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Geology of the Vardeklettane Terrane, Heimefrontfjella (East Antarctica)

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Abstract: In the southwest of the Heimefrontfjella mountain range a granulite-facies terrane is exposed in the small Vardeklettane nunataks. The Vardeklettane Terrane extends, however, at least 65 km farther WNW to the nunatak group of Mannefallknausane, where comparable granulites are exposed. The terrane is composed of mafic and felsic granulites, leucogranite orthogneiss and metasedimentary rocks. The maximum deposition age of the latter is constrained by detrital zircon U-Pb data ranging from 2000 to 1200 Ma whereas the leucogranite gneiss gave a late Mesoproterozoic crystallization age of 1135 Ma. The Vardeklettane Terrane is unique as being the only part of the otherwise juvenile Late Mesoproterozoic basement of Heimefrontfjella to have a Paleoproterozoic crustal component. Structurally, the terrane is separated from the main range by the Heimefront Shear Zone.

Zusammenfassung: In den kleinen Vardeklettane Nunataks im Südwesten der Heimefrontfjella ist ein Teil eines granulitfaziellen Terranes aufgeschlossen, das sich mindestens noch 65 km weiter WNW bis in die Mannefallknausane Nunatakgruppe erstreckt, wo vergleichbare Granulite aufgeschlossen sind. Das Terrane baut sich aus mafischen und felsischen Granuliten, Leukogranit-Othogneisen und Metasedimenten auf. Letztere enthalten detritische Zirkone, die U-Pb Zirkon-Alter zwischen 2000 und 1200 Ma aufweisen. Der Leukogranit-Gneis gab ein U-Pb Zirkon-Kristallisationsalter von 1135 Ma. Das Vardeklettane Terrane ist einzigartig im Vergleich zum restlichen, juvenilen spät-mesoproterozoischen Grundgebirge der Heimefrontfjella, weil sich ältere, paläoproterozoische Krustenkomponenten nachweisen lassen. Strukturell ist das Terrane durch die Heimefront-Scherzone vom Hauptgebirgsstrang getrennt.

INTRODUCTION

The two nunataks of Vardeklettane are located at 12°45' W 75°01' S (Fig 1.) on sheet Cottontoppen of the 1 : 25,000 geological map. Together with the isolated nunatak group of Mannefallknausane, 65 km west of Heimefrontfjella (at 14°30' W 74°35' S), they form the Vardeklettane Terrane sensu JACOBS et al. (1996). At Vardeklettane a metamorphic complex is exposed which underwent granulite-facies metamorphic conditions, in contrast to the rocks from the Sivorg and Kottas terranes which generally were metamorphosed at conditions not exceeding the amphibolite facies.

The first three rock specimens from Vardeklettane were collected by a British surveyor (ARDUS 1964) and were described by THOMSON (1968) as "quartz-mica schist" and "porphyroblastic feldspar-quartz-biotite-gneiss". Unfortunately, the collected samples are extensively retrogressed with abundant chlorite and sericitised plagioclase, so granulite-facies metamorphism was not identified. For the nunatak group of Mannefallknausane however, JUCKES (1968) reported charnockites and granulite-facies rocks. Granulite-facies rocks were subsequently recognised at Vardeklettane by ARNDT et al. (1987), who described charnockites as well as felsic and mafic granulites, interpreting the latter as meta-volcanic rocks. The following description is based on the systematic mapping at 1:10,000 scale completed during the international Heimefrontfjella expedition of 1994 (BAUER et al. 1996).

WESTERN VARDEKLETTANE

The western nunatak of Vardeklettane is composed of fine- to medium-grained leucogranite gneiss (Vardeklettane leucogranite, code Ch) with an ill-defined foliation. This rock type is composed of quartz (35 %), plagioclase (35 %), biotite (15 %), K-feldspar (10 %) and garnet (5 %), with accessory apatite and zircon. The Vardeklettane leucogranite gneiss has given an U-Pb zircon age of 1135 ±8 Ma (ARNDT et al. 1991).

