



# UNIVERSITY OF TWENTE.

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## FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION

FROM  
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DATE  
13 August 2013  
OUR REFERENCE  
ESA-020.13/ca

PAGE  
1 of 3

Dear Dr. Kolar,

Thank you for inviting me as external examiner to review the PhD dissertation of Mrs. Veronika Kopačková. Meanwhile, I read the PhD dissertation entitled 'Hyperspectral Remote Sensing for Environmental Mapping and Monitoring' prepared by Mrs. Veronika Kopačková with great pleasure. It presents an analysis of various remote sensing data sets along with field samples to link spectroscopy through foliar chemistry to mining pollution. In terms of analytical techniques (for spectral analysis) there is limited innovation in the way the author deals with the image data and correlates that with the field data. This is not a criticism, I think it is absolutely legitimate to work with existing (and demonstrated) techniques as this adds to the confidence one has on the results. In terms of a better understanding of the local mining pollution and in general in exploring the relation between spectroscopy and mining pollution (directly through mineralogy and indirectly through vegetation response) there is a lot of merit in the work. There is not so much literature on these topics presented in the thesis and the present thesis adds to the body of literature. It presents a good case study that serves the scientific community. Particularly the work on spectroscopy versus Ph in a mining setting is an excellent addition to our scientific understanding.

Below I provide some comments on the various chapters before arriving at a general conclusion on the dissertation as a whole.

Chapter 1 is an introduction to the thesis. It reads as a bit of mix of things. Some spectroscopy, some aspects of the mining operation, some geochemistry. The hypothesis and objectives follow logically from this. Main research questions relate to direct mapping of Ph using surface mineralogy and indirect mapping of AMD using foliar geochemistry and vegetation stress. Some minor remarks: Introduction instead of 'introduction' in the header. Referencing should be standardized; now some of the names are in capital letters and others not.

Chapter 2 presents an analysis of ASTER data to map Ph zones. The resulting map is validated with field data to an overall accuracy of 75%. Methodologically the work is done properly; there is not a lot of innovation in the methods. Nevertheless the results are interesting and there is not a lot of similar literature on Ph mapping so from this perspective the work contributes to the literature available. It is not clear how the differences in spatial resolution between the image data and the field Ph data is dealt with. The statistics may suffer from this resolution problem. Perhaps this explains the 25% unexplained variation. The chapter is not clear on how to interpret the 75% accuracy; is this good? Enough?

Chapter 3 is an analysis of hysmap data to map Ph through an analysis of surface mineralogy. This is one of the best chapters in the thesis. Very thorough image analysis, very well done and very well presented. Seemingly the mapping accuracy is of the same order as the ASTER results in chapter 2. It would, for the

P.O. Box 217  
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DATE  
13 August 2013

OUR REFERENCE  
ESA-020.13/ca

PAGE  
2 of 3

cross referencing of the thesis, be of interest to make a comparison with the results of chapter 2. Now the two 'Ph chapters' seem rather disconnected while they center on the same problem and the same area.

Chapter 4 deals with mapping of vegetation health status of Norway spruce using HyMAP data. The analysis is very straightforward. However it is not clear to me how the HyMAP image subset that is analyzed in this chapter relates to the HyMAP images used in Chapter 3. Visually they do not seem to compare. From fig 4.7 I also question the statistical seperability of the clusters. Seemingly there is a lot of overlap. The scientific literature is also not conclusive on the use of the REP as a stress indicator. The present study suggests that blue shifts are indicative of stress but other studies more general concluded that a anomalous REP against a unified background would be an indicator of stress. I doubt the validity of figure 4.10 based on 6 samples. Some critical notes in the text would be appropriate. Also on the other box plots it would be good to indicate on how many samples these are based ( $n=?$ ). Minor comments are that again another style of referencing is used now using numbered references in the text. Somehow the thesis would benefit from unifying this. Another minor issue is that the numbering jumps from 4.5 to 1.1.1. It seems the chapter is based on a paper that is first authored by Mišurec. In our university system a thesis can only be based on papers that are first authored by the PhD candidate. This to ensure that the work and the intellectual property of the work is solely by the PhD candidate. As it stands it is not easy to conclude the work that Mrs. Kopačková has done on the chapter. Overall a good chapter.

In chapter 5 a multitemporal remote sensing based analysis of vegetation stress is presented using HyMAP images acquired in two subsequent years. I think that this is a very interesting data set, rather unique. I am though rather critical toward the results as the chapter is written in a rather non critical manor. All the changes detected and that are processed out of the images are directly attributed to changes in the foliar chemistry and linked to stress. Errors in the processing, uncertainties in the assessments etc are thus completely ruled out. Somehow an analysis of an area that is not affected by potential stress should be included to avoid bias. I think this is a rather unique data set and a unique approach; a good chapter.

Chapter 6 deals with a comparison of soil chemistry data at various soil profile horizons in relation to forest foliar chemistry. In principle this is a noteworthy exercise to do as it can provide a more profound understanding of the underlying processes. I doubt however whether it is logical to include this as a separate chapter in the thesis and certainly it would be more logical if this analysis precedes the image analysis on the Norway spruce. The chapter concludes that the study contributes to better understanding of the relationships between soil and foliar chemistries, particularly in coniferous forests affected by anthropogenic pollution. However I had difficulties to deduce this from the correlation matrices. It just seems that the chapter is not completed and needs additional work to be more convincing. This chapter reads like it is not finished.

Overall I rate the dissertation entitled 'Hyperspectral Remote Sensing for Environmental Mapping and Monitoring' prepared by Mrs. Veronika Kopačková as good. It is based on a number of accepted and submitted ISI journal papers which demonstrates that Mrs. Veronika Kopačková is able to conduct independent research of good quality. She also has presented the work at various international conferences and contributed to education materials based on her work. I have no doubt that Mrs. Veronika Kopačková should be admitted to the public defense of her dissertation and I support awarding the PhD degree based on the dissertation. There is in my view no need for additional work on the dissertation although the readability would improve by choosing one universal reference system throughout the thesis. I would be in favor of one exhaustive reference list rather than references per chapter (which results in a lot of duplication). As the chapters are rather based on papers there is some overlap between the chapters (duplications in introducing the study area etc). I also feel that more cross referencing between chapters could improve the thesis. There are obvious links between the chapters, for example the comparison aster versus hymap, which are not explored. I would also advocate to devote more attention to process based

DATE  
13 August 2013

OUR REFERENCE  
ESA-020.13/ca

PAGE  
3 of 3

models as the emphasis is very much on statistical modeling. Thus a conceptual geochemical/ geologic model explaining the relationship between Ph and mineral stability (figure 1.2 but than in a spatial context and adapted to the local situation) and a conceptual model for uptake of pollutants by the vegetation would add to the quality of the work. This would also allow to translate the results to other geographic areas, or in other words it would allow to draw general/universal conclusions from the work that would apply to similar cases in other areas. Many studies in spectroscopy rely solely on statistical modeling and this is absolute legitimate to do, however I feel it will enrich the analysis to focus more on the interpretation of the results and the understanding of the underlying processes. The public defense would likely be a good opportunity to discuss this with the candidate.

In conclusion: As the thesis of Mrs. Kopačková is in large based on journal articles and since the thesis is of good scientific quality and up to international standards for a PhD I have no hesitation to support to admit Mrs Kopačková to the public defense of the thesis. Assuming she defends the theses properly I would support awarding the PhD degree based on the work presented in the thesis.

Yours sincerely,



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