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Prof. Ing. Shah Wali Faryad, CSc.
předseda komise pro obhajobu disertační práce doktorského studijního programu Geologie
Přírodovědecká fakulta UK
Albertov 6
128 43 Praha 2

Vážený pane předsedo,
na základě Vašeho dopisu ze dne 20.11.2024 o mém jmenování oponentem zasílám posudek disertační práce Mgr. Terezy Zelinkové.

Se srdečným pozdravem,

Prof. Jiří Konopásek, PhD.
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Assessment of the PhD thesis „Record of metamorphic and metasomatic processes at the contact of felsic granulites and garnet clinopyroxenites in the Bohemian Massif" submitted by Mgr. Tereza Zelinková

The PhD thesis of Mgr. Tereza Zelinková presents her research on granulites and mantle xenoliths of the St. Leonhard and Dunkelsteiner Wald massifs in the Moldanubian domain of the Bohemian Massif. The thesis consists of an introductory part summarizing the scope of the PhD project, geological setting of the studied granulite massifs and basic petrological characteristics of the studied rocks. In this chapter, the candidate defined the following objectives of the work:

- to assess the possibility of a metasomatic interaction between the garnet clinopyroxenites and the host felsic granulites at varioust scales,
- to develop a new genetic hypothesis for the origin of the transitional granulite types at their contacts

Another topic, though not mentioned in the objectives of the thesis, is the study of mineral phases enriched by elements of crustal origin which point at interaction of subcrustal mantle with subducted continental crust.

The body of the thesis consists of four chapters that summarize the results of the work. I appreciate how the thesis is built, starting from micro-scale studies of mineral inclusions in mantle rocks enriched by Ba and Cl, continuing with thin section-scale observations of metasomatic interactions between granulite hosts and mantle xenoliths and ending with assessment of metamorphic conditions and possible metasomatic interactions at the scale of hand specimens up to larger samples collected for whole-rock geochemistry.

The results presented in the first two chapters are published in internationally recognized journals, which means that they already went through an independent review process and their acceptance justifies the quality and credibility of the results. Though these chapters still show some problems that I will point out below, I would like to congratulate the candidate to those two publications – one in American Mineralogist and the other in Journal of Petrology.

The other two chapters present research intended for another article, as I understand not yet submitted. I will spend some more time with these two chapters (see below), as there is in my opinion still room for improvement, especially when it comes to the presentation of the results.

The language of the thesis is good and there are only minor issues which in most cases do not hamper understanding of the text.

Comments to individual chapters and possible topics for discussion:

Part I – Ba-Cl rich mineral phases in studied garnet clinopyroxenites – an evidence of metasomatizing fluid/melt

Results presented in this chapter were published in 2022 in American Mineralogist. It is somewhat unfortunate that the petrographic description of the samples used in this study is not presented. Instead, the readers are directed somewhere in another part of the thesis (Part III) or even to the published article.

Is some cases, the text refers to features that the reader is not able to assess, because corresponding figures are missing. It is mainly the reference in section 3.4 to non-existing correlation of the presence of multiphase inclusions relative to garnet chemical zoning (which is not presented), or to lack of correlation of Ti with Si and Al, positive correlation of XFe_{tot} with Al and a negative correlation of XFe_{tot} with K and Si (section 4.1). At the end of the section 4.1 and after the first sentence of section 4.2 there are missing references to existing diagrams.

Question for discussion: **At the end of the section 4.4 it is written: "*The micas with compositions close to chloroferokinoshitalite and oxykinoshitalite are therefore effectively anhydrous and the A position is completely occupied with Cl or O. This indicates low H2O activity in the metasomatizing fluid or melt, the composition of which may be regarded as silicocarbonatite.*" Do you envisage a fluid with such an extreme (low H2O content) composition? Is it possible that the H2O in the existing fluid was fractionated somewhere else?**

Part II – Metasomatic interaction of ultramafic mantle xenoliths with their felsic HP–UHT granulite host in St. Leonhard granulite massif

Results presented in this chapter were published in 2024 in Journal of Petrology. With respect to this chapter, I have one question for discussion and one comment.

Question for discussion: **In your discussion of differences in chemical potentials of various system components you use the calculated values for already modified chemistry of the garnet pyroxenite, as well as the composition of the opx-bearing granulite, which (if I understand it correctly) should be metasomatically modified felsic (ky-bearing) granulite. And you discuss the chemical potential values at PT conditions of supposed equilibration of those two "chemical systems". Aren't you comparing those two systems at conditions, when the diffusional exchange of the components has actually stopped (as might be seen from (nearly) zero difference in μ for SiO_2, TiO_2 and perhaps also MgO and CaO)?**

Comment 1: I am afraid that your table II.6 (*Restoring the hypothetical composition X0 of the Ky-bearing granulite…)* contains incorrect entries. In any case, the method of how you arrived at the values presented in column 6 is not explained and there is only a reference in the text that says: "The procedure of X0 composition calculation is summarised in Table I. 2.." (should be Table II.6). Unfortunately, the table is not self-explanatory and the calculation method deserves some description. If I am right and the table is not correct, then you should consider publishing an erratum, as the table appears with the same entries in the published article.

Comment 2: Diagrams in Fig. II.14 (also in Fig. S.4) are missing units for the components presented on the axes.

