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Palaeomagnetic Data Obtained from Recent Deglacial Sediments in the Baltic Sea: Modern Analogues May be the Key to Understanding (Much) Older Records

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1. INTRODUCTION

Palaeomagnetic data obtained from diamictite have provided evidence of low-latitude Neoproterozoic glaciations at sea-level (Evans 2000, Hoffman and Schrag 2002). Yet, knowledge about the mechanisms that cause these deposits to obtain a natural remanent magnetization (NRM) is incomplete due to the lack of work on relatively recent analogues. We utilise an extensive palaeomagnetic data set from the Baltic Sea Basin (BSB) to illustrate how glacially influenced deposits are prone to significant inclination error, which can lead to false virtual geomagnetic poles and hence palaeolatitudes if a geo-axial dipole (GAD) model is assumed.

2. METHODS

A total of approximately 1.6 km of core was recovered from 6 sub-basins of the BSB during International Ocean Discovery Program (IODP) Expedition 347 – Baltic Sea Paleoenvironment (Andrén et al. 2015). The recovered material consisted primarily of sediments that were deposited after the last retreat of the Scandinavian Ice Sheet. During the expedition onshore science party (OSP) a total of 1779 discrete paleomagnetic subsamples were taken from working halves of split cores and their NRM measured before and after alternating field demagnetization at 5 mT (in addition pilot samples taken from each lithologic unit were also demagnetized up to a maximum of 100 mT).

During the OSP it was noted that inclinations trended with increasing depth below the seafloor towards shallower than GAD predictions at most sites (GADs range between 70° and 75°). Some subsamples had reversed directions that were ascribed to high energy sedimentary environments (Andrén et al. 2015). A compiled palaeomagnetic dataset with 1423 palaeomagnetic directions was subsequently constructed by removing data from: (i) the core-catchers, (ii) lithologic units identified as folded and/or disturbed, and (iii) sections of cores known to be compromised by sediment expansion (Obrochta et al. 2017). We then subdivided the compiled palaeomagnetic data into two distinct groups that were based on the classification of the expedition sedimentologists into "glacially influenced" (e.g. diamicton and varved clays) and "non-glacially influenced" (e.g. greenish black organic clays deposited in estuarine or marine environments). Note that due to the aims of the expedition different lithologic units were sampled at different resolution, which resulted in significantly more paleomagnetic data from the non-glacially influenced deposits.

3. RESULTS

Figure 1 shows the whole palaeomagnetic data set and its projection onto Upper and Lower hemispheres. While the majority of the data points plot on the Upper hemisphere there is a large distribution and numerous subsamples have inclinations around 0°, including many that are negative.

We present the inclinations of the two sedimentologically-classified groups as histograms in Fig. 2. The group of influenced sediments is characterised by a roughly bimodal distribution with inclination peaks of about 5° and 45°, which are significantly lower than the range of GAD predictions for the sampled sites (70–75°). In contrast the non-glacially influenced sediments show a distinct main peak at 70–75°, in agreement with the GAD predictions and regional palaeomagnetic secular variations, although there is a tail of data with low inclinations. There is a distinct possibility that the subdivision of the data set into two groups led to some misplacement of data, but the size of the data set is big enough to draw some conclusions.

