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Magnetostratigraphy of Pliocene and Pleistocene sediments of the Heidelberg Basin

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Introduction

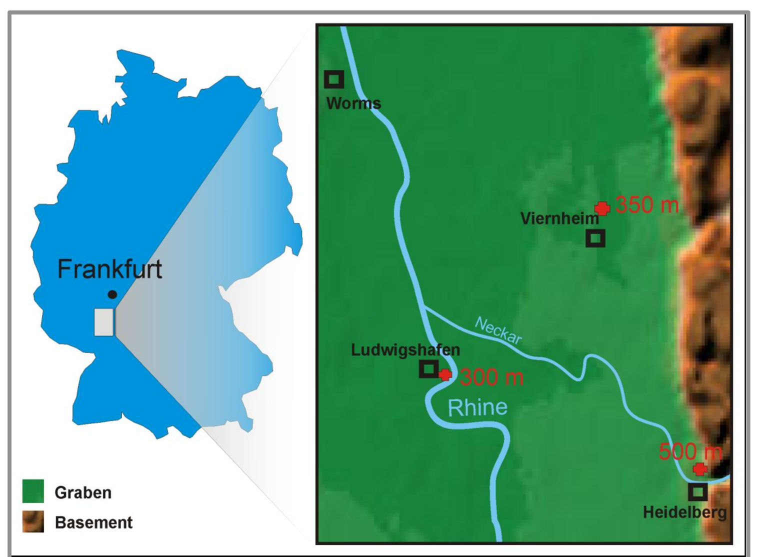


Figure 1.
Morphological map of the Upper Rhine Graben area embedded in a sketch-map of Germany (Röhr n.y., modified) . The drilled depths of the wells of Ludwigshafen (P34 and P36), Viernheim and Heidelberg are indicated in red.

The Heidelberg Basin in the North of the Upper Rhine Graben (Germany) acts as a trap structure for fluvial sediments delivered mainly by the rivers Neckar and Rhine. As a result of ongoing subsidence the Heidelberg Basin contains one of the thickest and most complete successions of Quaternary and Upper Pliocene sediments in Mid-Europe (Gabriel et al. 2008). However, terrestrial, highly resolved, long-ranging sedimentary records are generally hard to find. Furthermore, the fluvial to lacustrine gravels, sands, silts and clays of the Heidelberg Basin are expected to be basically discontinuous on short time-scales.

The sediments are made accessible by cores drilled at three locations (Fig. 1). The wells in Ludwigshafen are located at the western margin of the basin. The borehole in Heidelberg is situated in the centre of subsidence while the Viernheim drill core represents the central basin facies. First results of rock magnetic and rudimentary palaeomagnetic investigations of sediments from the Heidelberg Basin were presented by Rolf et al. 2005. Their most important finding is a change in magneto-mineralogy which was interpreted as a proxy for an environmental (climatic) change contemporaneous to the Plio-Pleistocene boundary.

Building upon the outcome of this work the project *'Environmental Magnetism' and Magnetostratigraphy on Pliocene and Pleistocene sedimentary sequences of the Heidelberg Basin* has arose. It is one of three individual grants of the research initiative *Scientific Drilling Heidelberg Basin* which are funded by the DFG (RO2170/8-1 and HA2193/10-1).

