Dear Mr. Massonne!

Thank you very much for the encouraging review. Your critical comments contribute to the quality and clarity of the paper, and are acknowledged accordingly.

In the following pages you will find your comments given in black color. My response to every comment is given in blue color. The text of the paper is given in two columns, italic typeface and blue color. The original text is on the left column, the modified one on the right.

I hope, I have responded satisfactorily to your critical comments.

With best regards

K. Petrakakis

Review of the manuscript "Ca-rich garnets and associated symplectites in mafic peraluminous granulites from the Gföhl Nappe System, Austria" by K. Petrakakis et al., submitted to Solid Earth

General comments: The authors present a petrological study on a mafic granulite from the southeastern Bohemian Massif. The study of this rock is very detailed as the authors considered also, for example, the various symplectites in the granulite and the application of modern thermodynamic modeling techniques. Because of that the derived exhumation path in terms of pressure-temperature conditions is well documented. Thus, previous works proposing high peak-temperatures in the range around 1000°C for the granulites of the Gföhl unit seem to have overestimated these temperatures.

In summary, I would like to see the manuscript published soon after minor revisions.

Specific comments:

page 3, line 12: batholith?

No, it is wrong; replaced with “Pluton”, thank you.

page 5, lines 6-7: "but at much lower pressures of >4.5 kbar" - I am not sure which pressure range is addressed by the authors. My suggestion: "but at pressures between 4.5 and 6.5 kbar".

The original formulation is indeed not clear, thank you. It is replaced as shown below.

The Ostrong Nappe System differs distinctly from the other Moldanubian nappe systems. It shows similar anatectic temperatures of c. 720 °C, but at much lower pressures of >4.5 kbar. Based on rare relics of kyanite and staurolite, the rocks had attained a prograde maximum at <600 °C and c. 6 kbar before anatexis (Linner, 1996).	*The Ostrong Nappe System is similarly anatectic, but differs distinctly in terms of pressure from the other Moldanubian nappe systems (Linner, 1996). Based on rare relics of kyanite and staurolite, the rocks had attained a prograde maximum at temperatures <600 °C and pressures of ~6 kbar. Subsequent anatexis took place at ~720°C and pressures not less than 4.5 kbar.*

page 13, line 10: kelyphitized?

My wrong formulation! Sentence replaced as shown below.

It is noteworthy that the whole garnet is keliphitized along the rim (cf. Fig. 2g) and, ….	*It is noteworthy that the garnet is replaced by keliphite along its rim (cf. Fig. 2g) and, ….*

page 15, line 20: "GRT-type extends" - which garnet type?

My sloppiness! Reformulated and (hopefully) better explained as shown below.

Modal analysis of the phases in crack-symplectites (Fig. 4d, Fig. 5e) combined with their chemical composition showed that the bulk symplectite composition is almost isochemical with the GRT-type C. GRT-type extends beyond the diffusion profile shown in Fig. 5e acquired over a crack-symplectite. An analysis practically identical with GRT-type C and lying on this profile is \#974 (Supplement, Table S3).

Garnet profiles acquired over crack-symplectites (e.g. Fig. 5e) show that GRT-type C extends beyond the diffusion-affected part of the garnet. An analysis practically identical with GRT-type C and lying on this profile is #974 (Supplement, Table S3). Modal analysis of the phases in crack-symplectites (Fig. 4d, Fig. 5e) combined with their chemical composition obtained by microprobe analysis showed that the bulk symplectite composition is almost isochemical with the GRT-type C.