The orientation of the regional foliation changes from steeply NW-dipping at the western tip of the nunatak to gently NE-dipping at its eastern end. The leucogranite gneiss is deformed by upright or N-vergent folds with shallow E-plunging axes. Locally, the foliation is absent due to pervasive but patchy migmatization. Such migmatitic areas form diffuse zones up to 30 cm in diameter and characterized by patchily-developed clots of garnet, surrounded by leucocratic haloes depleted in biotite (Fig. 2). LE BRETON & THOMPSON (1988) suggested an origin of such haloes from prograde dehydration melting in the early stages of crustal anatexis by following reaction: Bt + Pl + Al-silicate + Qtz → Kfs + Grt + melt (abbreviations after KRETZ 1983).

In other areas of the western nunatak, nebulous veins and patches of greenish charnockite are developed. Single orthopyroxene porphyroblasts up to 1 cm in size associated with quartz are typical and indicate metamorphism under granulite-facies conditions. Similarly, in the charnockitic patches, the metamorphic foliation, originally defined by biotite flakes, has been partially destroyed. This texture is indicative of "replacement type" charnockitization, and is broadly analogous to "incipient charnockitization" as defined by YOSHIDA et al. (1991).

Numerous mafic enclaves have been found in the leucogranite, some of which may be dismembered dykes. They contain typical granulite-facies mineral assemblages with clinopyroxene, orthopyroxene, plagioclase and hornblende. The preser-

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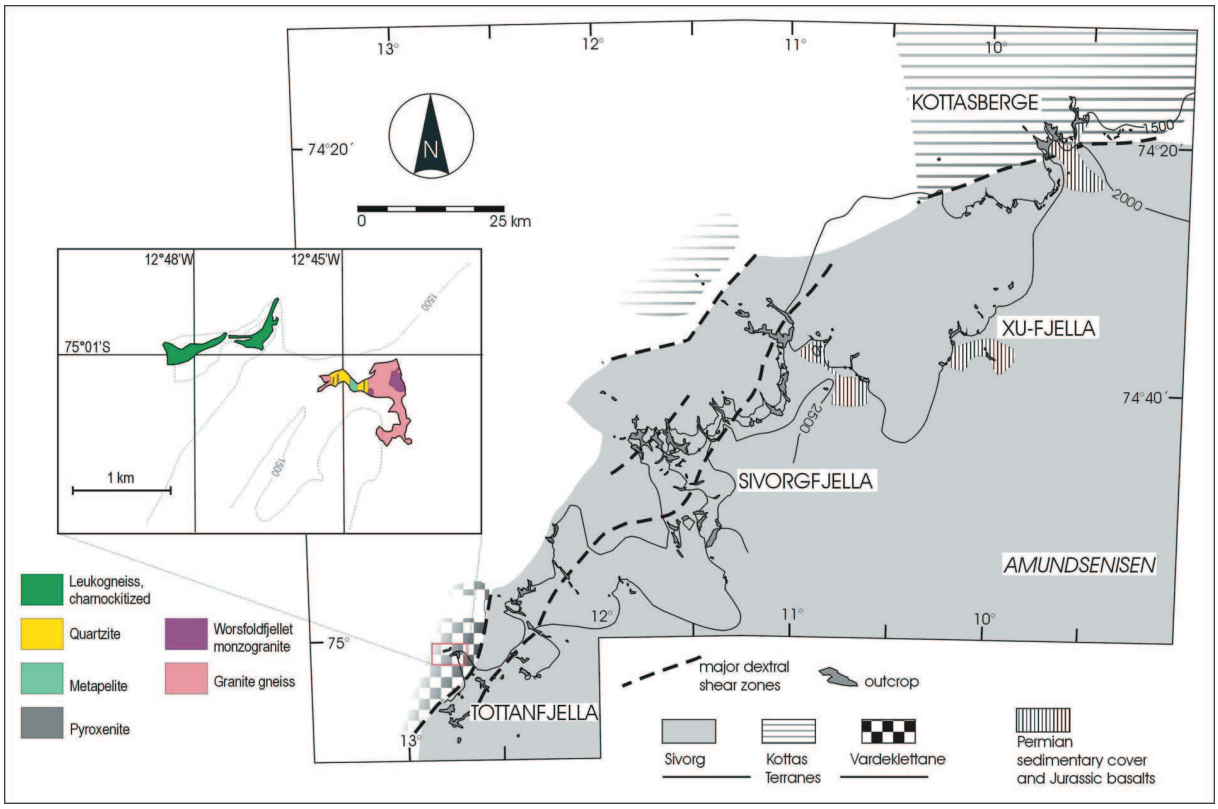

Fig. 1: Geolocial overview of the Heimefrontfjella with an insert map of the two Vardeklettane nunataks.

