Geochemistry and petrology of border zones between mafic/ultramafic bodies and surrounding TTG gneisses (SW Greenland)

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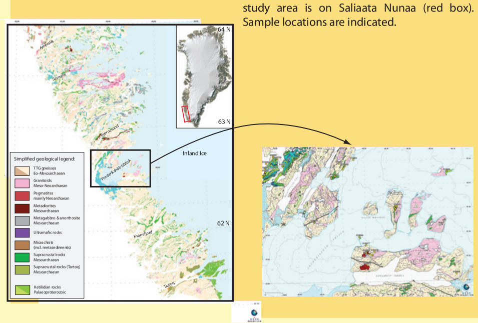
Abstract

Archean TTG field areas often contain different ultramafic and mafic bodies, which have been investigated from different points of view (e.g., Clemens et al. 2006). Some of such studies investigate such acid and basic rocks from magmatic point of view (e.g., protholiths for partial melting, magmatic fractionation, etc.). However, most TTG areas also show a metamorphic overprint, and the magmatism and metamorphism often occur within a narrow time interval. Multiple intrusions of the magmas may induce "autometamorphism" of already crystallized but similar country rocks. Because of large volumes of the TTG series, the possible temperature gradient did not occur as around single, isolated plutons. During this metamorphism low temperature partial melting may also occur alongside with small scale metasomatic changes related to potential fluid flow from crystallizing melts. The recognition of primary magmatic and secondary metamorphic changes is often ambiguous. Therefore, we present petrological and chemical data from migmatites, TTG gneisses and mafic and ultramafic bodies inside the TTG dominated area of the Frederikshåb Isblink area, SW-Greenland, in order to get insights into the interplay between basic and acid rocks in such areas.

Petrology data from garnet amphibolites constrain the condition of metamorphism of the mafic rocks in the amphibolite facies. The mafic rocks show systematic correlation between MgO and most other major elements (i.e. TiO_2, Al_2O_3, CaO), which is in accordance to magmatic evolutions. The large range of the MgO-content in this rock group (~4-19 wt%) include restitic compositions and intermediate material. The direct surrounding TTG gneisses are high-SiO_2 tonalitic rocks (SiO_2 content 65-74 wt%) and cannot be directly linked to the first described restitic rocks. In addition, local migmatites are present in the area, which are either related to an intrusive phenomena, partial melting and/or metasomatic processes. Possible intrusive development of the migmatites should be characterized by chemical mixing lines of the two rock groups (TTG versus mafic rocks). Major and trace elements exclude such processes for the migmatites. The local occurrence of leucosomes may reflect partial melting at water saturated conditions and/or metasomatic transport via a fluid. However, these processes are local (m-scale) as known from contact metamorphism. The use of such migmatites to reconstruct the genesis of TTG melts may lead to misinterpretation, if local metamorphic changes are played down.

Location of the study:

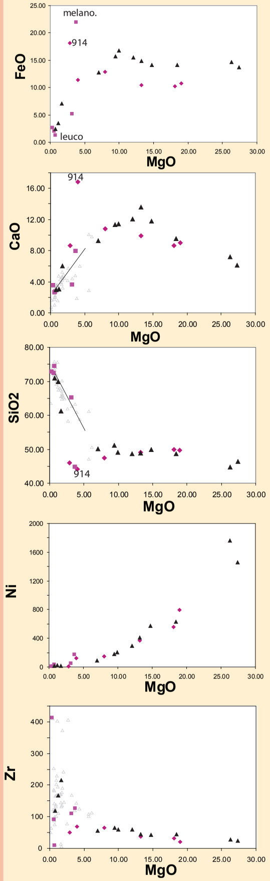
Geological map of the Frederikshåb Isblink area, including Dalager's Nunatakker. The main study area is on Saliaata Nunaa (red box). Sample locations are indicated.

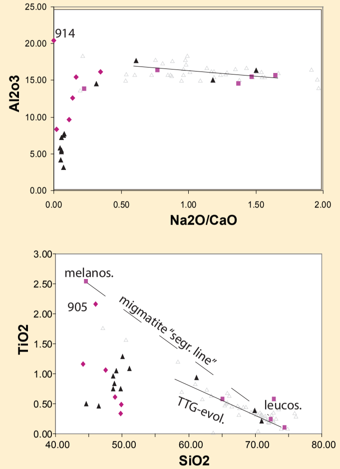


The ultramafic bodies are often lens shaped with diameters between several decimetres to several tens of meters

Local banded ultramafic bodies occur (see Figure below)

Some of these bodies are layered and their composition varies from more peridotitic (pyroxene and olivine) towards hornblendites.



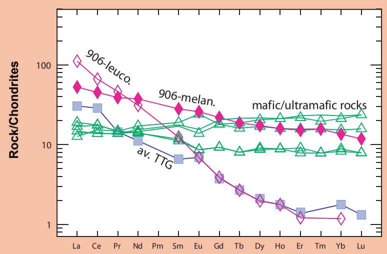


The main parts of the mafic to ultramafic samples show correlations between CaO-MgO. They have similar SiO_2 contents at highly variable MgO contents (see figures at the left). The MgO have a positive correlation with most transition metals (e.g., Ni, V, Cr) as expected for magmatic evolutions (see figure). The constant SiO_2 content excludes metasomatic origin for most of the investigated rocks, because the differences in chemical potential for Si is large and drives most of the metasomatism in blackwalls. With the exception of the migmatite sample (sample 906) and the metasomatic sample (sample 914), the other samples can be investigated as magmatic rocks.

The pyroxene rich rocks and the hornblendites have textural and geochemical characteristics to be part of the magmatic evolution. The TiO_2, Al_2O_3 and Ni content exclude the peridotite bodies as relics from mantle. The geochemical data and the textural data indicate relics of residues as developed in layered intrusions. The major elements evolution indicates a calc-alkaline type of fractionation (e.g., correlation diagrams MgO versus CaO, Al_2O_3 versus Na_2O/CaO). Some of the ultrabasic rocks represent the residue, whereas some of the metagabbros and amphibolites are part of the intermediate position along fractionation lines. The main (and often investigated) fractionation of the TTG series itself is not covered in this data set. Combining the data from the TTG in a larger area of SW Greenland and the ultramafic bodies, the ultramafic rocks can serve as residues of the magmatic process.

REE geochemistry

The REE pattern of the different samples can be clearly grouped in the ultramafic bodies and the TTG, but the two chemically altered samples (sample 914, 906 in the figure) differ clearly (see figure below). These compositions cannot be explained as mixing lines between these two rock groups 8see figure above). The metasomatic sample and the migmatite differ besides the major and trace elements, also in their REE pattern.



Conclusion:

The geochemical study of ultramafic lenses and their alteration zone indicates that some of these bodies related to primary magmatic fractionation processes. The ultramafic bodies can be interpreted as residues of a fractionation processes. This would coincide with REE patterns and REE concentrations. The melt contain the LREE, whereas the HREE are slightly enriched in the ultramafic bodies. Fractionation alone cannot explain all measured compositions and additional processes are necessary to understand the evolution of the TTG magmas (e.g., Clemens et al. 2010).

In addition, all rocks are overprinted by metamorphic processes, which include local metasomatism and partial melting. The role of partial melting is restricted to small areas, where water saturated conditions meet temperatures around 700°C. Except for the special locations of partial melting or metasomatic exchange, the ultramafic bodies will give insights into the magmatic evolution of the TTG.

The trace elements in local produced leucosomes differ from the major magmatic evolution. The potential combination of both processes produce varations in the overall compositions of the TTG.

References:
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