Variations of the Earth's magnetic field: dynamics and implications

Patrick Arneitz, Roman Leonhardt

In the middle of the 19th century continuous measurements of the geomagnetic field on a global scale were initiated by the Göttinger Magnetic Union. However, for scrutinizing geodynamo processes and long-term field evolutions an expansion of the data further back in time is essential. Therefore, we will use historical records of man-made measurements as well as records from remanent magnetized rocks or archeological findings. Past geomagnetic field variations will be modelled on the basis of these data. The results can be used for archeological dating.

Figure 1: Sundial, Georg von Peuerbach, 1455
Credit: Universalmuseum Joanneum/N. Lackner.

Since the first determination of the whole geomagnetic field vector, magnetic declination has varied by more than 15 degrees in Austria in the last 150 years. To extend the knowledge about such variations further back in time, our first investigations dealt with direct historical measurements of the geomagnetic field. In this context, magnetic declination measurements have been carried out for navigational purposes already at the beginning of the last millennium. The oldest known declination value is based on a sundial by Georg von Peuerbach in 1451.

In general, there is a large variety of potential sources in central Europe. For example, instrument constructors would stamp magnetic declination values on sundials, compasses, globes and maps from the 15th to the 19th century. Compasses were used to appoint the direction of mining tunnels. The hypothesis that the orientation of churches was also obtained with the help of compasses was rejected during our investigations in Lower Austria and Northern Germany. The growing interest in the geomagnetic field leads to an increasing number of measurements and an improved accuracy in scientific expeditions and at observatories. Regular observations of declination and inclination have been performed since the beginning of the 19th century in the monastery Kremsmünster. Moreover, surveys by the k. k. Navy in the Adriatic Sea date from that period.

Historical measurements before the middle of the 19th century provide only directional information about the geomagnetic field. Therefore, paleo- and archeomagnetic methods are essential to obtain intensity values. Within the scope of this project archeological samples will be collected and their acquired remanent magnetization will be examined. Moreover, uncertainties of applied methods will be investigated. Therefore the comparison of historical and archeomagnetic data will be fruitful.

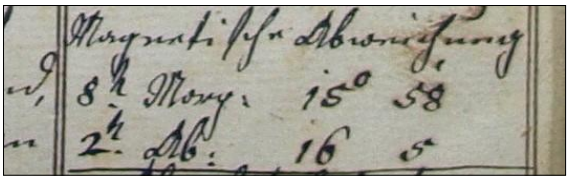

Figure 2: Declination recorded in the yearbooks of monastery Kremsmünster.

Finally, modelling of the geomagnetic field evolution will be performed with proper selection and weighting criteria for collected datasets. A Bayesian inversion method (Leonhardt and Fabian, 2007) will be used for a spherically harmonic representation of the field. The model results can be used for the interpretation of geodynamo processes, climatic changes or cosmic/solar particle impacts. Furthermore, adequate temporal field characteristics provide a valuable tool for archeological dating purposes.

Acknowledgement
The research is funded by FWF grant P24722-n19.

References:

Leonhardt R., Fabian K. (2007) Paleomagnetic reconstruction of the global geomagnetic field evolution during the Matuyama/Brunhes transition: Iterative Bayesian inversion and independent verification. Earth Planet. Sci. Lett., 253, 172-195.

Author:
P. Arneitz[1], R. Leonhardt[1]
1) Central Institute for Meteorology and Geodynamics, Vienna, Austria

Corresponding author:
Patrick Arneitz
Central Institute for Meteorology and Geodynamics
Hohe Warte 38, 1190 Vienna, Austria
Tel.: +43 (1) 36026 2510
e-mail: patrick.arneitz@zamg.ac.at