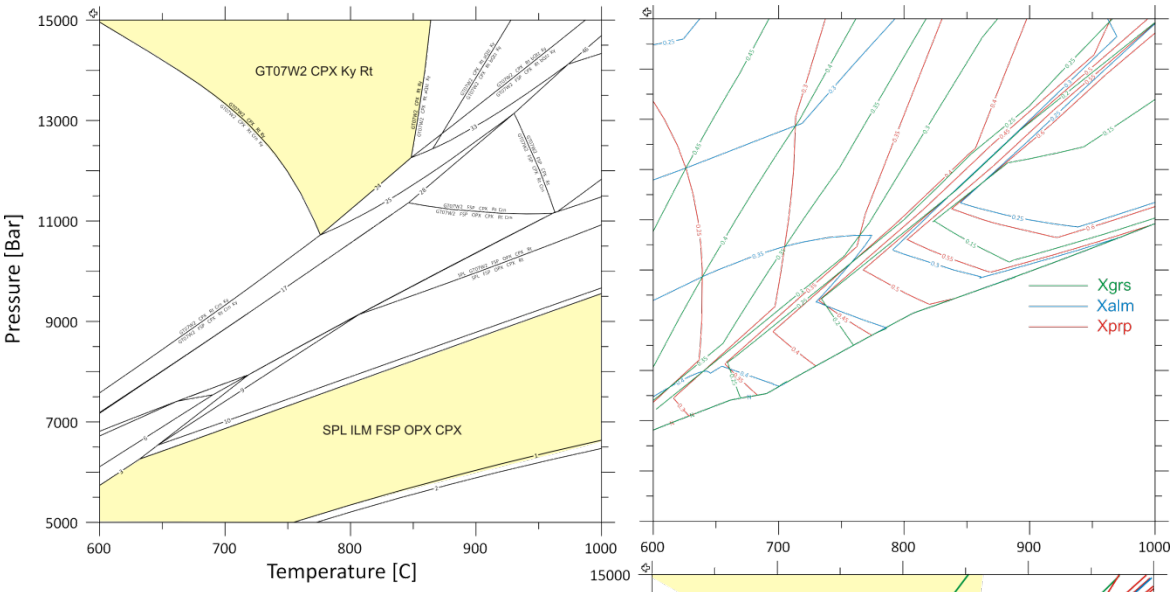
page 18, lines 13-14: "does a common intersection point ... exists, indication that none of the GRT-types corresponds to a preserved equilibrium state" - I agree that this statement is likely, but not compelling. But other reasons are also possible and should be mentioned here. Perhaps the selected solid-solution models (here especially garnet) could be not fully adequate. The authors did not test the selected models and did not achieve their pseudosection calculations with alternative solid-solution models. A further reason for the missing fit of the isopleths could be the used bulk-rock composition although I also think that it is very likely that this composition has not changed during metamorphism.

I fully agree with you that the absence of common intersection points of the garnet isopleths may be an artefact of the standard thermodynamic data and / or mixing models used. Let me follow you suggestion and focus on garnet.

The following figure is a re-calculation of the paper diagrams (Fig. 10) based on the widely used garnet data in the Thermocalc dataset tcds55_p07.

The two target assemblages GRT+CPX+Ky (primary assemblage) and CPX+OXP+SPL+PL (in crack-symplectites) are well reproduced (cf. Fig. 10). Expectedly, the calculated isopleths are somehow different. Nevertheless, the measured isopleths lack again any common intersection points for all GRT-types.

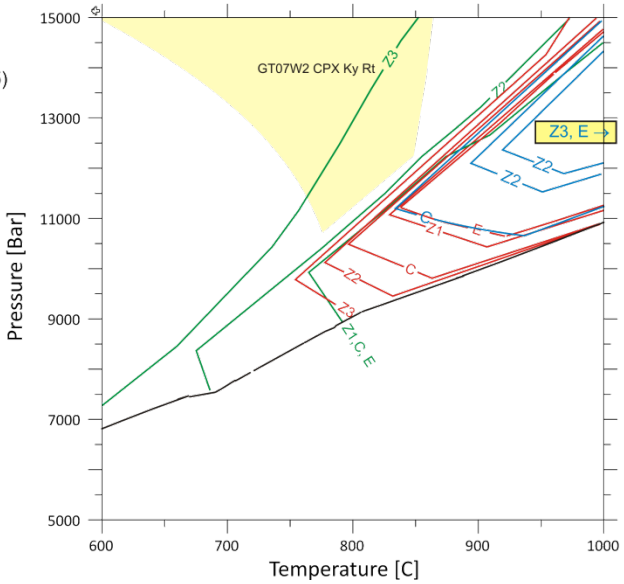
Now, it can be argued that also this garnet model is not fully adequate. This might be the case. I think that every model has its own problems. But, on the other hand, the usefulness and reliability of a model can be tested by its ability to reproduce the observed assemblages and microstructures, and the measured compositions of the minerals (not necessarily by calculated P and T that may be suitable or non-suitable to personal prepossessions). With the applied thermodynamic, the outcomes of the submitted paper model (cf. Fig. 10) are based not on thermo-barometric determinations of P and T, which imply equilibrium compositions of the involved phases, but on the reproduction of the target assemblages and, in case of the crack-symplectites, mineral compositions (Fig. 11 and Table 3). This is discussed also on page 20, lines 29- 34. The composition of CPX in the primary assemblage cannot be reproduced, because it has been reset. Such a resetting of CPX is frequently observed. Similarly, the garnet composition cannot be fully reproduced, because it has been modified, presumably by intra-crystalline diffusion and metasomatic alteration. Only GRT-type C shows a composition closest to an equilibrium composition pertaining to the low-pressure part of the stability field of the primary assemblage.



