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Report on the dissertation thesis presented by the student Tereza Zelinková

To whom it may concern,

I hereby, Prof. Silvio Ferrero, present my report on the dissertation thesis with title "Record of metamorphic and metasomatic processes at the contact of felsic granulites and garnet clinopyroxenites in the Bohemian Massif", presented by the student Tereza Zelinková for the Study programme Geology, Faculty of Science at the Charles University in Prague (Czech Republic). I declare that there is no bias against or conflict of interest in relation to the author of the work.

The PhD thesis of the candidate Tereza Zelinkova is a very nice and extremely thorough petrological study of some very intriguing, and yet classic, high grade metamorphic rocks coming from the renown Gfohl unit of the Moldanubian Domain in the Bohemian Massif. The scientific problem tackled in the work is the metasomatic interaction between mantle rocks and continental crust involved in orogenic processes. The work has been thoroughly done, and the thesis combines a very detailed and yet extensive petrological study with a

more targeted mineralogical investigation, which appears clearly necessary given the peculiarity of some of the phases found in the rocks, and with whole-rock geochemical investigations.

The approach used by the candidate is very interesting and rigorous, targeting the metasomatic process at remarkably different scales – from single poliphase inclusions preserved in garnet, to structures visible at the centimetric scale and finally at the scale of the bulk rock taken on several kilos of rocks. Such a progressively larger, and yet very detailed work is an excellent example of how an ambitious work on metasomatism should be done. The analytical methods used in the project are appropriate, cutting edge and perfectly suited for the task at hand. They include include several analytical techniques, among which electron microprobe and thermal-ionization mass spectrometer, along with targeted thermodynamic modeling to calculate phase equilibria and chemical potentials in the targeted rocks and between them. The candidate has moreover devised new strategies to solve the several scientific problems which appeared along the way by combining classic petrological approaches of microstructural investigation and geochemical quantification in novel ways.

The thesis is really nicely written, with appropriate terminology and it reads very well – my compliments to the candidate. This is an aspect that sometimes is left unsaid, but writing in correct and proper English is fundamental in order to ensure the appropriate dissemination of scientific work. As a non-native speaker myself, I know how hard is to produce something of this level, and I thus commend the candidate for the great job done. Few very minor typos are present here and there, something unavoidable on a product of this breadth and length.

In conclusion, the presented dissertation thesis is an excellent product which, in my opinion, entirely fulfils the criteria for doctoral theses. I therefore recommend it for defence in order to award the doctoral title to the candidate.

Comments and questions

Below I report some observations and questions regarding the work done during the implementation of the project. My research focus lies in microstructures and deep fluids trapped as inclusions, and therefore the part I and II of the work are the ones which stimulated the most observations and comments – hopefully constructive.

Primary vs secondary nature of the investigated inclusions

One thing I noticed missing from the work is a visual documentation of the structures at the polarized light optical microscope. It is true that the work has achieved splendid results with straightforward 2D imaging and elemental mapping at the electron microscope. However I feel compelled to point out that the study of 3D objects such as the multiphase solid inclusions (MSI) targeted in the first part of the thesis (and already published in the 2023 paper in American Mineralogist) would benefit immensely by the preparation and investigation of the doubly polished thick sections used for fluid inclusion investigation. Indeed, I suspect that the use of these type of sample preparation would actually reveal that the "chain" arrangement of the inclusions (the most appropriate terms would be "trails of secondary inclusions", as per classic literature as Roedder, 1984), interpreted to be former cracks now almost entirely annealed, in 3D observation most likely will correspond to a simple cluster arrangement. In the latter case, such distribution would tell us that the very same fluid was trapped during garnet growth. This is important in terms of interpretation, as (a) if they are secondary the fluid postdate the garnet formation (as correctly stated in the work), (b) if they are primary, that fluid then was present during the same metamorphic event responsible for garnet (and clinopyroxene?) formation. This does not change much the final point – that the inclusions contain a very peculiar fluid present at depth during formation of these rocks.

Going forward: can we measure/estimate the bulk composition of the original melt/fluid present in the inclusions?

In the thesis it is stated that generally the MSI found in garnet have a variable phase assemblage. This could be an effect of studying 3D objects on a 2D surface such as a thin sections, the common approach of a metamorphic petrologist. This approach is correct for classic rocks, but when it comes to objects much smaller in scale than a thin section, this may result in polycrystalline inclusions showing very different mineral associations when instead they are actually identical in phase assemblage. This is simply due to the fact that each inclusions can be approximated to a sphere containing a strongly heterogenous material, and each one of these object is cut absolutely randomly by the preparation surface, thus exposing different portions of the phase assemblage within and therefore resulting in apparently different inclusions. This is what myself and my collaborators have observed in countless case studies of nanogranitoids in garnet. The only way to overcome the 2D limitation is to investigate a statistically reasonable amount of MSI below the sample surface with MicroRaman spectroscopy in a doubly polished thick section as mentioned above. This would clarify immediately whether the original fluid is the same throughout the different MSI or not.

Building upon these results, one could then come even to estimate with a certain degree of precision the bulk composition of the original fluid/melt. A corollary to the aspect discussed above is the trace element (TE) cargo of such fluid. One very intriguing evolution of the study could be to analyse with LA-ICP-MS the MSI in order to calculate the TE signature of the fluid as well as the partition coefficients of those elements at the P-T-X conditions of formation. This is just food for thoughts. It must be pointed out that MicroRaman investigation, LA-ICP-MS and data interpretation would require a significant amount of work, quantifiable in many months, so please regard this as a hopefully useful suggestion for further work on the topic.

Nanogranitoids in the host Ky-bearing and intermediate granulites

Perusing the nice pictures of the thesis I noticed the presence of possible nanogranitoids in many different garnets in the St. Leonhard granulite massif, as well as at Dunkelsteinerwald - even if the picture itself generally did not have necessary resolution to resolve them. We know that similar felsic granulites in the Polish Sudetes (Ferrero et al., 2015) and in the Granulitgebirge of the Saxothuringian zone (Ferrero et la., 2018) often contain these kind of inclusions. As the melt is one of the players likely responsible for material transfer in and out of the rocks investigated here, having data (major and traces) on the anatectic melt in these rocks would be very interesting in terms of mass balance of the reactions taking place in this setting.

These are all my observations and comments for the moment. Thanks for the opportunity to evaluate this excellent dissertation thesis.

My very best regards,

Prof. Silvio Ferrero