Part III – Indications for the possible metasomatic origin of intermediate and mafic granulites at the contact of garnet clinopyroxenites with felsic HP–HT felsic granulites (Dunkelsteiner Wald granulite massif)

This part presents description of altogether 16 samples of granulites, pyroxenites and peridotites and brings large amount of microstructural and compositional data for mineral associations of individual samples collected in the Dunkelsteiner Wald massif. Although I understand that PhD thesis is a good repository of data obtained during the work on the project, such large amount makes this particular chapter somewhat heavy reading, and I believe that the candidate

understands that it can never be published in an article in such extent. Luckily, only one representative sample was selected from each sample group for the follow-up modelling of metamorphic conditions.

My comments to the modelling part of this section of the thesis are as follows:

1) Each description of the modelling results starts with a statement that there is an assumed mineral assemblage that represents peak metamorphic conditions. This however contrasts with the petrographic descriptions of the samples which never interpret relative timing of appearance of the various mineral phases. So, my question would be, whether the "peak mineral assemblage" is estimated from petrographic observations, or rather from the stability field where the garnet core isopleths cross.
2) The PT pseudosections are always contoured only by isopleths for the garnet compositional variables. However, each modelled sample also contains some other solid solution phases (Kf, Plg Cpx, Opx) however the match/mismatch of their composition in the stability fields for assumed mineral assemblages to which they belong is never mentioned. I know from my own experience that a mismatch of the observed vs. modelled mineral composition is often observed for at least some of the mineral phases, however it would be honest to report it (see e.g. Percival et al. 2022 in Tectonics or 2023 in JMG, or Battisti et al. 2024 in Int. J. Earth Sci.).
3) Some of the samples have a great potential for more detailed investigation of post-peak metamorphic evolution. Here I mean the various symplectitic microstructures (containing spinel, garnet etc.) in the matrix of some of the samples. Assessment of stabilization conditions of these mineral assemblages appearing in microstructural positions with limited equilibration volume would further enhance the petrological description of post-peak metamorphic evolution of the samples.
4) First sentence in section 2.5 P–T modelling of garnet clinopyroxenite (sample DS072C) mentions kyanite, which is neither mentioned in the petrographic description nor appears in the calculated PT diagram.

Section 3 (Zr in rutile thermometry) should start with description of how the Zr concentrations were obtained and what were the analytical conditions. Did you use electron microprobe with long counting time for each analysis? Or were the concentrations measured by laser and ICP–MS?

In section 4 (Ternary feldspar thermometry), in the first paragraph we read that "The reintegrated compositions of perthite … were used to confirm the estimated matrix metamorphic temperatures obtained from P–T pseudosections…" However, in my understanding the matrix already re-equilibrated during post-peak metamorphic process(es). So, in my opinion the perthite/antiperthite re-integration should provide an independent assessment of the temperature at metamorphic peak (which they do). The last sentence of the same paragraph does not make sense.

In the Discussion in section 5.3 the candidate discusses ambiguity in interpretation of the P–T evolution of the intermediate granulite sample DS071B. As mentioned above, one of the problems here may be that the calculated PT pseudosection was contoured only for garnet compositional variables. Maybe the composition of the clinopyroxene inclusions could help in solving this ambiguity?

Part IV – Geochemical characterization of granulites, garnet clinopyroxenites, and peridotites from Lower Austria

As I am not a specialist in the whole rock geochemistry, I am not entirely sure whether my comment will be appropriate. However, while reading this part of the thesis I had a feeling that the geochemistry of the various felsic to ultramafic lithologies confirms some degree of their mixing as a whole, by which I mean that one endmember is fully assimilated to various degree by the other. This is however a process very different from solid-state (or melt/fluid-assisted) diffusion of selected elements in a compositionally binary environment, where different concentrations of elements create differences in chemical potential as a driving force for diffusion. If I understand it well, then the conclusion from part 2 was that it is mainly the movement of CaO, Na2O and K2O that led to the formation of intermediate granulite as a result of interaction between the garnet clinopyroxenite and felsic granulite while TiO2 and SiO2 were considered as immobile. So, my question is whether the method used in part IV really can say something about "the degree and mechanism of possible metasomatic interaction between felsic granulites and garnet clinopyroxenites, presumably leading to the formation of intermediate and mafic granulites" (from the introduction to this section in the thesis). Especially the binary mixing test presented in the section 3.2 seems to me inappropriate to address the goal of this study.

I would like to discuss this closer during the defence, because I have a feeling that the results of the part II and part IV actually exclude one another.

Final assessment:

I would like to emphasize that my comments to the content of the parts III and IV do not lower the overall quality of the presented thesis. The candidate presented a large amount of work to evaluate metamorphic evolution of, and metasomatic interaction between, granulites and xenoliths of mantle rocks in the St. Leonard and Dunkelsteiner Wald massifs. Two articles were already published as a result of the PhD project and my comments to the parts III and IV should be seen as suggestions for improvement/completion of the work before these last two parts of the thesis will be submitted in form of a manuscript to some scientific journal.

It is thus my pleasure to suggest the committee to accept the thesis of Mgr. Tereza Zelinková for the defence.

In Prague, 09.12.2024

Prof. Jiří Konopásek, PhD