Abb. 1: Geologische Übersichtskarte der Heimefrontfjella mit einer Detailkarte der beiden Vardeklettane-Nunataks.

Fig. 2: Dehydration melting patch in leucogranite gneiss (above hammer head), western Vardeklettane.

Abb. 2: Helle Flecken im Leukogranit-Gneis, die Entwässerungs-Schmelzen bei hochgradiger Metamorphose anzeigen; westliches Vardeklettane.

vation of inverted pigeonite indicates peak metamorphic temperatures exceeding 900 °C. Adjacent to larger mafic enclaves, nebulous green incipient charnockite forms metre-scale aureoles with diffuse outer rims.

EASTERN VARDEKLETTANE

The nunatak of eastern Vardeklettane is structurally and lithologically different from the western nunatak. The eastern and westernmost parts of the nunatak are composed of two different orthogneisses. The younger gneiss is exposed at the north-eastern summit of the nunatak. It is a dark-grey to black, weakly foliated granitoid of quartz monzonitic composition. Large patches of graphite are sporadically developed. This rock type has equivalents farther south and east at Ardusberget and Worsfoldfjellet and was named "Worsfoldfjellet monzonite" (code SG4 on the geological map).

The monzonite intrudes an older porphyritic granite orthogneiss (code Opo). The latter is a very coarse-grained, foliated granitic gneiss with K-feldspar megacrysts up to 10 cm in size and contains large xenolithic rafts of leucogranite /charnockite similar to the western Vardeklettane rocks. Thus, megacrystic orthogneiss post-dates the leucogranite of western Vardeklettane. The former has been named "Mannefallknausane granite" by JACOBS et al. (1996) with the Type Locality situated at Baileyranten in Mannefallknausane, from where a U-Pb zircon age of 1073 ±8Ma was obtained by ARNDT et al. (1991). Generally, this rock type is composed of up to 60 % mesoperthitic K-feldspar set in a matrix of plagioclase, quartz, garnet, and ferrosilite. Retrograde overprinting has led to a partial replacement of garnet to biotite, ferrosilite to hornblende, and to sericitization of plagioclase. The granite is typically associated with extremely coarse-grained quartz-K-feldspar pegmatites with individual biotite flakes up to 0.5 m across (Fig. 3).

The oldest rocks are exposed along the western ridge of the nunatak, represented by an approximately 400 m thick succes-

Fig. 3: Very coarse-grained pegmatite, eastern Vardeklettane.

Abb. 3: Riesenkörniger Pegmatit, östliches Vardeklettane.

sion of metapelites and quartzites with two minor ultramafic enclaves. Detrital zircons from the quartzite have given a wide spread of conventional and SHRIMP U-Pb zircon ages between 2000 and 1200 Ma (ARNDT et al. 1991).

At the eastern as well as the western margin of the metasedimentary succession, ductile shear zones mark the contact against the adjacent meta-igneous rocks. From west to east the succession comprises 150 m of impure quartzites with minor two-feldspar gneiss intercalations and two 15 m thick ultramafic pyroxenite lenses; 80 m of garnet-cordierite bearing metapelites; 100 m thick quartzites with a 10 m thick band of a two-pyroxene metabasite, partly retrogressed to hornblende-chlorite-epidote schist, and few metres of ultramylonitic augen gneiss. This augen gneiss is relatively poor in K-feldspar, and was interpreted as highly deformed Worsfoldfjellet monzonite. The last two units form a 20 m wide, steeply-inclined mylonitic shear zone (S_{myl} 083°/74°) with a moderately north-plunging stretching lineation (L_{myl} 012°/ 50°). The sense of shear is sinistral, i.e. top-to-NNE. A sub-vertical, N-S to NE-SW trending foliation with locally developed steeply inclined minor fold axes characterizes the tectonic structure of the metasedimentary sequence.

