FACULTÉ DES SCIENCES ET TECHNIQUES
SAINT-ÉTIENNE

Review of a dissertation submitted by Mgr. Šárka Kubínová as part of the requirements for a degree of Doctor in Geology

Saint-Etienne, August 1st 2019

To whom it may concern

Mrs. Kubínová submitted a manuscript for a degree of Doctor of Sciences with Charles University, Prague. The title of this work is "*Mineral and chemical changes of magma crystallization during formation of post-Variscan intrusions and veins in the Moldanubian Zone of the Bohemian Massif*".

The 183-pages long thesis is made of an introduction, a conclusion and four published papers, such that most of the work has already been peer-reviewed before publication. Two of the papers are first authored by the Candidate while she is associated to another two. This is, of course, a very commendable achievement, and not all theses in geosciences achieve that level of output. If nothing else, this attests of the quality of the work. It also makes it somewhat hard for a reviewer to comment on the thesis – as presumably, the paper reviewers would have already picked anything of consequence.

In any case, I found these papers to be solid, well written and illustrated. The data is of good quality, it is adequately presented and summarized. On the other hand, the papers all are somewhat limited when it comes to interpretation. There is little in the way of creative use of the data (balancing reactions, petrogenetic calculations, etc.), and the discussions tend to be on the weak side – mostly some general statement on possible and impossible models, but not really quantification of processes or detailed treatment of petrogenesis. The two AMS papers (Chap. 4 and 5) are a bit better in that respect, which in a sense is unfortunate as these are two papers for which the candidate did not take the lead…

The rest of the thesis includes one introduction, and a conclusion chapter, that are meant to put the core of the work into perspective. I am rather more critical about them. The introduction is rather superficial – it is an introduction, but does not offer a review or a compilation of existing information, in other words it is hard to distinguish the state of the art, and what this thesis brings to the current knowledge. Although it includes a "geological setting" section, it is rather sketchy with critical information missing – much better such sections are found in the subsequent articles. The conclusion (as well as the abstract) is essentially a collage of the main findings, but does not open new perspective, answer big questions, etc. Essentially, what should be the main questions at the start/end of a thesis ("why must we look into this issue? What did we learn?") are not answered, and hardly asked.

It is, of course, an unavoidable side effect of an "article" thesis, but I also regret the lack of basic data. A thesis could, for instance, include detailed data tables (and not only the examples that can be fitted in the limited space of a paper), perhaps as extra material at the end of each chapter, after the paper text. The geological setting, outcrop description, sample description that are –inevitably— spread over the different papers could be grouped together in a larger, better and more comprehensive section. Here, I was often left wanting some information that quite often was present in the geological setting of a subsequent paper! Another unfortunate side effect is that nowhere is the whole database (of whole rock analyses for instance) presented and discussed.

In summary – this a competent and solid piece of work, but one lacks vision or context. Of course, on the basis of my conclusions, I believe that this piece of work is acceptable for a degree of Doctor of Science.

More detailed comments on each part are found in the following pages.

Yours truly,

Jean-François MOYEN

Detailed comments, part by part:

Abstract is no real abstract, just a summary of the data presented in the thesis. Lacks a "story". Also lacks some context (why are these rocks important to study ? What have we learnt at the end of the work ?).

Chapter 1. Not a bad review, but lacks maybe a bit of data compilation, to show the classification in action? How do the rock types that are mentioned differ, and what does this mean?
Are the "plutonic lamprophyric rocks" really equivalents of lamprophyres ? Especially when considering that (page 4) ".. they are not simply textural varieties of common plutonic or volcanic rocks,". Would be nice to see some data here.
The summary on the geology of the Variscan belt is a bit weak. A proper summary (maybe reminding the reader of zones, timing etc) would be useful. It would help to put the lamprophyric rocks in context. Interestingly we have much better geological settings in the rest of the thesis (chapters 4 and 5 in particular).
P. 7-8, the story of the magmatism would need some info on timing. Does this refer only to the subduction suites? Or to the whole magmatism ? The map Fig. 1 could be improved by showing the different types of lamprophysic magmatism and/or their age. This map also lacks a proper caption (meaning of the different orange, green, grey patterns ?).
The map of Bohemian massif (fig. 2) should at least be customized to include the info discussed in text (two belts of UK rocks, etc.)
The "study area" section should include info on the local geology, but we do not even know where the samples come from ! Sample map, coordinate table ?
Page 12, "Despite extensive and long-time study of the Bohemian Massif and the reconstruction of its Variscan evolution,…". This section does not do full justice to it, I think. We miss a compilation of occurences or composition, summary table, comparisons, compilation of available info, etc. What is the background information to the thesis ?