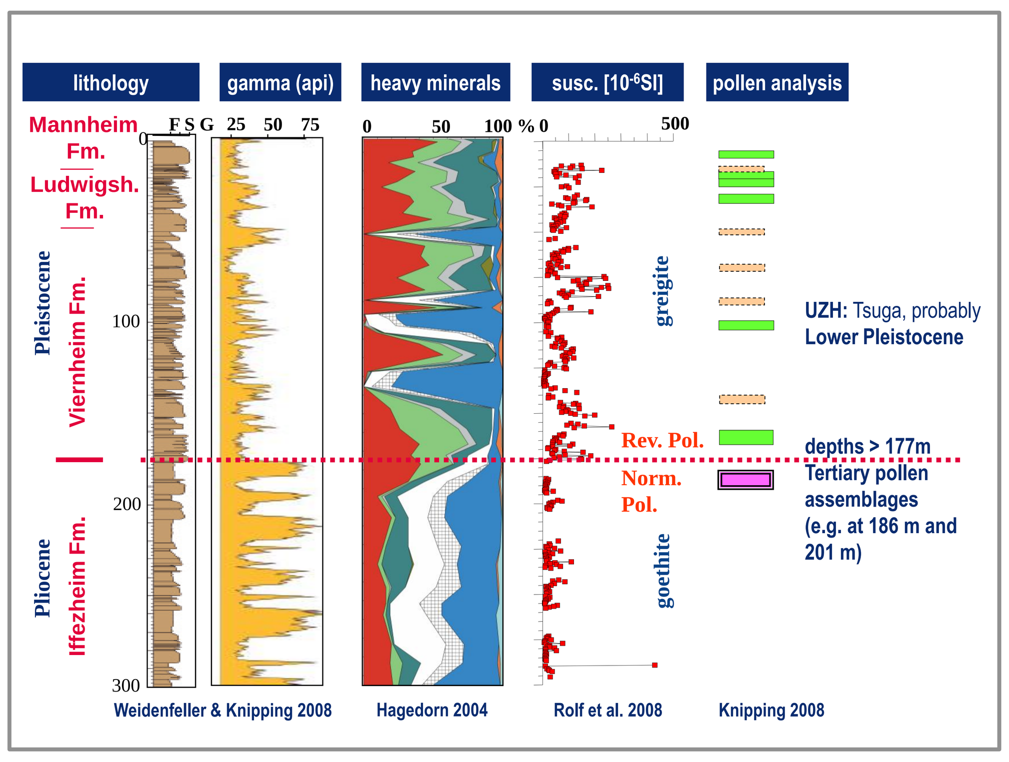


Figure 2.
General stratigraphy of the Heidelberg Basin at site Ludwigshafen P34. Correlation of lithostratigraphy, Gamma-ray- log, heavy mineral analysis, susceptibility profile and pollen data (image by Gabriel et al. 2010).

Based on pollen data (Knipping 2008), lithostratigraphic correlation (Ellwanger et al. 2008), heavy mineral analysis (Hagedorn 2004, Hagedorn & Boenigk 2008) and susceptibility data a preliminary relative stratigraphy has been established (Fig. 2). The magnetostratigraphy will provide an independent complementary chronology and will improve the chronostratigraphic framework.

Methodology and first results

Discrete samples were taken from cores from Viernheim, Heidelberg and from two cores of Ludwigshafen Parkinsel (P34 and P36) in order to use the recorded geomagnetic field to provide age constraints for the sediment encountered. Due to the missing record of the azimuth of the cores the Z-direction (downwards) is the only given orientation and the polarity is defined by the inclination component only. The location entails a bimodal distribution of the inclination values for primary polarity-records around +67° and –67° for normal and reverse polarity, respectively (including secular variation). The natural remanent magnetisation (NRM) is measured with the 2G Cryogenic Magnetometer (for details see Rolf 2000). Subsequently NRM components were separated by alternating magnetic field demagnetisation. The deduced characteristic remanent magnetisation (ChRM) is determined by principle component analysis (PCA).

Owing to low concentrations of magnetisable minerals and various synsedimentary and post depositional processes fluvial sediments are a special challenge for palaeomagnetic investigations. As shown in Figure 3 to 6 the distribution of the inclination values of the NRM and ChRM vary from well to well. Significant changes in the polarity of the ChRM data-sets of the cores P34 (Fig. 3) and P36 (Fig. 4) are interpreted as boundaries between magnetostratigraphic chrons. Table 1 shows the depths of boundaries between chrons of the investigated drill cores. Due to the sediment properties (dominantly coarse fraction) palaeomagnetic investigations were not practicable in the intervals in between the specified depth. The appearance of normal magnetisation in the Matuyama Chron might be caused by a secondary magnetisation acquired during the Brunhes Chron. These anomalous data might also represent either the Jaramillo Subchron or the Olduvai Subchron interrupting the reversed Matuyama Chron with normal polarity intervals (Fig. 7).

