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7.09.2020

REVIEW

Of the doctoral dissertation by mgr Christopher J. Barnes
“***Exhumation dynamics of high pressure rocks during Caledonian orogenesis: A geochronological perspective***”

under the supervision of:

Dr inż. Jarosław Majka, prof. from the University of Science and Technology
and

Dr David A. Schneider, prof. from the University of Ottawa.

This review was prepared on request of the Scientific Committee of the University of Science and Technology (AGH), based on decision from 29th of June 2020.

The PhD thesis is prepared in English and consists of three published first-author papers with 40 pages of introductory chapters including 8 figures as well as attachments with the statements of co-author contribution. Short abstract is translated to Polish.

List of Articles included in the PhD thesis:

A1. Barnes C.J., Majka J., Schneider D., Walczak K., Bukala M, Kościńska K., Tokarski T., Karlsson A. 2019. High-spatial resolution dating of monazite and zircon reveals the timing of subduction-exhumation of the Vaimok Lens in the Seve Nappe Complex (Scandinavian Caledonides). *Contribution to Mineralogy and Petrology*, 174:5. doi: 10.1007/s00410-018-1539-1.

A2. Barnes C.J., Walczak K., Janots E., Schneider D., Majka J. 2020. Timing of paleozoic exhumation and deformation of the high-pressure Vestgötabreen Complex at the Motalafjella Nunatak, Svalbard. *Minerals*, 10(2), 1-23. doi: 10/3390/min10020125.

A3. Barnes C.J., Jeanneret P., Kullerund K., Majka J., Schneider D., Buwała M., Klonowska I. 2020. Exhumation of the high-pressure Tsäkkok Lens, Swedish Caledonides: Insights from the structural and white mica $^{40}\text{Ar}/^{39}\text{Ar}$ geochronological record. *Tectonics*. doi: 10.1029/2020TC006242.

All scientific papers were published in internationally recognised journals from the *Journal Citation Report (JCR): Contribution to Mineralogy and Petrology* (IF=3.14), *Minerals* (IF=2.38) and *Tectonics* (IF=3.54). Mgr Christopher Barnes is the first author in all of them. The published papers have a logical order and indicate the pursuit of a well-thought-out goal achievements.

Prepared PhD thesis aims to improve the knowledge about the Arctic Caledonides, specifically to resolve the timing of the subduction and exhumation mechanisms of continental and oceanic crust. The work was conducted on metasedimentary rocks that host high-pressure lithologies from the Seve Nappe Complex in Swedish Caledonides and Vestgötabreen Complex in Svalbard. Regional results were compared to previously published data from the Jämtland localities. To reach the goal, various modern geochronological methods were used, such as zircon U-Pb geochronology with depth profiling, monazite chemical dating and white mica Ar/Ar method.

Assessment of the formal side of the published work

Prepared introduction consists of 5 chapters (numbered from 5 to 9), divided further to sub-chapters and it is intended to be the part that holds the published articles together. The chapters are as followed: *Introduction, Geological Background, Methods, Conclusions* and *Verification of the PhD thesis*. It is well written, but the structure of these part of the thesis is not clear and does not help to follow the scientific ideas. The *Scope of the thesis* includes mostly the information about methodology and justification of minerals selected for analysis. One could expect a clear information about scientific hypotheses and specific research goals set for the work on the dissertation. These are presented at the very end in the last chapter. Moreover, is not clear why three

sub-chapters (5.3, 5.4 and 5.5) have the same titles as next three sub-chapters (7.3, 7.4 and 7.5) and all of them describe methodology, even if the intention was that the 5.3-5.5 will be part of the introduction. Mr Barnes describes in great details minerals selected for isotope geochemistry (zircon, monazite and white mica) and methodology used, together with rock samples, however justification of selected study areas is vague. Why, for example, these particular lenses of the Seve Nappe Complex were selected? After the *Methodology* we have the *Conclusions* chapter, which actually is part of the results and the discussion. This part of the thesis is finished with graphical illustrations summarizing results from the papers.

Reading this part of the thesis, it is clear that Mr Barnes knows the literature, regional geology and the methodology. I really like the chapter 8.3 *Future Directions*, which proves that work of Christopher Barnes provided advancements for understanding the complexities of Caledonian orogenesis in this part of the Arctic and that his study opened new windows for next scientific goals.

It seems that the entire introductory part of the thesis was prepared in a hurry, and does not contain a followed up clear thoughts. Maps presented do not have geographical coordinates and during reading it is not always clear what work was published earlier and what is a new result of the thesis. In total, it does not fully reflect of what is in published papers.

Assessment of the scientific side of the published work

Mr Barnes did an excellent job implementing isotope geochemistry to solve the regional questions of the timing of subduction and exhumation of the (U)HP rocks of Arctic Caledonides. All three published papers are of a very high scientific quality, prepared with care and very good illustrations. The content of publications making up the doctoral dissertation of Mr Barnes, clearly indicates his gradual scientific development and pursuit of the set goals. The statements contained in each publication are consistent and form a clear logical sequence. The research methods were selected and used properly to achieve the set goals. The scientific methodology of presenting the results, analyses as well as

their tabular, graphical and photographic documentation meets the standards set for high-quality scientific dissertations. The variety of analytical methods used during the PhD studies deserves special emphasis.

Three research hypotheses were set during the PhD course:

- Subduction-exhumation along the Baltican margin was not contemporaneous; the northern exposure represents older subduction than the southern exposures.
- The geometries of the subduction zone(s) and/or Baltican margin had a direct control on the exhumation mechanisms of the Seve Nappe Complex (SNC).
- The Vestgötabreen Complex in Svalbard is a remnant of the subduction zone represented by the Seve Nappe Complex in the northern Scandinavian Caledonides.

Mr Barnes demonstrated that the record for subduction and exhumation in southern Norrbotten (area targeted for the PhD thesis) is considerably older than timing for subduction and exhumation for the previously investigated Jämtland localities. Furthermore, work on the Vestgötabreen Complex of the Motalafjella Nunatak in Svalbard and Tsäkkok Lens of the Seve Nappe Complex in Scandinavian Caledonides provided evidence that most probably these two localities were part of the same Caledonian subduction system.

In the presented work, discussion of results and conclusions are very logic. There are only few methodological aspects which are not clear for me: As neoblastic zircon is often thinner in diameter, why was the LAICPMS was used instead of SIMS? Another aspect is that in A1 paper, the EDS was utilized for monazite analysis, however it is impossible to resolve REE lines in monazite. What was the idea behind such procedure? And finally, Sr content in monazite from high-pressure rocks is crucial, why then in A2 paper has this element been sacrificed?

To sum up

Mgr Christopher J. Barnes demonstrated the ability to use various analytical methodology and proved that he has learned a wide range of research techniques. My negative comments are mostly for the 'technical' part of the dissertation, not for the scientific quality of the work. Thus, the overarching goal of the doctoral research project was achieved, and the scientific goals set out were achieved. Each of the work published presents an increasing scientific value. The figures in each of the paper are properly selected. Those that depict schematic models are very careful and clear. This dissertation is an original and modern scientific study of a very high quality.

With a pleasure, I confirm that presented PhD thesis meets the requirements for doctoral dissertation and that Mr Christopher J. Barnes can be admitted to the further stages of the process.

Sincerely yours,

A handwritten signature in black ink, appearing to read 'M. Kusiak', written in a cursive style.

Dr hab. Monika A. KUSIAK