Chapter 2 is a published paper (the actual ref with volume and page numbers would be appropriate to indicate). In fact it answers many of my comments on the summary of chapter 1 (local geology, sampling map, broader Variscan context, etc.). Here too, I feel that the abstract lacks a bit of depth –- it does describe the key findings of the paper but fails to put them in a broader context (why should we investigate this question ? What is new after our study ?).
Page 28 – I suggest you read some of our own work on the Massif Central (Couzinié et al. 2016 & Laurent et al. 2017) for more geochronological information. Vaugnerites (and allied rocks) in the French MC span a much longer time period, between 340 and 300 Ma, with implications on models (slab window ?). I also think that there are more ages available (Vosges…) from other parts of the Variscan belt, here again the background information / state of the art is a bit weak. The location of the blue stars in Fig 1a (that also lacks a caption for the different patterns…) are a bit aphazard in the part I know (French MC).

Likewise, I regret that there is no attempt at discussing the diversity of the HK/UK magmatism, to see if they are really similar or not!
Knowing the overall outcrop quality in the Bohemian Massif, I'm impressed by the degree of precision of the map fig.2 … impressed, and also a bit sceptical. How has it been possible to map ta ca. 1 x 1 km area in such details? In addition, the lack of grid coordinates (long/lat or other) or any other geographic framewok (road, village…) makes it difficult, for instance to go to Google Earth and check the outcrop situation… Only in Chapter 4 does it become apparent that the locality from which these rocks come (Nihošovice) appears to correspond a large quarry…
I would have appreciated some photos of outcrop or hand specimen, to give a better idea of what the rock looks like. Perhaps not appropriate in a Lithos article, but in a thesis…. ? As an appendix at the end of the chapter maybe?
Fig. 6b, I'm not sure the SiO_2 – K_2O diagram is after Scarrow ? Peccerillo & Taylor 1976 maybe?
Fig. 7, it is hard to describe systematic covariations when you only have 2 or 3 samples of each facies. Of course, the bulk of the dataset does show covariations – but unless you demonstrate that the magmas are cogenetic (doubtful, since there are cutting relationships in the field) these mean nothing. And, in any case, all the rocks on Earth more or less show the same correlations in Harker type diagrams, so the question is, does this correlation differ from the "background", global correlation? In the following chapters, it appears that other samples have been analysed. Presumably they were not available at the time of writing this paper, but a useful addition to the chapter (in the thesis) would have been updated figures, and a discussion on how this changes the conclusions of the paper (or not).
It would have been nice to go beyond the mere description, and propose, for instance, (balanced) reactions accounting for the mineralogical changes between stage 1 and stage 2 of crystallisation. Likewise, actually showing some phase diagrams would have helped to discuss the crystallization history… or the magma genesis one indeed.
The petrogenetic part is very short. Referring to an AFC model without showing it is not really convincing, and in any case AFC is full of problems (energy available, etc.) that deserve at least some discussion.
In general I do not quite see the link between the actual data (mineral chemistry mostly) and the geodynamic implication. Large part of the petrogenetic interpretation (on which geodynamic inferences are built) rely on the (relatively scarce) whole rock data, and I do not quite see how the mineral chemistry is integrated into the story.

Collectively, this paper has the same strengths and weaknesses as the global thesis. It is a competent acquisition (and description) of the data, but lacks a bit of depth in the interpretation, and above all, lacks context…

