Intracrustal partial melting of garnet amphibolite from southwestern Sweden – a possible analogue for TTG formation

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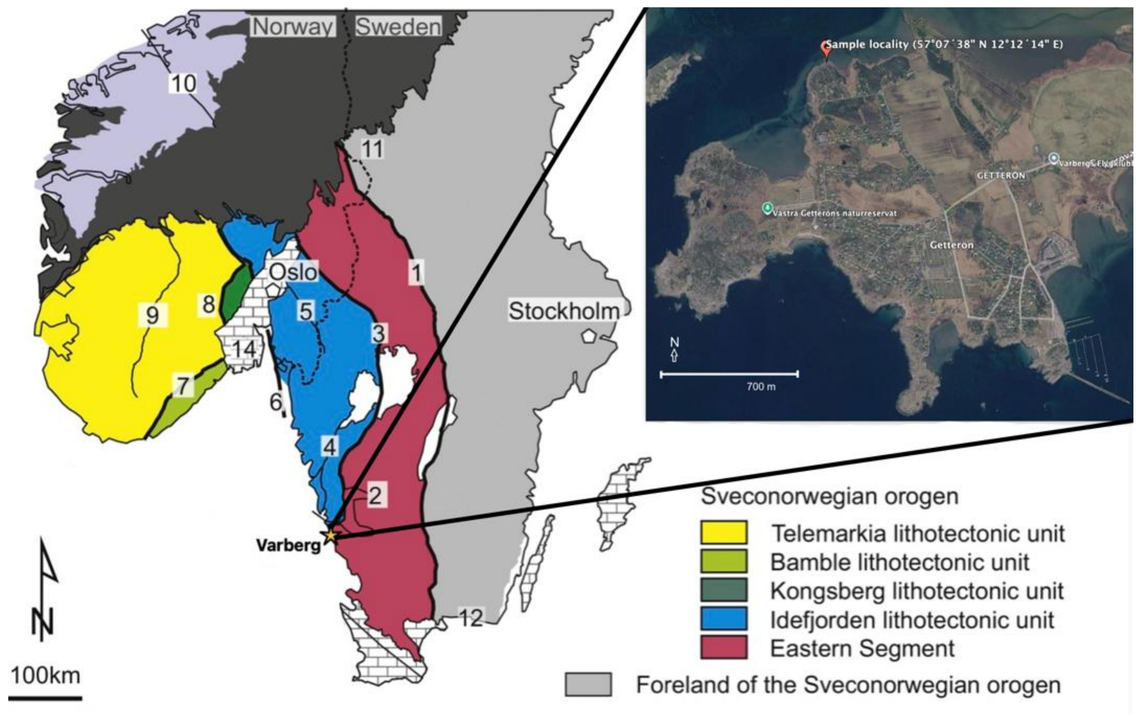
Introduction

