DOCTORATE OF THE CHARLES UNIVERSITY IN PRAGUE AWARDED BY THE FACULTY OF SCIENCE

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REPORT MADE OUT BY: MILLER John

REGARDING THE AUTHORIZATION OF DEFENSE OF:

METELKA Vaclav

Thesis title: "Geophysical and remote sensing methodologies applied to the analysis of regolith and geology in Burkina Faso, West Africa"

1°) GENERAL EVALUATION

By comparison with recently defended PhD theses or PhD theses that you have personally heard of in the same field, do you think this one is:

◆ **WORTH BEING DEFENDED**

☐ YES (without any changes)

☒ YES (with minor changes <u>AFTER</u> the defense)

☐ YES (with minor changes <u>BEFORE</u> the defense)

☐ YES (with major changes)

☐ NO

If yes, what would you say about the thesis:

◆ **SCIENTIFIC LEVEL**

☐ EXCEPTIONAL   ☐ EXCELLENT   ☒ VERY GOOD

☐ GOOD   ☐ FAIR

◆ **PRESENTATION**

☐ EXCEPTIONAL   ☒ EXCELLENT   ☐ VERY GOOD

☐ GOOD   ☐ FAIR   ☐ TO BE REDONE

.../...

2°) <u>CRITICAL REVIEW AND COMMENTS</u> (A detailed report may be attached, if needed, as an annex. The report has to be accompanied by the evaluation sheet supplied above**)**

I have no hesitation in recommending this thesis is worth being defended with minor changes after the defence.   I enjoyed reading this thesis and the overall quality is very good to excellent.

Firstly I will highlight some of the key aspects of the thesis that I think warrant the author being awarded a doctorate. I then cover some aspects that I think need to be addressed in the thesis after the defence. This is then followed by a list of grammatical corrections that I think will improve the overall quality of the thesis, but I will leave making these minor changes to the discretion of the author.

This thesis has 4 main chapters of new research. The first, third and fourth chapters clearly represent work undertaken by the author. The second chapter represents the utilisation of the new geological map presented in Chapter 2 to assess the Crustal evolution of Burkina Faso - this chapter is work first authored by Lenka Baratoux.

In terms of core outcomes from this thesis;

1) it presents a very robust and integrated approach for undertaking geological interpretations that should be used as a bench mark for work in other regions (Chapter 1). Many new structures have been identified (particularly with the intrusives) ,and a much better map of the distribution of the geological units has been produced. This is a core piece of data that underpins any interpretation of the system. Chapter 1 has already been accepted for publication in an international journal. In too many studies the geological and structural maps lack rigor, and the rationale for a given interpretation cannot be sufficiently queried (for example why has a certain unit been interpreted in one area and not another). Chapter 1 clearly outlines why certain units and faults have been interpreted and Table I-3 is an excellent example of the authors methodology (which defines lithologies via petrophysical and geophysical properties). If more maps were produced in this manner it would facilitate rational (and not emotional) discussion about the validity of different interpretations using data such as Table I-3 as the core of any discussion. One core aspect of this work is that the quality of the data inputs are clearly defined (for example on page 42 it lists the quality of the magnetic data) and it also gives a very defined work flow for the interpretation (e.g. page 48). Section 6.2 that discusses the strengths and weaknesses of the different data sets (page 70) is excellent. This robust interpretation also allows the researchers to clearly state when there are issues with the interpretation - for example in Chapter 2 on page 87 they state they are "less confident about the stratigraphy of the Banfora Belt".

2) The thesis really tackles the use of spectral data on weathered rocks in a very broad and comprehensive way that I have not seen done before. These types of data sets have been very useful in regions with unweathered rocks (e.g. in the Andes), but the application in more weathered terranes has been much less successful. Spectral data sets have massive potential for unlocking many aspects of a geological system (for example all geological surveys in Australia are currently scanning their drill core libraries with ASD devices similar to that utilised by Metelka in this study). One key outcome from the robust integrated interpretation he presents in Chapter 1 is that he highlights (on page 71) that landsat and ASTER data are not particularly useful for geological mapping (although he does highlight they are useful for mapping the regolith).   Chapter 3 of this

