

Interactive comment on “Interpretation of zircon corona textures from metapelitic granulites of Ivrea-Verbano Zone, Northern Italy: Two-stage decomposition of Fe-Ti oxides” by Elizaveta Kovaleva et al.

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Overview

The paper authored by Kovaleva and others presents a detailed description of metamorphic zircon textures in metapelitic granulites from the Ivrea-Verbano Zone, northern Italy. The authors suggest, on the basis of textural relationships, but limited geochemical data, that the zircon formed as a result of hydration reactions, where Zr was liberated from ilmenite and later from Zr-rich rutile during prograde metamorphism and then cooling after peak granulite facies metamorphism.

C1

The textures presented are an intriguing record of zircon formation during solid-state metamorphic reactions, and this work represents a valuable contribution to our understanding of zircon growth mechanisms. However, the current structure of the paper and how observations have been presented make it difficult to properly evaluate the veracity of the interpretations made and conclusions drawn. Direct criticisms and suggestions for improving the presentation of the paper are made below, with further comments made on an annotated PDF version of the manuscript.

General Comments

* Introduction

Much has been published on the mechanisms of zircon formation during metamorphism, a brief presentation of which would be very valuable in this contribution. The paper does cover some of the basics of “corona textures” and reports of these in metamorphic rocks, in particular meta-basic rocks. Although the focus on metabasites is curious, given this paper is on metapelites. However, it would be useful to see a recap of what we know about metamorphic zircon growth in all rock types as this does inform about the current study. In particular, this should cover differences between growth during major/accessory mineral breakdown, exsolution from accessory minerals, and precipitation from a fluid (vs growth as a result of major mineral decomposition during a retrograde hydration event). Some of this could be introduced during the discussion, but this background places the textures reported here in a clearer context. In this fashion, sections 1.1 and 1.2 could basically be integrated.

* Geologic background & sample description

The description of the outcrop and interpretations of the origin of the rocks needs a clearer description. I would suggest a layout similar to:

1) mesoscopic outcrop features 2) mineralogy of the rocks 3) pertinent textures 4) interpretation of metamorphic features (PT-conditions, PT-path) including integration

C2

with published info.

A more detailed description of the sample taken would come later (see comments below).

Some other points - the stromalolite (an outdated term that could do with replacing) has been interpreted by others to have formed through partial melting (not just "dehydration" during metamorphism). The leucosome in that rock may not just be injection of melt but melt formed in the rock itself. But what I find most curious is how a layer of metasediment can be discordant to layering in the host stromalolite. Can this be explained better? But the focus here should really be to say that the rock studied has likely lost partial melt, so is somewhat restitic. And then later it is cut by brittle faults. Somewhere in there ductile deformation affected the sample, but from the outcrop description is this not by any means given context.

The mineralogy and textural description of the sample itself (page 4, line 34 onward) should be moved and inserted into the results section (4.1), as this first introduces the zircon occurrences and should be integrated with the rest of the textural descriptions. When the sample description (separate from outcrop description) is moved into section 4.1, there needs to be a clear and succinct description of the sample's major mineral textures. It is difficult to understand the relationships between prograde mineral textures (if present), peak mineral relationships, post-peak and hydration reaction textures (including the veins). From the description, I can't tell if there is more than one vein type – one that is dominated by Fe-Ti oxide minerals, the other dominated by fine-grained phyllosilicates, or are all a mixture of these? And the relationship of veins to mesoscopic and microscopic structures needs to be clearer – how can one deduce that a veins in thin-section "stretch mostly subvertically"? Is this an inference made from an oriented thin section, or just that when you look at the thin section it runs up and down?

* Zircon textures (Results)

C3

This needs to be more systematic. At present, zircon textures are presented as different "occurrences" that have much overlap. This reads like they came from different veins or thin sections and so were considered separately. I see an advantage to integrating the descriptions into "types" of textures.

For example:

" Zircon occurs in 2 textural contexts (as 2 textural types). The first, ... The second, ... "

I see these types as the "vermicular" zircon (the coarser-grained zircon) and then the fine-grained "coronae" that occur either intergrown with Fe-Ti oxides mineral or in fractures. These may occur with different "vein types" but these are the basic textural types.

