Kobbefjord geology

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Introduction

Kobbefjord is situated south of Nuuk and hosted in the geological province referred to as the Faeringehavn Terrane, which forms a 30km wide stripe of land extending from Quillangarsuit to the south to Ivisaartoq to the north. The Faeringehavn Terrane recorded a prolonged history spanning more than a billion year of the earth evolution from the Paleo Archean (ca. 3850 Ma) to the Neoarchean (ca. 2600 Ma) (Nutman and Friend., 2007). It consists of the Itsaq gneiss complex (Ca. 3850 – 3600 Ma) which is intruded by the Ameralik Dyke suite at ca 3260-3510Ma, and overlain by the Simutat supracrustal cover that consists of metamorphosed basalts and sedimentary rocks (ca. 2840 Ma). The whole rock package was successively deformed during at least two orogenic cycles referred to as the Tasiusarsuaq (ca. 2700 Ma) and the Kapisillit orgenies (ca. 2615 Ma) (Nutman and Friend., 2007). Rocks of the Faeringehavn are often referred to as granulite and or amphibolite metamorphic rocks. Metamorphism is the process by which the minerals or geologic texture (distinct arrangement of minerals) in pre-existing rocks (protoliths) changes without the protolith melting into liquid magma. It is often referred to as a solid-state modification of the protholith. The change occurs primarily due to heat, pressure as the rock formation gets buried following their deposition / emplacement. In the cases of the Faeringehavn Terrane, and due the various orogenic cycles that have affected the area the rocks have recorded multiple metamorphic events and attest of deep burial (substantial heating and pressure increase).

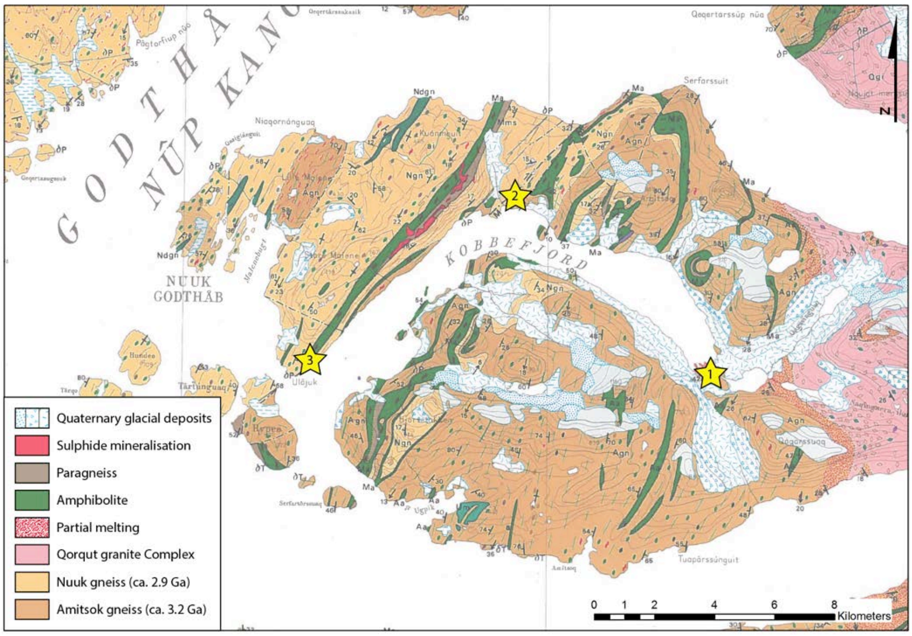

Figure 1: Geological map of the Kobbefjord locality. The yellow stars indicate the localities that were visited.

Geology around the Kobbefjord Greenland Institute of Natural resources field station (locality 1 on figure 1)

GINR Field station is localized at the end of Kobbefjord, which was build upon Itsaq gneiss complex. As mentioned above the Itsaq gneiss complex is the oldest component of the rock succession forming the basement in the Faeringehavn Terrane. Gneiss is the term that refers to the type of rocks formed by high-grade metamorphic processes from igneous or sedimentary protolith. Gneissic rocks are usually medium to coarse-grained and exhibit banding (gneissic banding) which developed under high pressure and high temperature conditions (figure 2). The gneissic bancs are also called compositional banding, because the layers, or bands, are of different composition. The darker bands have relatively more mafic (black) minerals (those containing more magnesium and iron). The lighter bands contain relatively more felsic (white) minerals (silicate minerals, containing more of the lighter elements, such as silicon, oxygen, aluminium, sodium, and potassium). Mineralogy of the gneiss in the Kobbefjord area is associated with quartz + plagioclase (both white or cream) and biotite (black mineral). In places large alkali feldspar maybe present giving the rock a eye texture commonly referred to as "augen gneiss" (Augen mean eyes in German) (Figure 2).
Upon close observation, the gneiss localized close to the landing point and along the shore line exhibit tight folding textures that are reminiscent of past deformation that affected the area (Figure 3).