The directional data of the cores Viernheim (Fig. 5) and Heidelberg (Fig. 6) show large scatter in inclination. Merely a clustering of reverse polarity provides an indication of the Brunhes-Matuyama boundary. Further studies will help to elucidate the diffuse distribution of data-sets by disentangling primary and secondary magnetisations and to solve remaining ambiguities. We have to date no reliable information about the depth of the Quaternary-/ Tertiary boundary of the drill cores of Viernheim and Heidelberg. Further analyses will hopefully help in separating secondary and primary magnetisations in order to make a precise and unambiguous statement about the polarity.

Our data corroborate the results of *Rolf et al.* (2005, 2008), *Hambach et al.* 2008, and *Wedel* 2008. The findings are also consistent to new pollen data from Knipping (unpublished) and Heumann (unpublished) and to lithostratigraphic correlations from Weidenfeller (unpublished).

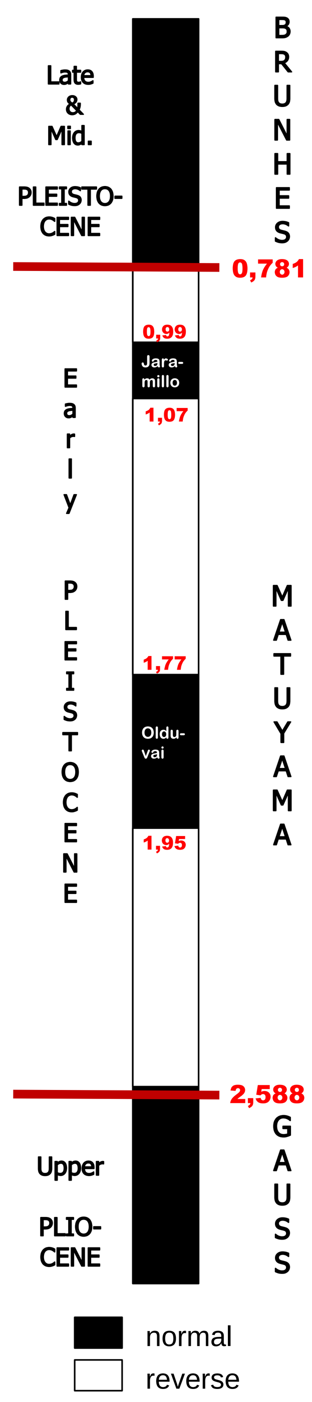
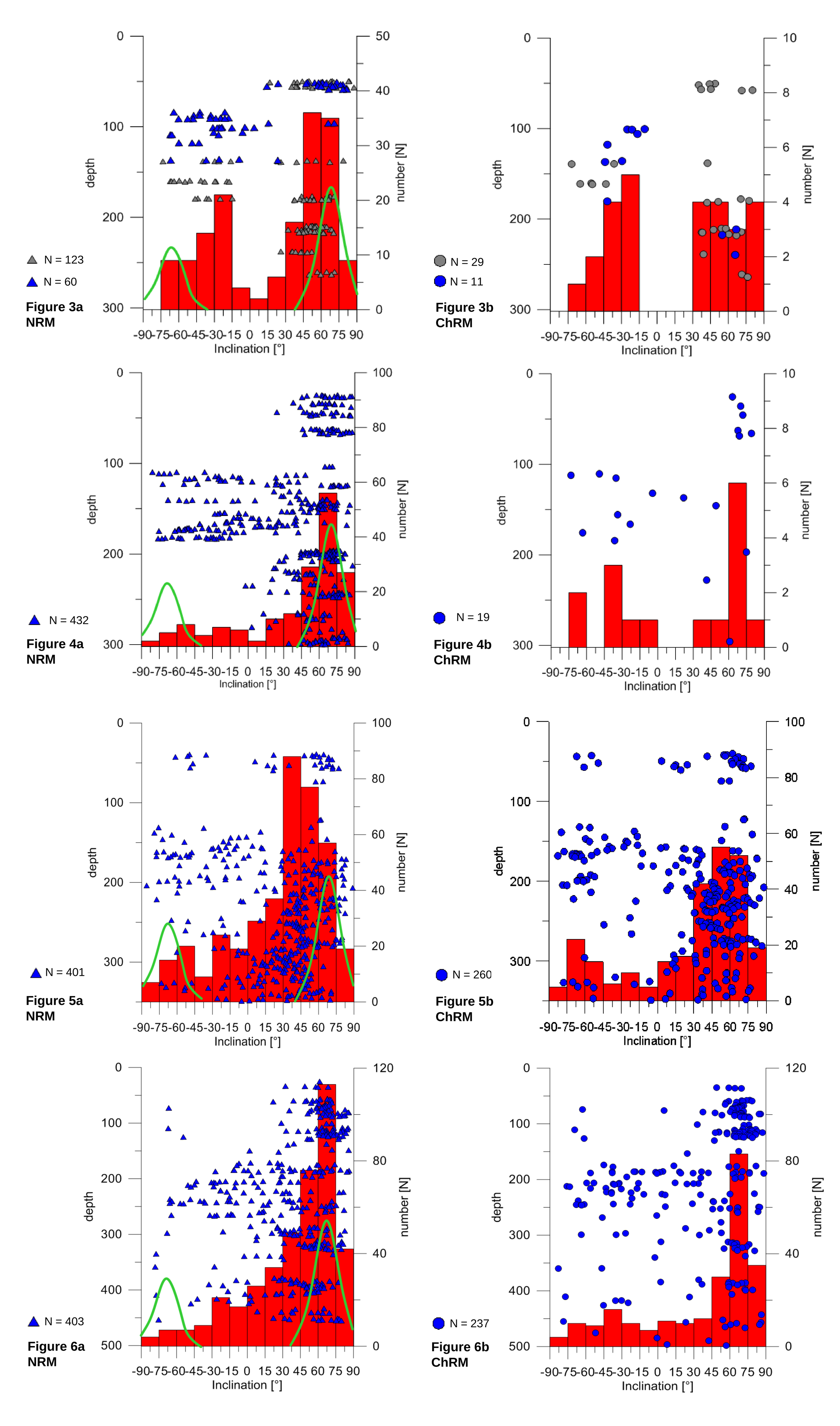


