

7th January 2020

Review of the Habilitation Thesis entitled “Electromagnetic Induction in the Earth’s Mantle and Oceans – Forward and inverse modelling”, submitted by Jakub Velímský to the Department of Geophysics, Faculty of Mathematics and Physics, Charles University Prague

Determination of the electrical conductivity of the Earth’s mantle using observations of the geomagnetic field started more than 100 years ago with the pioneering work of Arthur Schuster. By analysing geomagnetic daily variations as measured by a few ground observatories he concluded that the conductivity increases with depth; a result that Sydney Chapman confirmed in 1919 using more observatories.

A new era in the determination of mantle conductivity began about 50 years ago with the launch of satellites measuring Earth’s magnetic field globally. During the last decades quite a few studies were published on determination of mantle conductivity, but in the vast majority of these studies it has been assumed that conductivity only varies with depth (1D conductivity), at least for some specific region of Earth. The reason for this limitation is the (until very recently) incomplete global coverage with reliable magnetic observations, the lack of suitable forward and inverse schemes that are capable of modelling 3D conductivity structure, and the fact that a thorough inversion for the 3D mantle is much more complicated and computer intensive compared to determination of a 1D conductivity structure.

Studying the Earth’s mantle and oceans using geomagnetic field observations is a topic that Jakub Velímský followed during his scientific career. The submitted habilitation thesis summarizes the present status of these investigations.

Electromagnetic (EM) induction studies can be performed either in the time-domain or in the frequency domain. Both approaches have their specific advantages, and while most researchers use a frequency-domain approach for EM investigations for periods longer than, say, a few hours, Jakub Velímský follows the time-domain approach. He conducted pioneering work on this topic and developed the concept to a level that makes it comparable in performance to alternative methods.

The thesis consists of four chapters and an appendix with eight of the main scientific peer-reviewed papers authored by Jakub Velímský. After an introduction to the topic in chapter 1, Jakub presents the *Forward Modelling* scheme in chapter 2 (23 pages). *Inverse modelling* is the topic of chapter 3 (8 pages), followed by *Conclusions* in chapter 4. This first part of the thesis thereby presents details of the mathematical

and implementation background of the approach which are essential for understanding specifics of its applications to various geophysical problems, as specified in the published articles listed in the appendix.

The thesis is an original contribution to the determination of the electrical conductivity of the Earth's mantle using geomagnetic observations, and to the use of EM methods for studying ocean flow. I found it a real pleasure to read this thesis; the text is very well written, the used assumptions are always clearly stated, and the argumentation is convincing.

Based on this I strongly support the appointment of Jakub Velímský as an associate professor at Charles University.

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Finally, I would like to take the opportunity to express some more general remarks on Jakub Velímský, going beyond the specific task of reviewing his habilitation thesis. I have known Jakub for more than ten years, and I am impressed about the scientific quality and originality of his research. I have no doubt that he also in future will continue to drive rapid progress in the area of exploring Earth's magnetic field, that he will generate and implement important new ideas, and that he will greatly facilitate the education and training of the next generation of scientists.

In my understanding, an associate professor needs a solid scientific background, appreciation for the broader picture, and excellent communication and social skills. Jakub Velímský meets all these criteria. I am not in doubt that he would be a successful candidate for a similar position at my university.

Copenhagen, 7th January 2020



Nils Olsen