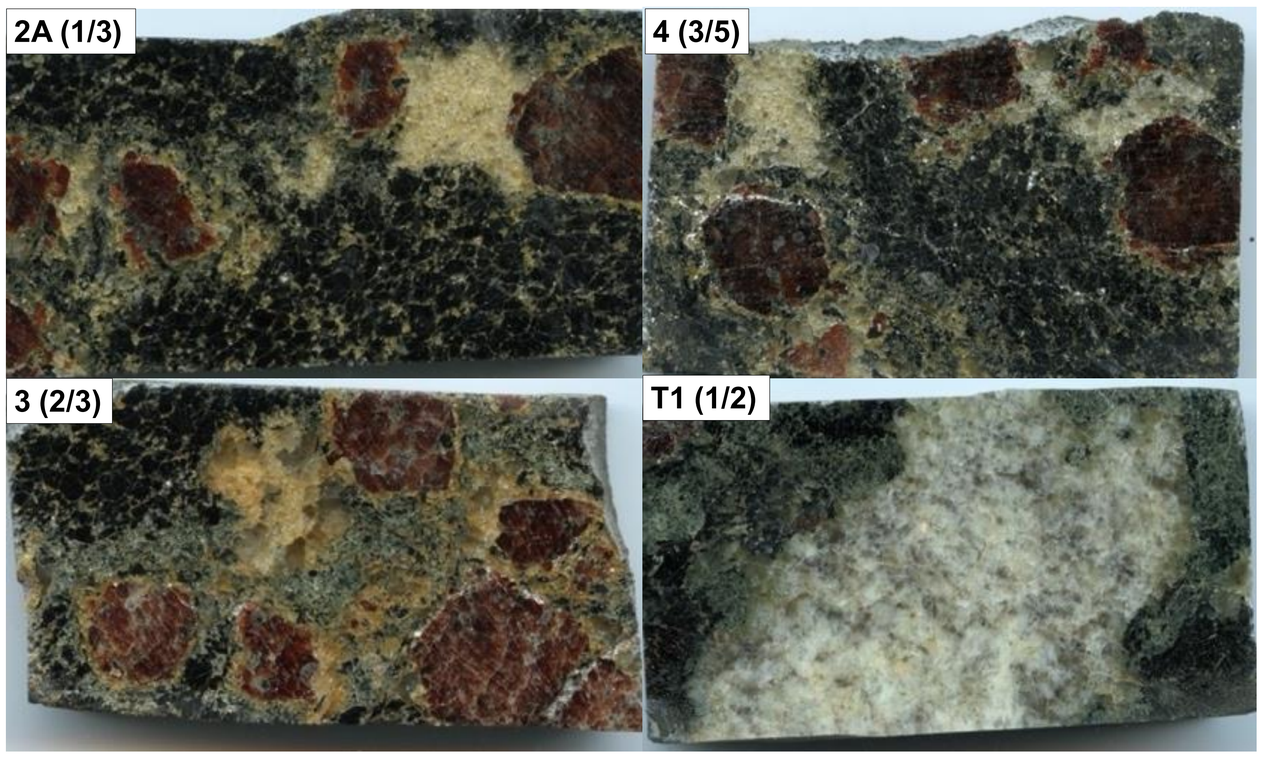
The purpose of this study is to increase the understanding of how the rock suite tonalite-trondhjemite-granodiorite (TTG) can form. It is based on a garnet amphibolite from the Eastern Segment of the Sveconorwegian orogeny, with quartz and plagioclase areas that are thought to be the result of partial melting and resemble TTG in composition. TTG makes up a large part of the Archean continental crust, which is the oldest preserved continental crust found on Earth today. Quartz and plagioclase are the dominating minerals of TTG rocks, that are characterized by high SiO_2, high Na_2O, and low K_2O. TTG rarely form today which have led to an uncertainty around their origin.