Figure 7.
Chronostratigraphic correlation table (after ICS). Time designations in million years.



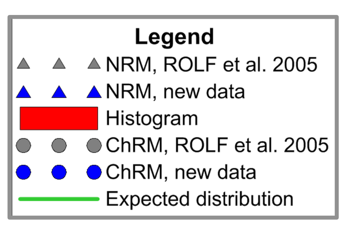


Figure 3 - 6.
Distribution of NRM inclination values (a) and ChRM inclination values (b) of discrete samples. Fig. 3 = Ludwigshafen P34, Fig. 4 = Ludwigshafen P36, Fig. 5 = Viernheim B1-06, Fig. 6 = Heidelberg (UniNord 1+2)

Boundary between Chrons	P34 (300 m)	P36 (300 m)	Viernheim (350 m)	Heidelberg (500 m)
Brunhes - Matuyama (0,781 Ma)	58,53 m - 83,84 m <103 (Knipping, pers. comm.)	104,37 m – 110,42 m	(131 m???)	(185 m???)
Matuyama - Gauss (2,588 Ma)	161,50 m -177,55 177 m (Rolf et al. 2005, 2008; Gabriel et al. 2010)	184,13 m -196,84 m 196 m (Knipping & Weidenfeller, pers. comm.)	No information 195 m – 223 m (Wedel 2008) < 221 m (Heumann, pers. comm.)	No information > 500 m (Gabriel et al. 2010)

Table 1. Depths of boundaries between chrons of investigated drill cores. New data (blue). Findings of previous work (black). Due to the sediment properties palaeomagnetic investigations were not practicable in the intervals in between the specified depth.

Perspective

The work presented here is just a brief extract from ongoing studies and it is focused on the stratigraphic perspective. Further palaeomagnetic data acquisition and magneto-mineralogical analyses are on their way. This project is aimed at establishing a high-resolution magnetostratigraphy and a palaeoenvironmental reference profile based on rock magnetic proxies. The prospective results might contribute to the given efforts to better understand the relationship between the evolution of Alpine and the Baltic ice-sheets during the Quaternary.

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