Figure 2: Typical Itsaq augen-gneiss outcrop near the Kobbefjord GINR field station

Figure 3: Folded structure of the Itsaq gneiss attesting of intense deformation that affected the Faeringehavn Terrane.

As the temperature increases during the orogenic process and associated burial, rock may start to melt. Since not all the minerals forming a rock melt at once and that often only a portion of the solid rock is melted, the melting process is commonly referred to as partial melting. The resulting rocks recording such partial melting process and exhibiting both evidence for the presence of solid and melt are called migmatite (Figure 4). Near the Kobbefjord GINR field station, the gneiss exhibits migmatitic textures that are related to the partial melting of the Itsaq gneiss. Partial melting changes rock strength and density, and leads to the generation of a two-phase medium allowing melt–solid segregation as indicated in Figure 4.

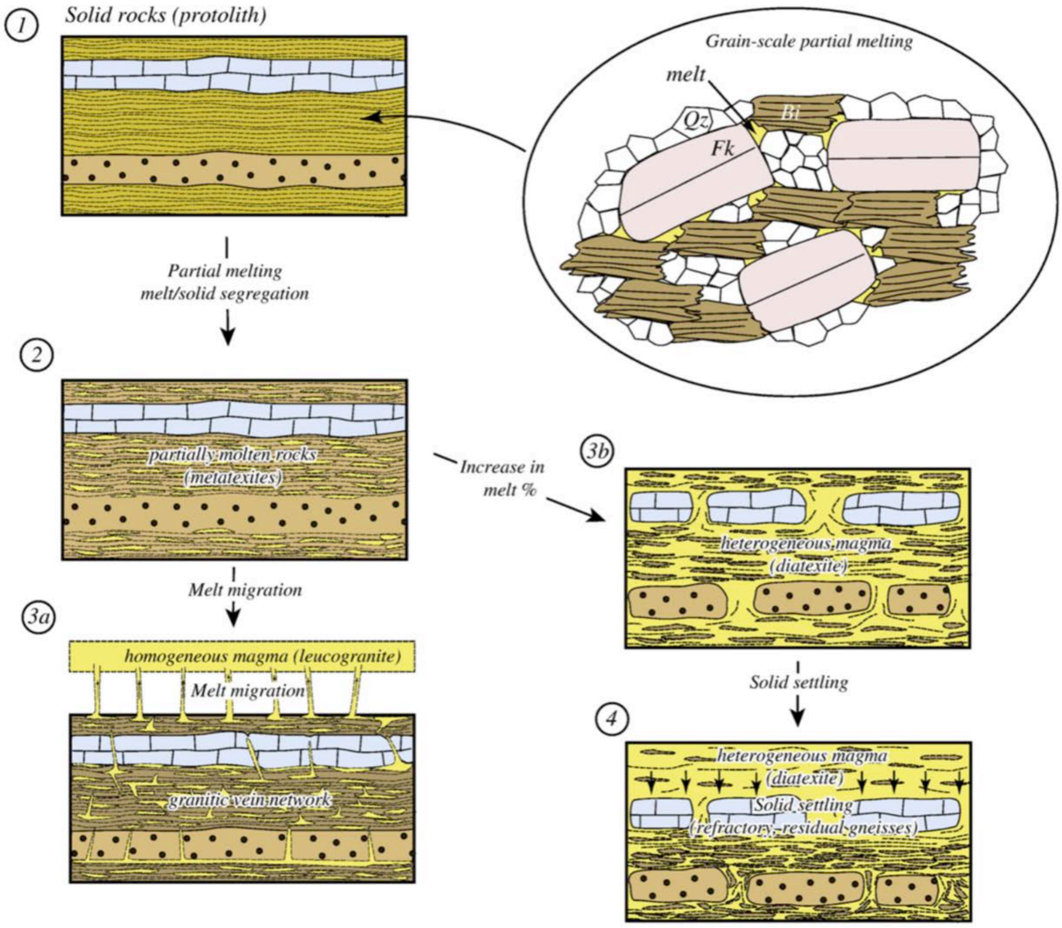

Figure 4: Model for the evolution of the melt/solid two-phase system during partial melting addressing melt migration and solid settling. 1. Partial melting of a solid rock leads to a melt phase trapped along rock-forming minerals. 2. Melt segregation at the grain-scale is permitted by melt connectivity between melt pockets and leads to the formation of granitic veins. 3a. Melt migration, allowed by melt connectivity beyond the grain-scale, leads to the formation of laccolithic leucogranites. 3b. In case of inefficient drainage of the partially-molten rock, partial melting proceeds beyond the partially-molten rock/magma transition. 4. Solid settling in the magma is associated with the accumulation of refractory solids leaving a more differentiated magma. (From Vanderhaeghe, 2009)

When describing migmatite, geologists commonly talk of leucosome (white bands or melt segregations) and melanosome (black bands or restite). At the macroscopic scale, one can observe the leucosome bands or melt segregations connecting to larger domain that are transecting the original gneiss banding but also injecting in between gneissic bands (Figure 5). As the leucosome is collected and becomes prominent and homogeneous it eventually give birth to a new rock, which is often of granitic composition. Such melt collection and accumulation is obiquitous in the western most point of the Kobbefjord shore line near the GINR field station where granite outcrop occur in direct contact with the migmatitic Itsaq gneiss (Figure 6).

Figure 5: Field photographs showing the partial melting of the Itsaq gneiss. (left) injection of melt within the gneiss banding.

Figure 6: Granite outcrop on the west point slightly south of the landing area showing the granite melt accumulation directly in contact with the migmatitic Itsaq gneiss.

