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CZECH ACADEMY OF SCIENCES **INSTITUTE OF GEOLOGY**

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Review of doctoral dissertation

Rock magnetic properties of lower Paleozoic gas-bearing shale rocks from northern Poland

presented by *Dominika Krystyna Niezabitowska* in January 2021.

The present doctoral dissertation is a very complex scientific study dealing with magnetic properties of Ordovician/Silurian gas-bearing shales from the Baltic Basin, Pomerania region, northern Poland. The main goals are to define the preferred orientation of magnetic minerals, sedimentary and diagenetic factors controlling the precipitation and preservation of magnetic particles and the relationship between magnetic minerals and organic matter content. These goals point to a common aim to apply rock magnetic methods for more effective hydraulic fracturing in an intended shale gas extraction. The studied material was provided by shale gas industry and comes from six exploration wells from depths of 3500-4000 m.

The actual thesis is a compendium of three published high-quality peer-reviewed papers in which the present doctoral candidate is the principal author with claimed contribution at least 70%. Based on the original submission dates, the papers represent the state of the art of ca. 2018-19.

1. Niezabitowska, D.K., Szaniawski, R., Roszkowska-Remin, J., & Gąsiński, A. (2019): Magnetic anisotropy in Silurian gas-bearing shale rocks from the Pomerania region (northern Poland). **Journal of Geophysical Research: Solid Earth** (author contribution: 70%, originally received: July 2018)
2. Niezabitowska, D.K., Szaniawski, R., Jackson, M. (2019): Magnetic mineral assemblage as a potential indicator of depositional environment in gas-bearing Silurian shales from Northern Poland. **Geophysical Journal International** (80%, December 2018)
3. Niezabitowska, D.K., Roszkowska-Remin, J., Szaniawski, R., and Derkowski, A. (2021): Magnetic susceptibility variations in lower Paleozoic shales of the western Baltic Basin

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(northern Poland) – a tool for regional stratigraphic correlations and the decoding of paleoenvironmental changes. **AAPG Bulletin** (75%, August 2019)

The actual paper compendium is introduced by a concise and easy-to-understand (1) introduction outlining the problem to be solved, (2) summary of the results of each published paper and (3) an overall summary combining the results of all three papers, pointing to some unsolved problems and proposing some ways of future research aimed to solve them. In the individual papers, I highly appreciated the methodology chapters providing a precise but concise description of used methods and data processing techniques. Respective discussion chapters, the cornerstones of each publication, are very well written discussion multiple aspects of observed phenomena. Each paper is accompanied by rather extensive list of citations indicating that the doctoral candidate went through a great deal of literature in order to validate her research results.

As the individual papers were subjected to a thorough peer-review process, their scientific merit and originality is certainly guaranteed. I have, nevertheless, some minor questions or comments:

Paper #1

1. How the original drill cores were oriented?
2. I really miss the supplementary figures. I understand that in the original paper they were accessible only electronically, but in the actual dissertation they may be discussed more thoroughly. It would be interesting to see the comparison of SEM-BSE preferred orientation, graptolite stipes orientation and AMS lineation. Could this issue be presented/discussed during the defense?
3. Do you see any evolution of AMS parameters (principal direction, degree of anisotropy and fabric shape) with depth?
4. Could you present anhysteretic remanent magnetization coercivity spectrum? By selecting AF field window to 0-100 mT for the AARM, you address the preferred orientation of both MD and SD of [relative low-coercivity, i.e. magnetite] particles. Was it possible to try a partial AAMR, in e.g. 0-15, 30-100 mT coercivity windows to discriminate between detrital and authigenic magnetite?
5. Were the graptolite stipes measured in bedding planes in places where the original drill cores came accidentally apart or was the core intentionally broken in certain places to access the bedding planes? You conclude that the preferred orientation of graptolite stipe is just by water current without any tectonic influence. Have you considered the influence ductile deformation by assessing the spacing of graptolite thecae and/or a change in angles of the thecal aperture (c.f. Goldstein et al. 1998)?

Paper #2

1. You claim that frequency dependent susceptibility would be the superior method for addressing the content of SP nanoparticles but, due to the high contribution of paramagnetic

signal, this method could not be performed (page 8). Have you actually tried $k(f)$ measurements? If yes, would you present your results during the thesis defense.

2. If any future research is done, I suggest to measure out-of-phase susceptibility and decay of viscous magnetization as alternative proxies for the content of SP particles. The latter method is free from the contribution of paramagnetic signal.

Paper #3

1. You claim that you had expected the correlation between MS and natural gamma-ray log (page 17). Why did you expect it?
2. Did you use separate logs for K, U, Th? If yes, is there any correlation between K vs MS, U vs MS, and Th vs MS and other proxies, e.g., TOC? U is usually bound to organic matter, K could be linked to feldspars or micas, Th is associated with stable detrital fraction (e.g. zircons, monazite).

In summary, the present dissertation represents a very high-quality scientific work. One of the papers results from Dominika's short term fellowship in the Institute for Rock Magnetism (University of Minnesota) where she collaborated with Mike Jackson who can be considered as one of the leading experts in rock magnetism. In addition to her papers, I met Dominika in several international scientific meetings where she showed her good ability to present her work to a wide audience. All that combined testifies that Dominika Niezabitowska is able to work as an independent researcher and qualifies her to obtain a doctoral title.

I highly recommend the present doctoral dissertation of *Dominika Krystyna Niezabitowska* for defense.

In Brno, 30th March, 2021



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References

Goldstein et al. 1998: Deformed graptolites, finite strain and volume loss during cleavage formation in rocks of the taconic slate belt, New York and Vermont, U.S.A., *Journal of Structural Geology*, **20**, 1769-1782.

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