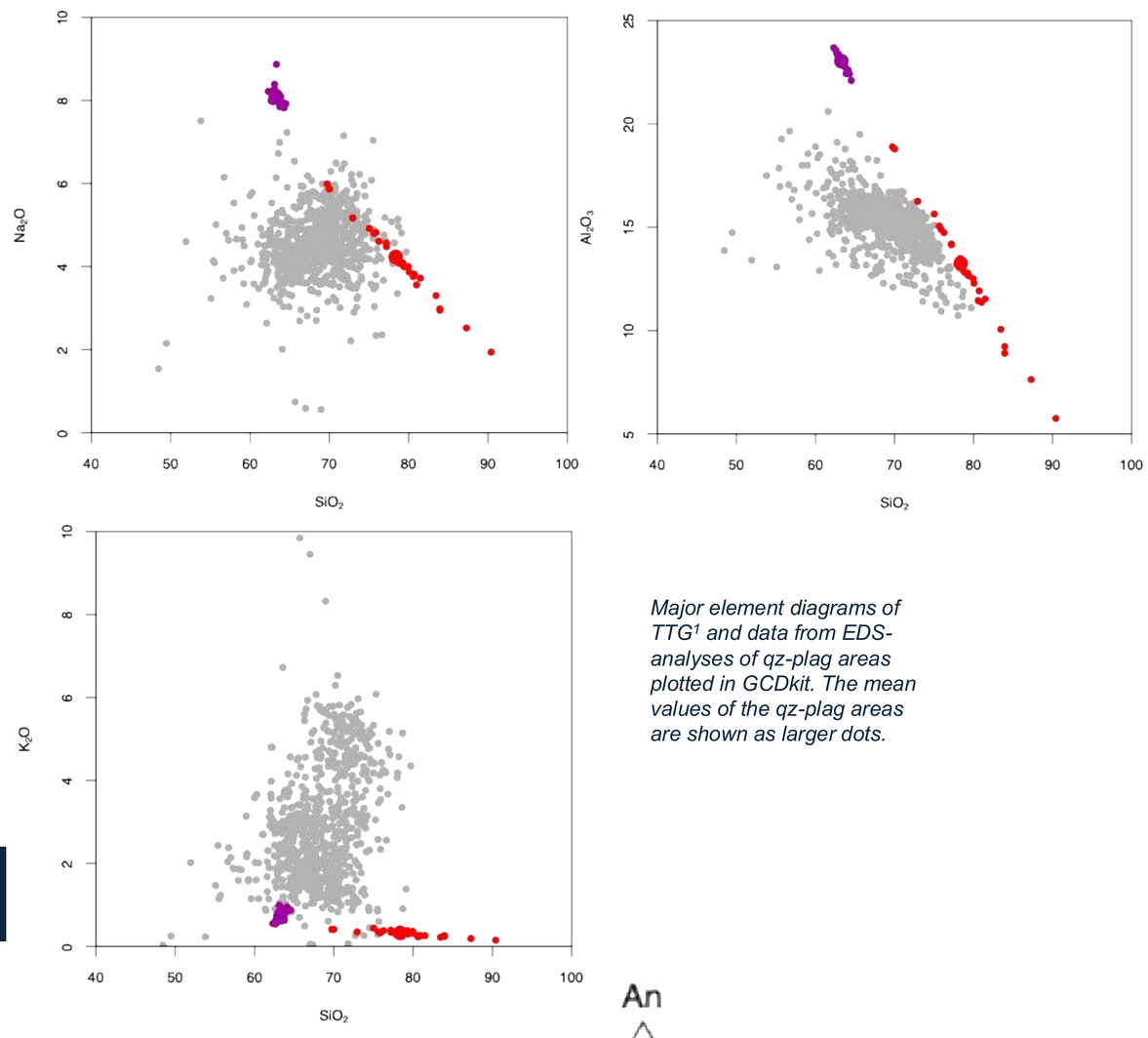
Regional division of the Sveconorwegian belt with the sample locality Varberg marked out (modified after Bingen et al., 2021). Additional map over Getterön with sample locality marked out (retrieved from Google Earth Pro v7.3.7.).

Methods

Two rock samples collected at Sillhallsvik on Getterön, Varberg were examined - a garnet amphibolite and a melt accumulation vein. Petrographic studies and chemical analyses of the rock were carried out through scanning electron microscopy (SEM) coupled with energy dispersive spectroscopy (EDS). Multiple 2000x2000 μm areas were marked out in the quartz-plagioclase areas and amphibolite matrix to determine average element composition of the domains and point analyses were used to identify minerals.