CONCLUSIONS

The Vardeklettane Terrane is poorly exposed. However, aeromagnetic data show that it makes up a continuous crustal block west of the Heimefront Shear Zone. It thus falls within that part of the basement, which was only weakly affected by Late Neoproterozoic-Cambrian overprinting (GOLYNSKY & JACOBS 2001). In Gondwana reconstructions the terrane has a lithologically and geochronologically similar counterpart in the Natal Sector of the Namaqua-Natal Province of South Africa, known as the Margate Terrane (BAUER et al. 2003). The Palaeo- to Mesoproterozoic detrital zircon ages and negative εNd values (ARNDT et al. 1991) indicate that the Vardeklettane Terrane metasediments were derived, at least in part, from the erosion of pre-Mesoproterozoic basement, probably situated farther south, beneath the rhyolites of the Coats Land nunataks (KLEINSCHMIDT 2002). The rocks probably represent an extensional back arc setting in Mesoproterozoic times with sedimentary input from an older cratonic area in the south (Fig. 4). Considering the generally dextral sense of shear and the transport distance necessary to create a major structural lineament like the Heimefront Shear Zone, the Vardeklettane Terrane has probably been displaced from a position much farther southwest from its present location at the end of the late Mesoproterozoic orogeny.

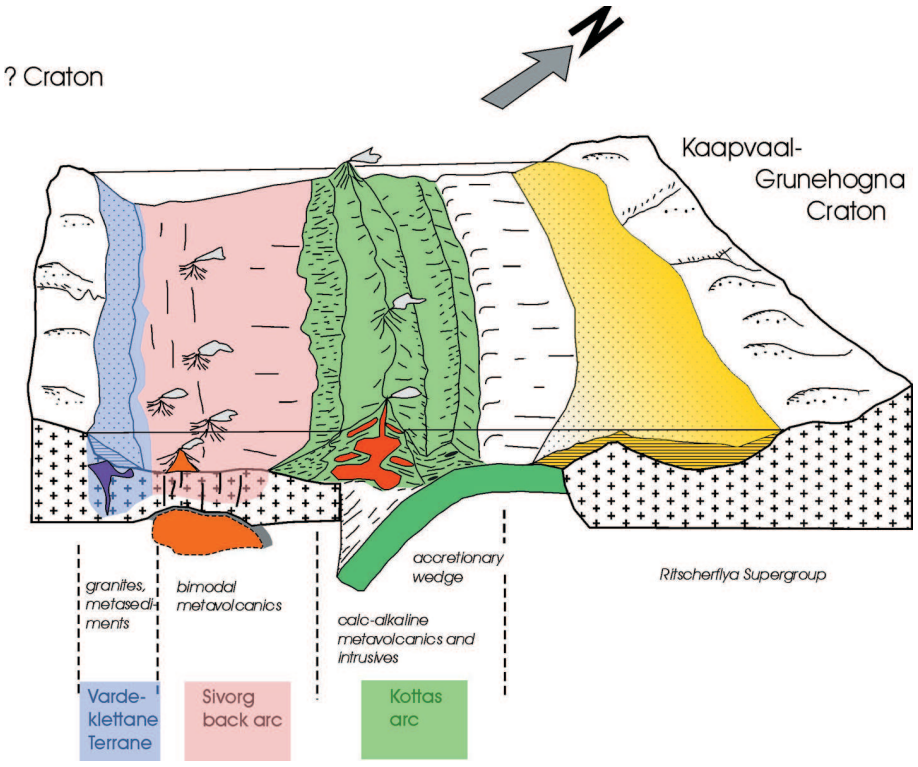

Fig. 4: Block diagram showing the Vardeklettane Terrane as a marginal part of the Sivorg back arc with sedimentary input from a cratonic area in the South (arrow = present north of Antarctica).

Abb. 4: Das Blockbild zeigt das Vardeklettane-Terrane in einer Randposition zum Sivorg-Back-Arc mit sedimentärem Eintrag von einem Kraton im Süden (Pfeil = heutige Nordrichtung für Antarktika).

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