Bulk= SI(16.697)TI(0.057)AL(9.543)FE(1.058)MG(4.875) CA(6.336)NA(0.894)O(?)

Used garnet standard thermodynamic data and mixing model GT07W2 from the Thermocalc database tcds55_p07, as compiled for Theriak/Domino by Douglas K. Tinkham (http://dtinkham.net/index.html).

DKT is acknowledged for this precious work.



So, is the formulation in submitted paper justified? Taking account of your critical comment, I changed the formulation as follows.

Based on this figure [Fig. 10b] , *Fig. 10c shows the isopleths distribution for the observed GRT-types. For none of the GRT-types does a common intersection point of the isopleths for the measured Xalm, Xprp and Xgrs exists, indicating that none of the GRT-types corresponds to a preserved equilibrium state.*

Based on this figure [Fig. 10b] , *Fig. 10c shows the isopleths distribution for the observed GRT-types. According to the applied thermodynamic model, for none of the GRT-types does a common intersection point of the isopleths for the measured Xalm, Xprp and Xgrs exist. We consider this as an indication of perturbation of garnet composition from equilibrium.*

page 18, line 19: "some prograde" - better: "a prograde"

Yes, it is better. Replaced as suggested.

page 20, line 9: "+PL, seed more" - probably: "+PL shed more"

Yes, it is better, thank you. Replaced as suggested.

page 22, line 5: "of reaction" - rather "of reactions"

Yes, it is better, thank you. Replaced as suggested.

page 22, line 16: something is missing at the end of the line - my suggestion "at hand, these conditions are characterized by"

Thank you. Replaced with minor modification of your suggestion as shown below.

Symplectite formation is initiated by a change in the environmental conditions of the rock. In case of the sample at hand, by decompression at a more or less constant high temperature.

Symplectite formation is initiated by a change in the environmental conditions of the rock. In case of the sample at hand, this change is characterized by decompression at a more or less constant high temperature.

page 23, line 4: "they allow for the calculation" - better: "they allow us to calculate"

Replaced as suggested.

page 23, line 6: "It is often observed" - better: "It is frequently suggested"

Replaced with minor modification of your suggestion as shown.

It is often observed that the characteristic inter-granular spacing (and size) of the symplectite phases decreases with decreasing temperature of symplectite formation. Remmert et al. (2018) presented experimental evidence corroborating this view and argued that the characteristic spacing of symplectite phases is small at low temperatures, ….

It is suggested that the frequently observed change of characteristic inter-granular spacing (and size) of the symplectite phases correlates positively with the temperature of symplectite formation. Remmert et al. (2018) presented experimental evidence corroborating this view and argued that the characteristic spacing of symplectite phases is small at low temperatures, ….

page 23, line 12: Replace "earlier" by "above"

Replaced as suggested.

page 23, line 15: "in ultramafic rocks have" - " in ultramafic rocks that have"

Missing word inserted as suggested.

page 23, line 23: replace "composition" by "compositional"

Replaced as suggested.

page 23, line 27: "the Mn" - "the entire Mn"

Word “entire” inserted as suggested.

page 24, line 4: "A limited fluid availability" - "A limited availability"

Word “fluid” deleted as suggested.

page 24, line 6: "zonation" might be better than "structure"

Well, it is a matter of taste. I think, for most of the people, “zoning” or “zonation” is intuitively associated with “co-centric” element distribution patterns, for example, as those related to growth zoning. As this is not the case in the measured garnets and in order to avoid possible misunderstandings, I have chosen the phrase: “The complex compositional structure of the garnet”.

page 24, line 9: "conditions." - "conditions using pseudosections" or do the authors mean "thermo-barometric estimate"? If yes, I would not agree with as the size of the lamellae delivered (rough) temperature constraints.