Chapter 3 is also published, in Mineralogy & Petrology (same comment).
More details is given on the mineralogy and mineral chemistry of the dykes (as well as the occurrence, location, etc.). This chapter again answers some of the questions I had about the previous one. I think it would have been more logical to swap the two, firstly discussing the

crystallization and evolution of the dykes before showing their petrogenesis and moving on to geodynamic implications. In fact, the two papers seem to have a similar focus and approach, and I struggle a bit to see in what respect they differ (apart from not using the exact same data and samples, but the focus seems very similar).
Here again, a phase diagram would have helped to understand the textural evolution, the reactions, etc. The illustration is rather restricted in this chapter/paper, and in any case only the data is illustrated – we lack some illustration for the discussion for instance.
The comparison of normative and actual mineralogy, p. 88, is interesting – finally, some attempt to go beyond data presentation and try to use it for some quantitative analysis! However, this would also need some illustration (a table, showing the mineral compositions selected, the residua of the calculation, and so on). The outcome of the calculation is a bit surprising to me – how can a normative composition featuring quartz correspond to an olivine—biotite mass balance calculation, since these two minerals have very low SiO_2? Hard to discuss without seeing the actual calculations (even if they can be considered as out of place in a paper, they could find their way at the end of the thesis chapter). Finally, I do not see how this discrepancy can be used to infer anything at all on petrogenesis. Of course, a normative composition does not reproduce the mineralogy of a biotite-rich rock, hardly a surprise since CIPW norm does not take biotite into account…
Here again, I find the discussion lacking depth and not very quantitative. Balanced mineral reactions would help, or perhaps some fractionation/mixing calculations. Magma mixing should be evidenced by zoning profiles, with sharp breaks and reversals. They are vaguely mentioned but not that clear. There is at last a phase diagram (fig. 8), but it does not show where the samples are, it is not related to the studied rocks!
We then return to the geodynamic setting (and how is this different from the first paper exactly?) and to a conclusion section that is, again, just a repetition of the main findings of the paper without further implications or discussion. Essentially, this second paper is very similar to the first one in any respects and does not bring much new.

Chapter 4 is another published paper, of which the candidate is third author (out of seven). She is said to have contributed 30% to the paper, apparently mostly the sampling and petrology (not the main thrust of the paper). It is probably a bit unfair to comment at length on a paper for which the candidate was obviously not the main driver.
Page 101: “crustally derived mafic dykes” ? This surprises me more than a bit…
The geological setting (description of the dyke swarm) is better than the previous ones. I understand the need of the article format, but it is a bit unsettling to get the most basic information (local geology…) arriving piecemeal, and in an order that is the reverse of what I would have expected.
There also seems to be more WR geochemistry there, than in the first article supposedly dealing with this aspect. Probably this is due to practical reasons having to do with the thesis development, but it is unfortunate then that we do not have somewhere a global overview/presentation of the whole dataset.

The fabric analysis in at least some of the dykes seems to relate to hydrothermal alteration. It would be nice, then, to link this with petrological observations (as presented in the first two chapters!). At least, is there a correlation between the dykes that show an atypical fabric, and their mineralogy, texture, etc.?
It is a bit hard to see what is the "petrology" contribution to this paper (besides the simple sample description/characterization). It is mostly a fabric analysis paper (not a bad one), but it does hardly rely on petrology. Some integration of the data from various sources (AMS, petrology, geochemistry…) would be welcome.

Chapter 5 is another paper (5 authors) of which the candidate is third author, with a 30% contribution. This paper again examines magnetic fabrics of dykes, this time focussing on one unique, composite dyke, with also composite fabrics.
Again, it is not clear to me how the petrological and geochemical information presented here relates to the other rocks studied in other papers of this thesis. As before, I do not really see an attempt to correlate petrology and fabric type (for instance, figs. 3, 6 and 11 depict the entire dyke as "lamprophyre", despite the fact that it is described as composite, with different rock types in it). It would have been interesting (in Fig. 3) to correlate the physical properties here plotted with petrological or geochemical properties. Again, it is hard to see what is the contribution of petrology to this paper.

The **conclusion** is a summary of the findings of all papers, effectively summarizing the main observations. But the papers, as mentioned already, lack a bit of data treatment and interpretation, and the conclusion does not go any further. It is true that there is a "future research" section, but it still does not really open perspectives, outline what knowledge has been gained, how this thesis brought a better understanding of geological mechanisms of interest. And it is a bit hard to see from the perspectives outlined how further studies would help, for instance (to cite just one) "to clear geodynamics and mantle melting processes": what is still unknown, what are the competing hypotheses to test, how would the proposed work help in deciding?

In general, one would expect a thesis (even a "paper" thesis) to include additional information (all the background data that typically cannot make its way to publication), such as maybe data tables, more detailed field/sample descriptions, etc. It is also the place for a lengthy state of the art, some personal reflections by the candidate on the topic (even if not publication-ready), etc. This is unfortunately missing.