,

[1] Lehr- und Forschungsgebiet Geologie – Endogene Dynamik, RWTH Aachen, 52056 Aachen, Germany.

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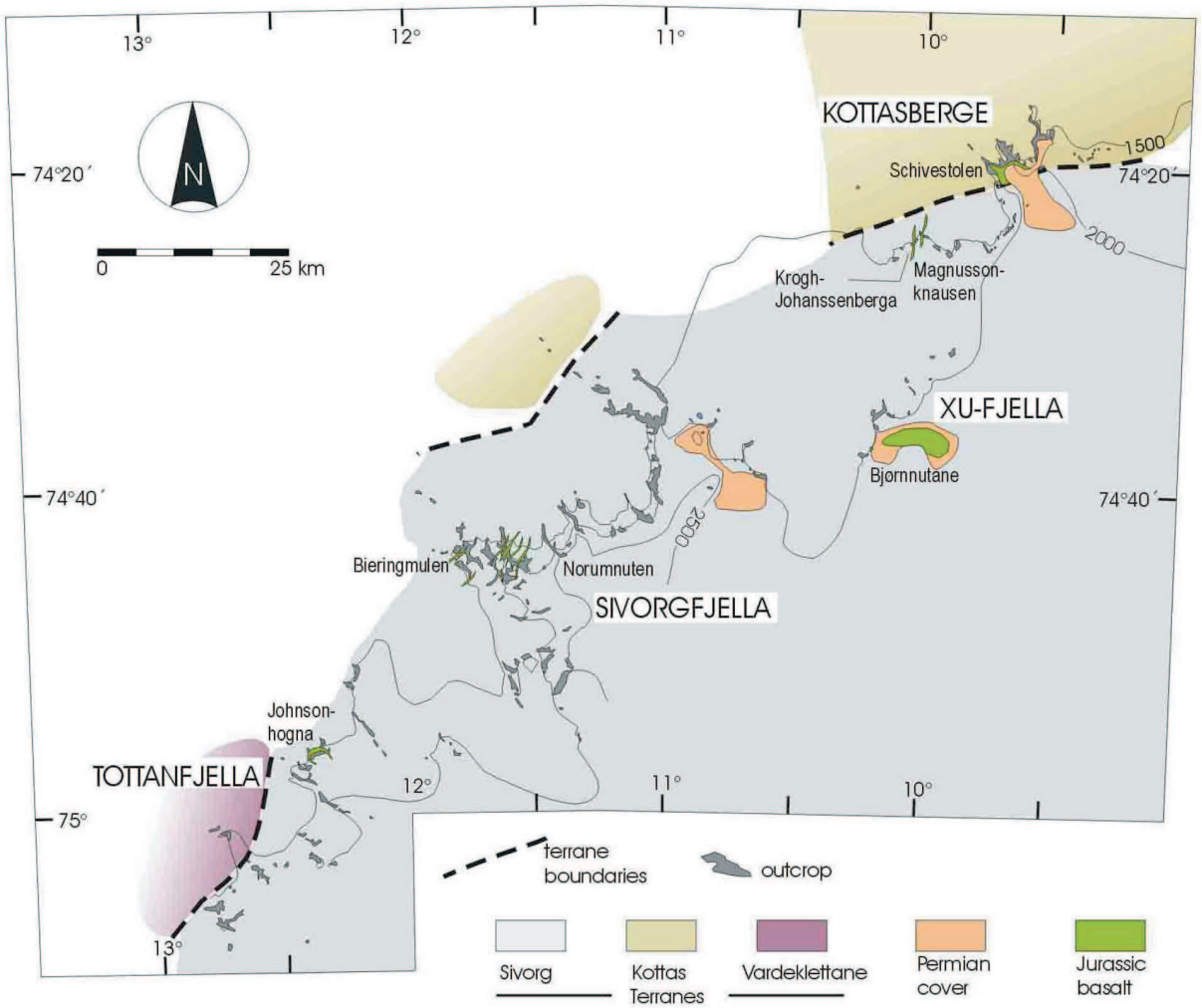

Fig. 1: Simplified geological map of Heimefrontfjella with locations of Jurassic basalt outcrops. The dyke swarm at Norumnuten is strongly generalized.

Abb. 1: Vereinfachte geologische Karte der Heimefrontfjella mit Lage der jurassischen Basaltvorkommen. Der Gangschwarm bei Norumnuten kann nur schematisch dargestellt werden.

Fig. 2: Jurassic sill, approximately 10 m thick, in Permian sandstones at Schivestolen, Kottasberge. Note the small branch in the centre of the picture. The dark rocks at the right bottom are Late Mesoproterozoic orthogneisses.