thesis gives an excellent over view of the effects of weathering on visible and infrared spectra and really explains the reason why this type of dataset hasn't been particularly useful for the regional geological interpretation of weathered terranes. This work is also combined with the presentation of a new spectral library. Figure III-5 really shows the effects of weathering on the reflectance curves. This clearly demonstrates the way different rocks can be discriminated when fresh, but with weathering the spectra become very similar (e.g. Tarkwaian versus the granite are quite distinct for fresh surfaces but are not that distinct on a weathered surface). This chapter elegantly highlights that there are differences in the spectral responses between rock types, but that they become much more subtle with weathering. This demonstrates that a lot more work will need to be done to characterise this before this method can be utilised more comprehensively in weathered terranes (*indeed chapter 3 should be mandatory reading for any geological surveys doing routine ASD work on their drill core libraries*). Figures III-8 gives a really good example of fresh rocks to weathered rocks to soil. I noted he cites work by Dr Tom Cudahy from CSIRO. I have actually been doing projects with Tom and we have been having a lot of problems with the utilisation of hyperspectral data for geological mapping. This thesis has really clarified for me what the issues are.

3) Chapter 4 gives a new approach to regolith landform mapping using neural networks (and he highlights that Neural Network Classifiers are better than Standard Maximum likelihood classifiers. The results from this work are excellent and have a broad range of applications. One key outcome he also highlights in Chapter 4 is the power of jointly using Gamma Ray Spectrometry and SRTM digital elevation models for this type of mapping. For example eTh/K ratios can map duricrust. Once we became aware of this research outcome at the University of WA we have been utilising the same approach in our research programs*. This highlights that his research has already had impact in other research institutions.*

4) The new geological and tectonic model presented in Chapter 2 in my view is a landmark piece of *integrated* work on the geology of a region of west Africa. This paper has been accepted for publication in an international journal will be very heavily cited. Whilst Metelka is not the lead author, his geological map is one core aspect that underpins the paper. One issue I highlight below is that I would like to have a clear statement on how much of Chapter 2 is work by Metelka. This is more to set a clear outline of what is his work and what isn't in the thesis. Even if the bulk of the geochemistry, geophysical and structural work presented in the paper was done by Baratoux this would not affect my recommendation that the thesis is worthy of a PhD.

5) One clear outcome from this thesis is that he outlines what data sets are useful for different aspects of geological and regolith interpretations - one very common question asked is "What data sets do I need to undertake a robust interpretation?".

The following points highlights some issues that I think need to be addressed after the defense.

1) There needs to be clear statement as to how much of Chapter 2 is his work. This has geochemistry, field structural data, forward modelling of a profile and a new geodynamic model. All research of this type is collaborative and I have no issues with the fact other workers are included as coauthors on the chapters of the thesis. In Australia a simple statement of % work by the different authors is made. Note as previously discussed, I am not concerned if the percentage of work by Metelka in this chapter is small, but I would prefer that it was clearly stated.

2) Whilst I am happy with the core chapters (1, 2, 3, 4). I think the introduction/ background section needs some additional text to provide sufficient background to chapter 4. Some explanation of what Neural Networks are and how they work is required. Chapter 4 has sufficient information for submission to a specialist journal, but not in my view for a thesis - this would be best addressed by adding some additional text to the introduction/ background section. Terms such as "confusion matrices" and ANN classifications are introduced in Chapter 4. On page 150 he should define what is an "Agglomerative Hierachial Clustering Algorithm" if the method is going to be discussed. Also he needs to cover regolith terminology in more detail - for example on page 152 in Chapter 4 he introduces terms such as "buttes", and "inselbergs", once again this is not an issue for a specialist journal, but needs to be defined in a thesis.

3) The introduction/ background section has a lower level of grammar that the following chapters which are much higher quality (and also the general conclusions section). This introduction/ background section needs a thorough proof read (for example it needs a lot more commas). At the moment this really stands out, is easily remedied, and it currently pulls the overall impression of the thesis down, as it is one of the first things a potential reader will come across.

