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Report on the manuscript « Details of magnetic reversal and paleosecular variations from sediments », by Hakan Ucar for the degree of Doctor of Philosophy from Charles University, Prague

Hacan Ucar's 215-page thesis manuscript is composed of seven chapters: introduction, four chapters articulated around three published papers and one paper in preparation, a conclusive chapter and an outlook chapter.
The overall objective of the thesis is to contribute to the understanding of the fascinating behavior of the geomagnetic field, in particular secular variation and reversals. To achieve this, the thesis investigates the relationship between magnetic reversals, paleosecular variation, the magnetic recording properties of sediments, and the fidelity of their paleomagnetic record.

The first study is based on the study of two lacustrine sedimentary cores collected in Poland to investigate the Holocene paleosecular variation of the geomagnetic field in Central Europe. This study is in preparation for publication. High-frequency variations of the intensity, declination and inclination are revealed by the paleomagnetic data, and interpreted as evidence for rapid regional variations of the geomagnetic field, implying non-dipolar contributions to the geomagnetic field. As explained below, I think a little additional work is necessary on this chapter before submission for publication.
The experimental work is of high quality. I have some minor concerns about the reliability of the interpretation in terms of geomagnetic field variability. Are there quantitative approaches to estimate the coherency between the results of your two cores? I would have liked to see a figure with a stereographic projection of your two directional datasets, and not only separate declination and inclination plots. Indeed, the geomagnetic field being vectorial, the separation into declination and inclination is somewhat artificial, and a stereographic projection is the best way to display the data. For the literature datasets that have both declinations and inclinations, a stereographic projection would be useful too, to compare your data with the existing one.
Some features in your relative paleointensity record seems quite at odd with the literature data, for instance a decrease of the paleointensity around 4600 BP. This decrease is by a factor of 5 in your core WTS1 between 4700 and 4500 BP, which looks very dramatic. A discussion about the reality of these change is necessary.
I have a concern with the identification of the Verwey transition on figure 2.5a on page 47. I cannot see it in the data. There is a very slight decrease of susceptibility around -155°C, but this is almost at the noise level. Moreover, the Verwey transition should be marked by an *increase* of susceptibility, and not a decrease. There is also a problem with the initial value of susceptibility in this low temperature experiment: it is strongly negative and steeply increasing. This is likely

due to some issue of sample holder correction associated to evaporation of liquid oxygen at the start of the experiments.
I have a concern too with the interpretation of the IRM acquisition unmixing (figures 2.5b and c). The overall signal is quite noisy, which is understandable, so the interpretation should be kept to reasonable levels. The identification of five components seems a little bit pushy, and I would simplify it to 2 or 3 components only.
On page 54, you indicate that your rock magnetic experiments and SEM observations indicate that magnetite is the main magnetic carrier. Why do you have two peaks, at about 10 and 30 mT) in your coercivity distribution then? On the same page, you mention that the diamagnetic behavior is linked to the presence of organic matter. I don't understand this affirmation.

The second study, published in Quaternary Journal, focuses on the magnetic pole evolution during the Matuyama-Brunhes reversal. It is based on cave sediments from the Czech Republic. The paleomagnetic record is compared with the literature data, with an interesting discussion about the existence of a precursor event before the actual magnetic reversal.
Although it has been peer-reviewed and published, I still have questions and comments.
On page 74, you mention that the transition of maghemite to magnetite upon heating can be seen with an increase in susceptibility values at approximately 250–350 °C. My understanding is that maghemite transforms into *hematite* in that temperature range, leading to an irreversible *decrease* in susceptibility (the so-called maghemite inversion).
There are noticeable differences between your paleomagnetic record and the literature datasets. In particular your declination never reaches 180°C, in contrast with literature data. Why is that?

The third study, published in Physics of the Earth and Planetary Interiors, focuses on the effects of greigite formation on the paleomagnetic record, with implications on the magnetostratigraphic interpretation and reliability. The study is based on lacustrine sediments from the Czech Republic. This work has been peer-reviewed and published and is very convincing.
I just have one comment, again, about the claim of identification of a Verwey transition in the low-temperature experiment of figure 4b on page 110. Like in the first study, there seems to be a problem with the start of the experiment due to evaporation of liquid oxygen, and more importantly I don't see an *increase* of magnetic susceptibility around the Verwey transition temperature.

In the fourth study, published in Cretaceous Research, Hacan Ucar is not the lead author, and contributed to the paleomagnetism and rock magnetism aspect of this paper more focused on the biostratigraphy. A normal polarity remagnetization is evidenced in the studied marine sedimentary sections, as observed in other parts of the Alps.
I have only one minor comment. On page 182, you mention that "Magnetic susceptibility (Fig. 5.11A), a parameter sensitive for magnetic mineral concentration, shows mostly dia- and paramagnetic signal". I agree that negative susceptibility implies the dominance of diamagnetism, but for the positive values (and even the slightly negative values), a minute amount of ferromagnetic minerals can have the same effect as paramagnetic minerals. And in fact, you mention later in the paper (page 183) that samples that show correlation between ARM and susceptibility are likely to contain ferromagnetic minerals.

In the outlook chapter, on page 214, you mention, writing about inclination shallowing in sediments, that "in future studies, individual records should be examined to determine the level

of flattening or whether flattening exists at all ». I think inclination shallowing (rather than "flattening") is a well-established phenomena that has been evidenced both experimentally (e.g., Tauxe and Kent, 1984) and in natural paleomagnetic record (e.g., Dupont-Nivet et al. 2002).
This outlook section is a little bit short. I would have liked to read what where the possibilities to go further with the big questions discussed in the thesis: magnetic pole movement during reversals and high-frequency variability of the geomagnetic fied.

Overall, this PhD manuscript is of high quality. Hacan Ucar has demonstrated his excellent mastery of an impressive variety of rock magnetism techniques and methods, and shows excellent expertise in the careful interpretation of diverse datasets. His interpretations of the paleomagnetic record of the studied sediments is carefully backed up by the rock magnetic data.
Having worked on cave sediments, lacustrine sediments, and marine sediments, Hacan Ucar has demonstrated that he is an accomplished specialist of sediments rock magnetism and paleomagnetism. He masters all the tools and concepts that are necessary to continue working on the topic of the behavior of the geomagnetic field as recorded by sediments. But his overall knowledge in rock magnetic and paleomagnetism will enable him to continue working on any topic that require rock magnetic and paleomagnetic analyses.
Besides his rock magnetism and paleomagnetism mastery, Hacan Ucar has had a strong publication activity in well-established journals during his PhD work.

In summary, the thesis manuscript present by Hacan Ucar is of excellent quality and attests that he has the necessary qualities and knowledge to obtain the degree of Doctor of Philosophy.

Jérôme Gattacceca