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# Review of the PhD Thesis

Palaeomagnetic and rock magnetic investigations of the Triassic rocks from Svalbard Archipelago

by Katarzyna Dudzisz

The reviewed PhD thesis deals with palaeomagnetic and rock magnetic properties as well as with the anisotropy of magnetic susceptibility (AMS) of the Lower Triassic rocks of the Svalbard Archipelago. The aims of the thesis are (1) to reveal how the AMS can help us in discovering the role of the tectonic deformation (both the small-scale and large-scale one) in creation of the geological structure of the Svalbard Archipelago and (2) to explain why the natural remanent magnetization (NRM) in the Lower Triassic rocks investigated is extremely complex and multi-componental.

The thesis consists of a summary of the results obtained by the PhD candidate in her rock magnetic research of the Svalbard Archipelago and three publications presented in renowned scientific journals. The publications are by small teams of authors with Katarzyna Dudzisz being the first author and, as stated by the other authors, her shares being 50 %, 55 % and 65 % in these publications.

An every effort was made to identify magnetic minerals carrying the AMS and remanent magnetization. Namely, the individual magnetic minerals may behave differently in different geological situations and the knowledge of the dominant carriers of AMS is vital in correct geological interpretation of the AMS data obtained by measurement. Similarly, knowledge of the carriers of the remanent magnetization is crucial in the palaeomagnetic interpretation, because some ferromagnetic minerals may be primary in origin, while the others may be secondary, originated even under relatively low temperature conditions.

In this work, all accessible magnetic and non-magnetic methods were used. The results obtained are excellent and enable the contributions of individual minerals to be assessed even quantitatively. The contributions of paramagnetic and ferromagnetic minerals were evaluated from the slopes of the high-field magnetization (hysteresis) curves. They are presented in terms of *Ferro/para content (%)*. It should be said that this term characterizes the ratio of ferro to para magnetizations at 0.5 T. It is pity that the para magnetization is not re-calculated into field-independent paramagnetic susceptibility. Subtracting it from low-field rock susceptibility, one could obtain also the low-field ferromagnetic susceptibility. Nevertheless, this would not affect the conclusion that the main carriers of low-field susceptibility are the paramagnetic minerals represented by phyllosilicates. In high-field torque curves, the torque is dominated by a $2\Theta$ component and its amplitude increases linearly with the field squared. This testifies dominant effect of paramagnetic minerals on rock's high-field anisotropy. Again, it would

be possible to convert the 2Θ torque components measured at variable fields into paramagnetic susceptibility differences. By combining high-field (hysteresis) magnetometry, high-field torque magnetometry and low-field AMS, it would be possible to determine complete low-field paramagnetic and ferromagnetic susceptibility tensors. Again, this possibility would in no way affect the conclusion that the main carriers of the low-field susceptibility are the paramagnetic minerals represented by phyllosilicates.

I am not sure whether the term HF-AMS is the most convenient one. Namely, in very high fields when the ferromagnetic minerals are saturated magnetically, the magnetization curve passes parallel to the abscissa. If the susceptibility is defined as the slope of the magnetization curve, the high-field susceptibility would have no physical meaning. Even though the magnetization curve of the rocks investigated increases with the field and the term high-field susceptibility cannot be rejected, I would recommend use the term high-field magnetic anisotropy (HF-MA) instead.

Detailed investigation of the ferromagnetic minerals carrying the natural remanent magnetization (NRM) has shown extremely important, because it helps explain why the NRM in Lower Triassic rocks of the Vardebuka Formation is extremely complex and multi-componental. It has shown that some minerals, perhaps most of them, are not primary and coeval with sedimentation, but originated later, during later geological history. Nevertheless, at least some of them originated before final creation of the structure of the West Spitsbergen Fold and Thrust Belt (WSFTB).

The AMS was primarily investigated in the WSFTB. In order to better identify its possible ductile deformation, the AMS was also investigated in stratigraphically and lithologically equivalent foreland rocks of Sassenfjorden area, which are presumably ductile deformation free. It was found that the AMS of these two groups of rocks differ clearly and the difference is explained by assuming that the WSFTB rocks underwent stronger ductile deformation than the foreland rocks. This is in agreement with macroscopical structure of the rocks investigated; the strata of the WSFTB are intensely folded, while the foreland rocks are sub-horizontal.

Even though the AMS was the main working method, the candidate used also anisotropy of magnetic remanence (AMR) and anisotropy of out-of-phase component of magnetic susceptibility (opAMS). Using these technique has shown very fruitful, because the AMS dominantly indicates in the case investigated the fabric of paramagnetic minerals, while the AMR and opAMS indicate solely the fabrics of ferromagnetic minerals. As demonstrated in the thesis, these groups of minerals may represent different stages in the rock deformation. These investigations are in the very beginning on the world scale and will probably require much additional studies to become standard techniques of structural analysis of rocks. Nevertheless, they seem to be very prospective at the moment.

Mrs. Katarzyna Dudzisz clearly demonstrated in her thesis that she is able to work with international scientific literature in a creative way, i.e. to read and critically analyse it, to discover remaining problems, and to formulate the aims of her follow-up investigations. She mastered a wide range of rock magnetic, AMS, and palaeomagnetic techniques convenient to the problems solved. She also showed good organizational skills, the methods that were not available at the PAS, she made abroad (Switzerland, Czech republic). She is able to correctly analyse the results of the measurements, creatively interpret them geologically, and to draw adequate, not overinterpreted, conclusions. She proved to be full-blown scientist.

**Final evaluation statement**

The thesis by Katarzyna Dudzisz represents an important contribution to the understanding of the geology of the Svalbard Archipelago. The results of both AMS and palaeomagnetism investigations are interpreted on a high scientific level and are presented in such a way to meet international standards, which is testified by the acceptance of their publications by renowned scientific journals. The thesis no doubt meets the criteria described in art. 13(1) of the Act of 14 March, 2003 of the Laws of the Republic of Poland laid down for the PhD degree in geological sciences and is ready to be defended orally. *I apply for admission of Mrs. Katarzyna Dudzisz to further qualification proceedings.*

Hrouda

August 14, 2018

Prof. RNDr. František Hrouda, CSc.