* Microprobe data

It is difficult to see, in it's current form, what this contributes to the overall understanding of the problem. Very little is made of the data (apart from showing some compositional zoning in garnet). Nothing is made of the analysis of the phyllosilicates. But perhaps most striking, is that zirconium hasn't been analyzed in rutile (or ilmenite). This would be very illuminating! This would lend credence to the interpretation that Zr was probably sourced from ilmenite and rutile, and could also be used to estimate the temperatures of formation. Zr-in-Rt is very doable my electron microprobe. It would be beneficial to have Ti-in-zircon, although I understand with the fine-grained nature of the textures this would be impractical.

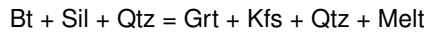
* Mineral reactions

The cool thing about textures such as those presented here, is that they do provide insights into the reactions that could have led to growth of zircon during metamorphism. However, this is weakly dealt with in this paper.

First – reaction 1 makes no sense.

C4

The metapelitic rocks have been shown to have experienced partial melting. Given the assemblage, I would suggest the reaction:



This is not a “hydration” reaction, but a dehydration reaction, as water goes into the melt. This is also a prograde to peak reaction.

Formation of the veins, which host biotite, and the development of elevated Fe and Mn in garnet rims, likely occurred during retrograde hydration. Resorption of garnet during retrograde breakdown has been commonly reported as a mechanism to elevate Fe and Mn in rims. But, this mechanism MUST post-date the peak of metamorphism. While one can accept that the rock could have been hydrated from an external source and so could theoretically form during prograde metamorphism, the description of the mineralogy and textures does not support this. If you disagree with this interpretation, there must be an argument presented for it, and it is not present in the manuscript.

There also needs to be a more developed discussion of the mineral relationships in the veins. For example, rutile is interpreted to have formed from the breakdown of ilmenite, which still occurs as relics in the veins, which (at least some of) are dominated by rutile-quartz intergrowths. What was the mineralogical make-up of the veins before reaction? Does ilmenite (or rutile for that matter) occur elsewhere in the rock, or just confined to veins? Can you mass balance any reaction (even with a thought to open system)? Did Ti come in with H₂O and SiO₂? What is the distribution of new zircon relative to the different vein types – is there less zircon when less rutile (and ilmenite)?

* Zircon textures

Leading on from the above discussion, are questions about whether fine-grained zircon formed from solid-state mineral breakdown (rutile, ilmenite) or due to exsolution of Zr from these minerals. The assumption in the paper is that this is just mineral breakdown-growth. However, many papers have suggested fine-grained textures rep-

C5

resent exsolution during cooling.

Without a clear understanding of the veins themselves, I can only speculate, but it seems to me that a viable option for the formation of these textures involves the coarser zircon grains forming at high-T. They could have formed in the presence of crystallizing melt (e.g., zircon in Fig. 5 is seen associated with Sil, or included in garnet). With cooling, Zr was less compatible in rutile, so began to exsolve, hence the close textural relationship with rutile, and the lower-T not allowing grain coarsening. No doubt presence of fluids aided Zr mobility – hence presence along fractures and major grain boundaries with coarser-grained garnet or quartz. But evidence for pure metasomatic-driven reactions is not demonstrated here.

Some comments on figures:

* there are some wonderful textures here. However, they are a little too small to see in some cases. Consider re-arranging and increasing the size so the relationships are clearly visible.

* be sure to define all abbreviations – what is Phyl?

* there needs to be some clearer photomicrographs that show the metamorphic textures and the relationship to veins. If you want to push the idea of fluid-driven reaction, it would also help to present a systematic description (in the images) of the veins: the hydrous veins, rt-qtz intergrowths, etc. . . The current images make this very difficult to evaluate.

* while schematic figures are excellent to explain the processes invoked, it would help if they properly described the textural development. In figure 6, the process starts with a single grain of ilmenite, which reacts to form a single grain of rutile, which reacts to form rutile-quartz aggregates. I don't recall this being described in the text. And in any case, the paper presents these textures as occurring in veins. I am left confused about the process here.

C6

Please also note the supplement to this comment:
<http://www.solid-earth-discuss.net/se-2016-164/se-2016-164-RC1-supplement.pdf>

Interactive comment on Solid Earth Discuss., doi:10.5194/se-2016-164, 2016.