Well, I don’t quite understand the point here, especially in respect to “as the size of the lamellae delivered (rough) temperature constraints”. I may guess, your comment may be related with the discussion above. Therefore, the formulation (page 24, lines 7-11) is slightly changed as follows.

Additionally and as shown by the measured isopleths, the composition of all garnet types deviates from equilibrium, precluding thus any reliable thermo-barometric estimate of their formation conditions. The “older” GRT-type C occupies the large interior part of the garnet; its composition shows the least deviation from equilibrium, corresponding closest to the stability field of the primary assemblage GRT+CPX+Ky

.

Additionally and as shown by the measured isopleths, the composition of all garnet types seems to deviate from equilibrium. The “older” GRT-type C occupies the large interior part of the garnet; its composition shows the least deviation from equilibrium, corresponding closest to PT conditions pertaining to the stability field of the primary assemblage GRT+CPX+Ky.

page 24, line 10: "stability field" - better "P-T field" as the stability of the mentioned assemblage is more extended.

Right, thank you! The necessary change in line 10

> *…, corresponding closest to PT-conditions pertaining to the stability field of the primary assemblage GRT+CPX+Ky.*

is already included in the previous reformulation.

page 24, line 12: "It is developed" - better: "It formed"

Replaced as suggested.

page 24, lines 18-20: Seems to me somewhat speculative. This should be mentioned.

We are trying here to give an answer to the question, when did the metasomatic alteration take place along the PT-path of the rock. We argue as following.

The “younger” GRT-type Z3 (cf. Ca-distribution map, Fig. 2g) might have been evolved from the “older” GRT-type C by removal of Fe+Mg. This process should have taken place before symplectite formation, because diffusion profiles have overprinted this GRT-type (Fig. 5). Additionally, the “youngest” GRT-type Z1 (replacing GRT-type Z3, see the Ca-distribution map, Fig. 2g) shows intracrystalline deformation that, as explained further below in the text, is related to the tectonically induced decompression. This argument is added in the new formulation below. So, the answer to the question may be the following: The metasomatic modification should have taken place before decompression, i.e. under conditions most probably close to those of the primary assemblage. All these features comprise a line of argumentation or suggestion (or speculation?) with emphasis given by the used formulations “may evolve”, “we may conclude”, “may have taken place”. Taking account of your critical comment, the new formulation (of course without underlining) is as follows.

All these features provide convincing evidence that the garnet shown in Fig. 2g has undergone diffusion-aided metasomatic modification during the late stages of its evolution represented best by the GRT-types Z3 and Z1. Accordingly, the "younger" GRT-type Z3 may evolve from the “older” GRT-type C by removal of a total amount of ~12 mol-% of Fe + Mg (Table 1; Fig. 5a). Recalling that GRT-type Z3 also predates symplectite formation, we may conclude that the metasomatic alteration that formed GRT-type Z3 along the lower garnet margins in Fig. 2g took place under PT conditions not substantially different from those of the primary assemblage.

All these features provide convincing evidence that the garnet shown in Fig. 2g has undergone diffusion-aided metasomatic modification during the late stages of its evolution represented best by GRT-types Z3 and Z1. Accordingly, the "younger" GRT-type Z3 might have been evolved from the “older” GRT-type C by removal of a total amount of ~12 mol-% of Fe + Mg (Table 1; Fig. 5a). Recalling that GRT-type Z3 predates symplectite formation and that the GRT-type Z1 shows intracrystalline deformation (Fig. 7) due to tectonic displacement (see below), we may conclude that the metasomatic alteration that formed GRT-type Z3 and Z1 may have taken place under PT conditions close to the formation conditions of the primary assemblage.

page 24, line 26: "is more than questionable" - "is questionable"

Changed as suggested.

page 25, line 9: "pre-date formation" - "pre-date the formation"

Changed as suggested.

page 25, line 10: "to activity" - "to the activity"

Changed as suggested.

page 25, line 13: "in depth" - "in detail"

Changed as suggested.

page 25, lines 15 and 31: "related with" - "related to"

Both changed as suggested.

page 26, line 16: "rather, than with increasingly" - "rather than increasingly"

Changed as suggested.

Hans-Joachim Massonne (Universitaet Stuttgart)