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Prof. Mariusz Majdański
Institute of Geophysics
Polish Academy of Sciences
ul. Księcia Janusza 64
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Dear Prof. Majdański,

Thank you for the invitation to serve as External Examiner for the doctoral examination of Miłosz Mężyk. I am pleased to be able to provide my assessment of his dissertation entitled "Imaging the East European Craton margin by reprocessing and interpretation of the PolandSPAN reflection seismic profiles supported by machine learning". After careful reading, I strongly support the admission of Mr. Mężyk to the public defense of his doctoral dissertation, and provide a more detailed assessment below. I provide a list of questions for the candidate at the end

Near-vertical seismic reflection surveys provide the highest resolution images of the subsurface, and over the last 50 years, such surveys have revealed previously unknown crustal structures, revised numerous tectonic models, and revolutionized our understanding of the continental crust. In his PhD dissertation, Mr. Mężyk has focused on topics that I regard as fundamentally important to the optimal exploitation of deep crustal seismic reflection surveys as a complement to other geoscientific studies of the continental crust and uppermost mantle. Though considerable resources are often devoted to the processing of seismic reflection data, less effort is applied to extracting the maximum amount of information for interpretation. Likewise more emphasis should be placed on improved characterization of the near-surface through which reflections from the deep crust must propagate, but the considerable time required to pick the arrival times for inversion of the first-arriving refractions makes this difficult. In fact, many existing reflection datasets could be reprocessed and improved if this picking problem could be solved in an efficient and automated fashion. Mr. Mężyk is to be commended for developing creative and original approaches to both the first-break picking and interpretation problems.

In his study of first-break pricking, Mr. Mężyk devises various attributes that can be used to characterize a recorded seismogram, and then incorporates them into a machine learning approach that he evaluates using different algorithms, comparing the results to existing auto-picking and manual methods. He clearly demonstrates an improved accuracy with the machine learning approach, even when using a relatively small training dataset. It should be noted that it is particularly difficult to pick first arrivals on vibroseis data such as the PolandSPAN survey, so his work is a welcome addition to the available techniques, though it's not clear how easy it is to apply the method to different seismic lines where the statistical properties of the data may differ. Mr. Mężyk has then used his expertise in machine learning and abstraction of seismic data properties to extract using clustering analysis a number of fundamental attributes from migrated seismic reflection images to aid in their interpretation. Mr. Mężyk has clearly understood key concepts in machine learning and data abstraction, applying them in creative ways to exploration seismology.

The PolandSPAN regional seismic reflection profiles are an important resource for understanding the present structure and evolution of the crust in eastern Poland, and the reprocessing of these data by Mr. Mężyk represents a considerable amount of work. He has demonstrated a good understanding of reflection processing techniques, including the extended correlation method used to increase the recording time to 22 s. His interpretation of these data utilizes the various post-stack attributes he obtained from his clustering analysis, and clearly presents some significant results that refute, or refine, previous interpretations based on earlier low resolution seismic data and/or geological constraints. For example, though the suture between Fennoscandia and Sarmatia has been known for some time, the seismic data reveal for the first time the crustal ramp along which Sarmatia was thrust over Fennoscandia crust, and the broad nature of the crustal root. These are difficult seismic data to work with owing to their relatively low signal-to-noise ratio, but I wonder if there is more information that could be extracted; for example, could the apparent change in the thickness of the sedimentary strata near CDP 8700 on line 1000 be an indication of the later extension/rifting mentioned in the text? Nevertheless, I'm sure these new result will be a revelation to the geoscientists who have previously studied this region.

In my opinion, this dissertation includes a number of original contributions not only in terms of the development of new techniques for the processing and interpretation of deep crustal seismic reflection surveys, but also in terms of a

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new characterization of the continental collision zones that gave rise to the East European Craton during the Paleoproterozoic.

The thesis is well organized, and the written English is of reasonable quality with the meaning quite clear, which is probably a result of Mr. Mężyk publishing three peer-reviewed journal publications on his research, for which he is to be commended.

Sincerely,

Andy Calvert

Andrew J. Calvert
Professor
Department of Earth Sciences

Questions for Mr. Mężyk to answer at the defence:

1) Write down the formula for the amplitude of a linear vibroseis sweep as a function of time, explaining the meaning of all the variables in the expression. How is the difference between an upsweep and a downsweep represented in this formula?
2) How were the amplitude decay curves, for example in Fig. 4.7 corrected for the reduction in bandwidth at late times due to the extended correlation?
3) Please give a brief overview of the role played by the pre-FB, post-FB, and ensemble models in the machine-learning algorithm for picking first arrivals.
4) What are the characteristics of secondary arrivals that give them a high probability in the FB prediction result? Is it possible to use multiple traces to reduce this probability?
5) Can you show a plot of the picks from the FB-picking algorithm superimposed on a shot gather of field data?
6) In the cluster analysis, you use two amplitude values: sample value, and 3x3 RMS amplitude. What would be the effect of using coherency enhanced amplitude estimated along the most coherent dip? Can you preserve or

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extract lateral coherency of the phase of seismic arrivals, so that it is possible to follow better peak-to-peak or trough-to-trough correlations?

7) What additional information does your cluster analysis bring to your interpretation of line 1000, on page 48 for example?
8) What are the deepest, reflective sedimentary strata on line 1000 (page 48, 75)?
9) Are the pink bodies in the igneous crust interpreted to be plutons; if so what is your justification? Could these zone of low reflectivity be due to poor signal penetration through the sedimentary section?
10) What is your justification for interpreting the Sarmatia-Fennoscandia suture as the thick blue line on line 1000 in Fig. 5.6?
11) What is the explanation for the offset at the base of the sedimentary section at CDP 8700?
12) What do you think is the most important original result in your PhD dissertation?

Typographic errors:

p.27: TN should be FP for False Positive
p.40: There is no Fig. 4b