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Review PhD Dissertation MSc Anna Gumsley
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Introduction

The submitted and reviewed PhD Dissertation of Mrs. Anna Gumsley MSc entitled '*Variscan to Early Alpine magmatic and metamorphic evolution of the Strandja Zone (SE Bulgaria/NW Turkey)*' consist of three first-author publications of Mrs. Gumsley:

Sałacińska, A., Gerdjikov, I., Gumsley, A., Szopa, K., Chew, D., Gawęda, A., Kocjan, I. (2021). *Two stages of Late Carboniferous to Triassic magmatism in the Strandja Zone of Bulgaria and Turkey*. Geological Magazine, 158: 2151–2164.

<https://doi.org/10.1017/S0016756821000650>

Contribution of Mrs. Anna Gumsley: 70%

Sałacińska, A., Gerdjikov, I., Kounov, A., Chew, D., Szopa, K., Gumsley, A., Kocjan, I., Marciniak-Maliszewska, B., Drakou, F. (2022). *Variscan magmatic evolution of the Strandja Zone (Southeast Bulgaria and Northwest Turkey) and its relationship to other North Gondwanan margin terranes*. Gondwana Research, 109: 253–273.

<https://doi.org/10.1016/j.gr.2022.04.013>

Contribution of Mrs. Anna Gumsley: 60%

Gumsley, A., Szopa, K., Chew, D., Gerdjikov, I., Jokubauskas, P., Marciniak-Maliszewska, B., Drakou, F. (2023). *An Early Cretaceous thermal event in the Sakar Unit (Strandja Zone, SE Bulgaria/NW Turkey) revealed based on U-Pb rutile geochronology*. Lithos 448-449, 1-17.

<https://doi.org/10.1016/j.lithos.2023.107186>

Contribution of Mrs. Anna Gumsley: 60%

Additionally, seven other publications are also listed which are not directly related to the main research topic.

Aim of the PhD Dissertation

This PhD dissertation aimed to unravel the Late Paleozoic and Mesozoic magmatic and metamorphic evolution of the Strandja Zone (SE Bulgaria/NW Turkey).

The Strandja Zone is an NW-SE-trending mountain belt consisting of pre-Late Cretaceous autochthonous and allochthonous units located on the Bulgarian-Turkey border and variously assigned as part of the Balkanides or the Pontides. In the Strandja Zone, the Paleozoic and Early Mesozoic geological evolution is obscured by Late Jurassic to Early Cretaceous metamorphic and structural overprinting, traditionally called the 'Early Alpine' event. In Bulgaria three lithotectonic units are distinguished: the Strandja, the Sakar and the Veleka unit.

The PhD dissertation focuses on the Sakar Unit of the Strandja Zone, which is dominated by the presence of Late Carboniferous to Triassic granitoids of the Sakar Batholith in the central part, the Harmanli Block Magmatic Complex in the south-western part, and the southern plutons of Izvorovo, Levka and Ustrem, previously grouped as the Lesovo Complex.

The Late Carboniferous to Triassic granitoids of the Sakar Unit (western part of the Strandja Zone) were selected to be a major subject of the study. The primary questions concern Late Carboniferous to Triassic magmatism:

- 1) Are there any differences between granitoids of various ages?
- 2) Were they formed in the same tectonic setting?
- 3) Is there any evidence apart from geochemical signature for prolonged magmatic arc magmatism or were the granitoids formed in more than one magmatic episode?

The research was also conducted to test if there are any unaffected granitoids and where they occur. The least deformed and metamorphosed portions of the Late Carboniferous plutons containing country rock xenoliths were used to answer the question about the possible influence of pre-Late Carboniferous high-grade metamorphism in the Strandja Zone. Albitized granitoids

and associated rocks of the northwestern Sakar Unit were selected to estimate the timing and conditions of the albitization and its connections with Late Jurassic to Early Cretaceous metamorphism. These studies of Late Carboniferous to Triassic granitoids were also conducted to better correlate the Sakar and Strandja units of the Strandja Zone, as well as the Strandja Zone and surrounding regions during Paleozoic and Mesozoic, which helps with understanding the evolution of the southeastern part of Europe.