4) He needs to rewrite/rethink part of his hypothesis 2 on Page 30. He states here that the plutons are emplaced by buoyancy driven forces However, on page 117, he states " "Emplacement of granitoids was structurally controlled"...."Gravity instabilities .... were not the dominant driving force". With some rewording of Hypothesis 2 this inconsistency in the thesis could be removed - this should also say the thesis will produce regional maps that will help to answer questions about buoyancy versus structurally controlled emplacement.

5) The abstract is not succinct enough - for example the start is just a cut and paste from the problem statement.

6) Personally I would like him to highlight in the problem statement that this type of fully integrated interpretation of this many data sets with a focus on *the bed rock geology and the regolith* has not been done in many areas globally (in fact I am not aware of any comparative studies of such a broad scope in weathered terranes). The examples he cites of Zumsprekel and Prinz 200 and Rowan et al., 2004, 2005 don't cover as much as this work does.

The following are some minor typographical corrections or questions I have where I think the meaning is unclear. If possible these should be corrected as it will improve the thesis.

Page 20, 1st paragraph, 2nd sentence. What does he mean by "typical Archean-like" Add some references here - there are some big changes in the Archean!

Page 21, 2nd paragraph, 2nd sentence. "apparently ordered" this gives the impression there is some doubt here - is the author questioning the model or not? Otherwise delete apparently.

Page 23, last sentence. Insert a comma and also "and". Change "subjective process because of that" to "subjective process, and because of that"

Page 26, 3rd sentence use parentheses' to define the terminology. i.e. change to **Schetselar et al., (2007) uses the term "Radiometric ....".**

Page 27, 1st paragraph. Define "PCA".

Page 41, 2nd paragraph, 3rd sentence. He cites Baratoux et al. submitted - this is Chapter 2 and should be mentioned as such. The same issue occurs on pages 50 and 68. This should be corrected throughout the thesis.

Page 41, 2nd paragraph, 4th sentence. Insert "to the" i.e. "extends *to the* Ivory Coast".

Page 61, 2nd paragraph, 5th sentence. reword sentence "lithological contacts, especially at places, where the duricrust" e.g. "lithological contacts, especially ~~at places,~~ where the duricrust"

Page 65, 1st paragraph, 3rd sentence. Insert "The". i.e. change "Magnetic grid" to "The Magnetic grid".

Page 65, 3rd paragraph, 1st sentence. Reword sentence "granite, can be very well traced" to something like "granite, can be *clearly* traced

Page 68, 2nd paragraph, 1st sentence. "and andesites can be well distinguished". Delete well, you could use easily i.e. "and andesites can be *easily* distinguished".

Page 68, 2nd paragraph 2nd sentence. "may be misinterpreted". The meaning not clear, is this misinterpretation being made by the author or others or potentially both? Reword the sentence.

Page 69, 2nd paragraph. Reword "S1 structures are difficult to be distinguished from the S2 shear zones" e.g. "S1 structures are difficult to distinguish from the S2 shear zones".

Page 69, 2nd paragraph. There's no need to cite a pers. comm. from me here (the reference he refers to is for the Subika deposit that is hosted entirely within granitoid in Ghana) - one of Allibone's papers on Ashanti/Obuasi has a map showing gold mineralisation inside a granite and would be a better citation.

Page 111, Paragraph 3. the sentence "Given that the tholeittic and calc-alkaline volcanic and plutonic rocks are indeed related to subduction zones" reads like a fact and not an interpretation. Alternate possibilities should be considered.

Page 116, 1st paragraph. Change " , or by Goscombe" to ", and by Goscombe".

Page 150. 7th sentence. "an" needs to be inserted in front of Agglomertaive. I.e. "Martelet et al., (2006) used Agglomerative Hierachial Clustering Algorithm" needs to be changed to . "Martelet et al., (2006) used *an* Agglomerative Hierachial Clustering Algorithm".

Page 152, top of page the term "apparently ordered" - same query as for page 21 i.e. "apparently ordered" gives the impression there is some doubt here - is the author questioning the model or not? Otherwise delete apparently.

Page 170, section 5.2, sentence 3. "important is also the". This needs to be reworded.

Once again I enjoyed reading this thesis.

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DATE 3/9/2011

SIGNATURE

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