The partial melting as recognized in the Kobbefjord GNIR field station remains undated but it is likely to be associated with the major thermal event leading to the formation of the Qôrqut granite complex (ca. 2560 Ma) at the end of the Kapisillit orogeny (Nutman and Friends 2007).

Geology on the northern and westernmost shore of Kobbefjord (locality 2 and 3 on figure 1)

In these areas, the Simutat supracrustal cover that overlay the Itsaq gneiss can be observed. The Simutat cover is dominated by fine strips of metamorphosed igneous rocks (such as basalt), called amphibolite, and metamorphosed sedimentary rocks (such as sandstone, limestone, etc…) (Figure 1). The metavolcanic and metasedimentary rocks forming the supracrustal cover in the Archean are commonly referred to as greenstone belts. The amphibolite unit consists of fine grain migmatitic mafic rocks whose mineralogy is dominated by hornblende, plagioclase, (± garnet, clinopyroxene, biotite and quartz; Figure 7 and 8). Accessory minerals such as clinopyroxene and garnet are marker of specific metamorphic conditions and can be used to reconstruct the temperatures and pressures that affected the protholith as it went through burial (geologists talk of prograde path) and exhumation (geologists talk of retrograde path). Prograde path refers to the increase of temperature and/or pressure, whereas retrograde path refers to the decrease of temperature and/or pressure. Rocks from the Kobberfjord greenstones as presented in Figure 7 (top) for example show plagioclase coronas (white mineral) around the garnet crystals (red minerals) indicative of retrogression through decompression (exhumation), lowering of pressure. In the leucosome shown in Figure 7 (bottom) however, clinopyroxene and plagioclase (± quartz) are retrogressed into hornblende indicate that the temperature remained quite hot (~800°C) during the exhumation process.

Figure 7: left) Garnet-rich amphibolite. right) Boudinaged leucosomes showing clinopyroxene (green), plagioclase (white) surrounded by hornblende (black corona).

The paragneiss unit of the greenstone, is generally fine grained and consists of quartz-plagioclase-hornblende-biotite-garnet ± sillimanite ± cordierite (Figure 10). The paragneiss can sometimes conserve their primary sedimentary features such as their original bedding planes. However, in Kobbefjord the paragneiss are often strongly deformed and foliated and associated with a quartz-biotite-sulphide-(garnet) alteration, either pervasive or presenting itself as veins (Figure 10). The sillimanite and cordierite found in the paragneiss are used as low to medium temperature indicator minerals.

Figure 8: Folded migmatitic amphibolite from locality 3. Looking to the north.

Figure 9: Fine grain quartz-plagioclase-hornblende-biotite-garnet-sillimanite-cordierite paragneiss. Note that the photograph was taken in Bjornoen Island

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