Results of the PhD Dissertation

The PhD dissertation presents zircon, titanite and rutile U-Pb dating coupled with geochemical, petrographic and field studies. It provides:

- 1) crystallization ages of the Izvorovo (ca. 251-256 Ma) and Levka (ca. 306 Ma) plutons;
- 2) a constraint on the emplacement age of the Sakar batholith (ca. 319 Ma);
- 3) evidence of Variscan metamorphism and deformation in the Sakar Unit (> ca. 319 Ma);

4) evidence of two stages of Early Alpine metamorphism and deformation with a Late Jurassic (ca. 154 Ma) regional phase and Early Cretaceous (ca. 125 - 116 Ma) localized hydrothermal activity.

The work thus revealed that magmatism in the Strandja Zone is represented by two age groups of granitoids, Late Carboniferous and Permian-Triassic, respectively. The older group is interpreted to be related to a post-collisional setting, whereas the younger group was probably formed in either rift- or subduction-related settings. The similarities of the Gondwana-derived country rocks affected by Variscan metamorphism and deformation and intruded by Late Carboniferous granitoids in the Strandja and Sredna Gora zones leads to the conclusion that these share a common Late Paleozoic evolution. Both zones were a part of the metamorphic core of the Variscan Orogen. Subsequent, the Strandja Zone was affected by Late Jurassic to Early Cretaceous metamorphism and deformation coeval with (ultra-) high-grade metamorphism in the Rhodope Zone.

The PhD dissertation furthermore addresses problems in the interpretation of geochemical and geochronological data, such as:

- 1) the discrimination of tectonic settings for granitoids based only on geochemical data, which is presented together with zircon population characteristics and magma Zr-saturation temperatures;
- 2) the meaning of dispersed U-Pb zircon age data spread along the Concordia, for which the proposed solution assumes partial lead loss due to a metamorphic event;
- 3) the interpretation of highly-radiogenic initial Pb composition in rutile, presented with isotopic and textural evidence of igneous titanite being a precursor.

Review

I am not too familiar with the regional geology of the Strandja zone in Bulgaria. I thus probably cannot suitably judge the necessity and potential impact of the proposed research. But taking the outcome of the research into account, I can give the following findings:

The formulated research plan definitely has an international level and was adequate to solve the raised geological problems. The geological research aims have been reached to a full extent. The submitted PhD dissertation has addressed and successfully answered all the formulated research topics. This fact is well revealed by the publication of the results in international high-ranking journals. In this respect, the aims set into the PhD dissertation has to be regarded as have been completely fulfilled.

The respective work contributions of Mrs. Gumsley to the three relevant publications are far above average, especially in view of the numerous co-authors of the publications. It is evident that Mrs. Gumsley has intensively and very successfully worked on and contributed to the research. In these aspects the demands and research quality set into a PhD dissertation, also on an international level, have to be considered as having been completely fulfilled.

For what concerns methodological aspects, I have a few comments to add. Although the research plan is absolutely adequate to generate and collect the geochemical and the geochronological data needed to potentially answer the geological research questions, the used methodology is in parts not quite up to date. Especially I address here issues

with the Zr-saturation temperatures where the chosen methodology is not entirely correct (i.e., see the work of Boehnke *et al.*, 2013; Gervasoni *et al.*, 2016). Also, I ask why the age data reduction is made using the somewhat outdated Isoplot software of Ken Ludwig in view of the availability of the far more modern IsoplotR software (Vermeesch, 2018)? I find the presentation of some of the U-Pb isotope data not absolutely satisfactory. Why not present the age data exclusively in Terra-Wasserburg concordia plots as is normally done in our community? This approach allows to plot, reduce, and interpret the isotopic data which has been gained by the mass spectrometric analysis (i.e., ^{238}U , ^{207}Pb , ^{206}Pb , among possibly others) and not to plot ^{235}U which is solely calculated from ^{238}U . In my opinion this is a more 'honest' approach to U-Pb age data reduction.

I also somehow miss a bit the methodological innovation in this research.

Nevertheless, my overall conclusion is that Mrs. Gumsley has very successfully worked on and presented her PhD dissertation. As far as I can see, Mrs. Gumsley has fulfilled all necessary legal and scientific points recommended for a PhD dissertation. I therefore see absolutely no problems in granting her a successful completion of her PhD dissertation. This I highly recommend.

Kind regards,



Urs Klötzli