Abb. 2: Jurassischer Sill, etwa 10 m mächtig, in permischen Sandsteinen, Schivestolen-Massiv, Kottasberge. Bemerkenswert ist die kleine Apophyse in der Bildmitte. Die dunklen Gesteine im rechten unteren Bildteil sind spätmesoproterozoische Orthogneise.

i.e. greenish staining due to chloritization are lacking. Dykes are not only characterized by their discordant spatial relationship with respect to the prevailing metamorphic foliation, they also exhibit a prominent columnar jointing and chilled margins.

The thickness is variable, ranging from 20-30 cm up to 4 m. The average thickness is around 1 m. They can be traced over long distance, some dykes have been traced over whole nunataks. They show a remarkable continuity of strike, scattering only weakly around the SW-NE direction. Their dip is also relative contant, with one exception they are very steep with dip angles between 80° and 90°. The sills dip shallower (max. 10°) towards the SE, which is equivalent to the Mesozoic fault-related tectonics of the Heimefrontfjella Escarpment (JACOBS et al. 1995).

A detailed petrographic and geochemical study of these doleritic rocks was not published yet. Some data are published in overview articles, such as WORSFOLD (1967), JUCKES (1972) and SPAETH & SCHÜLL (1987). In these publications, Juckes (1972) gives a detailed description of the thick Vikenegga sill, whereas WORSFOLD (1967) focusses on the sill from Johnson-

hogna. All sills and dykes from Heimefrontfjella and Mannefallknausane known until 1986 are considered by SPAETH & SCHÜLL (1987) in their geochemical study with average values and ranges for main and trace elements as well as modal analyses. According to these studies, plagioclase with An_{40-55} forms the main constituent with 40-50 vol. %. Euhedral, tabular plagioclase crystals show polysynthetic twins and normal zoning, without any signs of alteration. Pyroxene is the second main component with 30-40 %. Pinkish-brown titanaugite or greyish augite are the most common pyroxenes; orthopyroxene (ferrosilite) was found in small amounts. Olivine occurs in some samples as a minor (<10 %) component, and opaque minerals like skeletal ilmenite and euhedral magnetite are always below 5 %.

The texture is fine- to medium-grained and, with exception of the chilled margins, only a very small amount of aphanitic groundmass was observed. The fabric is subophitic to ophitic, in some cases porphyritic. On a newly cut face, the rocks always look very fresh, detailed microscopic studies, however, reveal a deuteric alteration of olivine and occasionally pyroxene.

Geochemical analyses of a limited number of samples have been published (JUCKES 1972, SPAETH & SCHÜLL 1987). They show low SiO_2 and alkali oxide values, but high Fe_2O_3 and TiO_2 values. These features are also typical for other basaltic rocks in western Dronning Maud Land (Vestfjella, Ahlmannryggen), but in a strong contrast to the contemporaneous volcanic province of the Ferrar dolerites in the Transantarctic Mountains with their relatively high SiO_2 and alkali contents. The western Dronning Maud Land volcanic province shows more similarities to the Karoo dolerites in South Africa. The dolerites of western Dronning Maud Land plot in discriminate diagrams, using main and trace elements, within the fields of *within plate basalts,* i.e. they have a continental tholeiitic character (SPAETH & SCHÜLL 1987), which is important for their geotectonic interpretation.

GEOCHRONOLOGY

Only one single K-Ar whole rock age of 179 Ma of a sample from the sill at Vikenegga has been published so far (REX 1972). The same author published also Jurassic K-Ar ages of 162 and 173 Ma for the lava flows at Bjørnnutane. These data are in coincidence with K-Ar ages published by PETERS (1989) for dolerite intrusions at Vestfjella.

With good reason, it can be assumed that all unmetamorphosed dykes of western Dronning Maud Land are of a similar Middle Jurassic age. Their tectonic orientation, morphological features, freshness of the rock surfaces and lack of internal deformation as well as their geochemical similarities support this statement.

GEOTECTONIC INTERPRETATION

The intrusion of dolerite dykes during Middle Jurassic time indicates the beginning Gondwana break-up. The SW-NE tectonic orientation prevails in the whole Dronning Maud Land sector of Antarctica and is coincident with the direction of Mesozoic fault tectonics. In comparison to adjacent mountain ranges in the NW and NE, the Heimefrontfjella is in a peripheral position regarding the magmatic activity of the beginning rifting process. The total number and frequency of Mesozoic dykes are decreasing towards the east and southeast, i.e. with increasing distance from the recent Antarctic continental margin, which are very typical features of a rifted continental margin (SPAETH & SCHÜLL 1987).

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