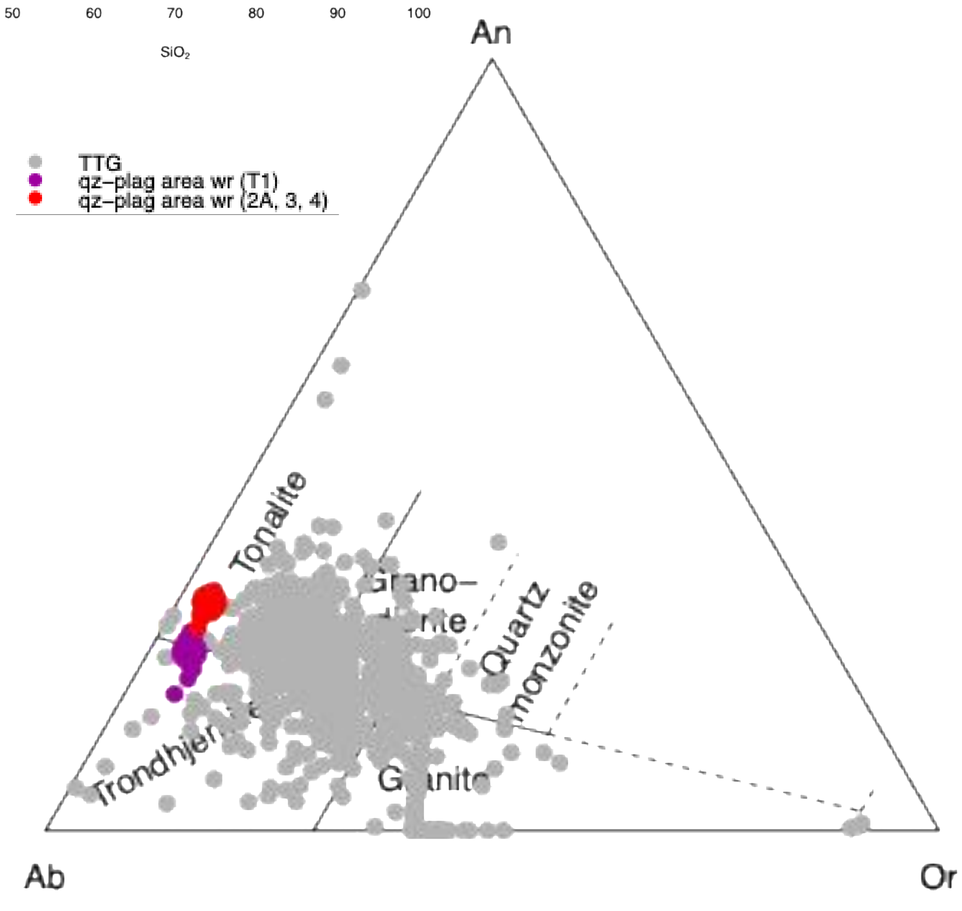
Scanned 45 x 25 mm sections of the garnet amphibolite (2A (1/3), 3 (2/3) and 4 (3/5)) and melt accumulation vein sample (T1 (1/2)).



Major element diagrams of TTG[1] and data from EDS-analyses of qz-plag areas plotted in GCDkit. The mean values of the qz-plag areas are shown as larger dots.

Results & Interpretations

Analyses of the quartz-plagioclase areas show a high SiO_2 (>70 wt. %), high Na_2O (2.0-6.0 wt. %), and low K_2O (<1.0 wt. %). The quartz-plagioclase areas are commonly distributed along sides of garnet porphyroblasts but also occur isolated in the amphibole matrix. This together with the presence of hornblende inclusions indicates that the areas were not formed through element depletion as the garnet crystals grow. The amphibolite matrix is largely dominated by hornblende and plagioclase, but variations occur with finer grained clinopyroxene bearing areas. These could be the result of dehydration melting where hornblende breaks down to clinopyroxene with the release of water that triggers liquid to form. Melting experiments has shown that this process begins at 850 °C at a pressure of 10 kbar. The presence of garnet and absence of epidote further indicates temperatures above 800 °C and pressures over 10 kbar.



Normative feldspar diagram of TTG[1] and data from EDS-analyses of the qz-plag areas plotted in GCDkit. The mean values of the qz-plag areas are shown as larger dots.

Conclusions

- Observations of the quartz-plagioclase areas and variations in the matrix corroborates the assumption that the rock has been through partial melting.
- The presence of garnet, absence of epidote and the clinopyroxene bearing areas in the matrix, indicates temperatures above 850 °C and pressures over 10 kbar.
- The mineral assemblage and major element composition of the quartz-plagioclase areas confirms that they correspond to K-poor tonalite and that they are comparable to TTG.
- Based on conditions that affected the area during the Sveconorwegian orogeny, the results suggests that TTG-melts could be generated through intracrustal partial melting of garnet amphibolite and without the need of an extensive subduction zone.

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References
[1]TTG data is composed of 172 trondhjemite samples, 304 tonalite samples and 277 granodiorite samples (Data were downloaded from the GEOROC database (https://georoc.eu/) on 1-2 April 2026, using the following parameters: geological setting = Archean Cratons).