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Review of the PhD thesis

‚Studying a possible inclusion of selected methods of estimating stress field changes and seismic activity to the analysis of anthropogenic seismic processes'

by Maria Kozlowska

The PhD thesis by Maria Kozlowska comprises studies related to anthropogenic seismicity in mines. The focus of the studies performed is on the spatiotemporal occurrence of seismic events in relation to mining activity and in relation to induced stress changes with the aim to investigate the feasibility of methods assessing the impact of exploitation and induced coseismic stress changes on the future occurrence of earthquakes and their associated hazard.

The thesis is written in cumulative form. The scientific backbone is represented by a total of four publications in all of which Maria Kozlowska is the first author. Three of the publications were published in peer-reviewed journals with high reputation. One publication is written in Polish (which is why I cannot judge on the content in detail other than from the Figures and their captions; but to a large extent it seems to provide the foundation for the follow-on publication in Appendix 2). Three publications in ISI journals that are already published at this state of the PhD is a substantial achievement of the candidate and documents the strength of the scientific work contained in this thesis.

The topic covered in this thesis is of central scientific but also socio-economic relevance since anthropogenic seismicity is a concern evident to mining but also other human activities in different mine settings and geological reservoirs (such as e.g., geothermal, shale gas, waste-water disposal). A quantitative understanding of the physical processes is of great importance but several questions remain to be unanswered as of

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today. This makes the thesis by Maria Kozlowska important also beyond the seismological, geophysical and mining communities.

The paper Kozlowska (Acta Geophysica, 2013, Appendix II) presents the analysis of spatial distribution of induced seismicity in the Rudna Copper mine. The study appears to be an extension of the paper Kozlowska (2012, Appendix 1). The results show that most of the events –including the largest ones- occur within 50m of the working face stressing the direct relation between the mining activity and the occurrence of induced seismicity. Moreover, the results also show that the high-seismicity areas in mines are in good accordance with high-stress areas as predicted by models in the relevant literature. The study is sound while the striking difference on horizontal (~25m) and vertical (~400m) hypocenter location precision could have been discussed in more detail.

The following chapter (Kozlowska et al., Journal of Geophysical Research, 2015, Appendix III) has been published in a journal with very high reputation. It makes use of a unique data set of several thousand of aftershocks of a potentially mining-induced M2.2 earthquake in the Mponeng gold mine in South Africa by applying the rate-and-state approach. The results indicate that induced seismic events may be followed by a stress relaxation expressed through aftershocks located on the rupture plane and in regions of positive Coulomb stress change. One of the main points of this work is that it extends earlier similar studies down to a magnitude level of M~ -3.4 which is novel to my knowledge and thus complements our understanding of how the stress is relaxed in mining conditions at >3 km depth. Besides, the results also allow assuming that such processes are similar at all scales studied so far.

In the final chapter of the thesis (Kozlowska et al., Int. J. Rock Mech. Min. Sci., 2016, Appendix IV) studies on the seismicity pattern related to coupled natural and human-induced plus coseismic stresses in the Bobrek coal mine in Upper Silesia are presented. Particular attention is given to a M3.7 event that occurred near the coal-mining activity, but at greater depth. Studying this event in detail using advanced seismological approaches and geomechanical modelling leads the author(s) to the conclusion that this event was in fact a tectonic event triggered by the mining activity and that the following seismicity was affected by coupled natural, exploitation-induced and coseismic stresses. One particularly interesting result of this study is the statement that this event was a 'slow-rupture event'. Since the observation of a M3.7 in direct vicinity to mining activity and in presence of a reasonably good station coverage, the nature of this event could have been studied in greater detail. The conclusion on a slow rupture in conjunction with the absence of a typical aftershock activity is a striking observation that deserves strong attention. This does not mean that a potential follow-on study necessarily should have been part of this thesis but might be seen as potential future work.

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In summary, the PhD thesis comprises extensive work of high quality which has been documented by the fact that three first-author publications in ISI journals have been published by M. Kozlowska. As for the thesis a slightly more extended in-depth introduction into the methods used throughout the different studies would have been beneficial (such details by nature cannot be included in published manuscripts but form their basis).

Overall, I state that the PhD thesis of Maria Kozlowska meets the requirements of the law on academic degrees and title and degrees and title in the arts and I request for admission of Maria Kozlowska for the further stages of a doctoral degree.

(Prof. Dr. Marco Bohnhoff)

Berlin, June 27, 2016

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