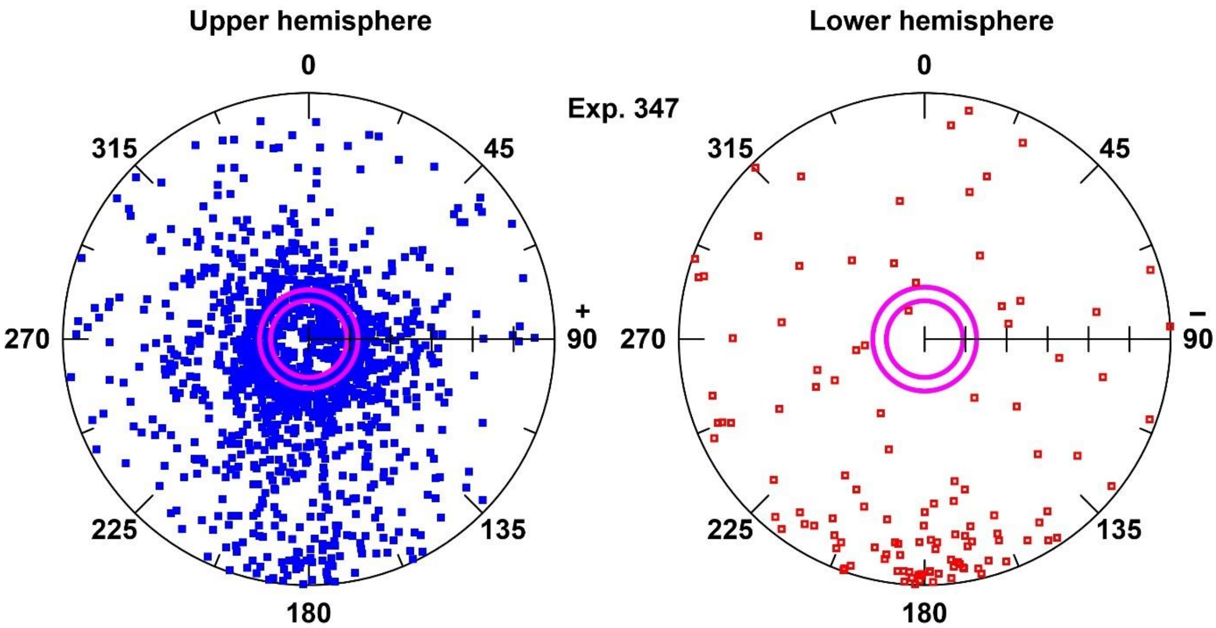

Fig. 1. Stereo plots of the complied paleomagnetic dataset divided into a group that plots on the Upper hemisphere (blue, positive inclination) and another that plots on the Lower hemisphere (red, negative inclination). Magenta circles show the minimum (outer) and maximum (inner) range of inclinations predicted by a GAD model for the latitudes of the site locations.

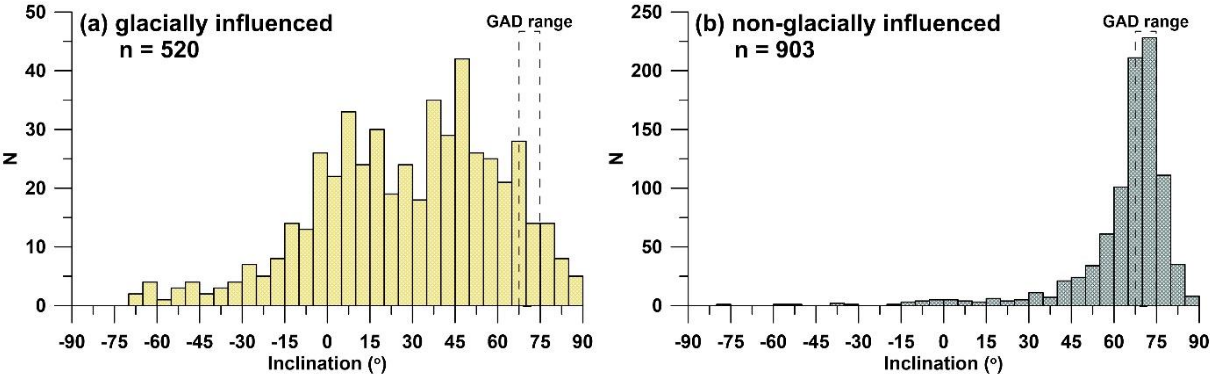

Fig. 2. Histograms that show the range of paleomagnetic inclinations for: (a) glacially influenced sediments and (b) non-glacially influenced sediments recovered during IODP Expedition 347. The group of glacially influenced sediments is characterised by a broad, but roughly bimodal distribution of inclinations, with the vast majority shallower than the GAD predictions. The group of non-glacially influenced sediments has a much narrower distribution, with a peak within the range of GAD predictions.

4. CONCLUSIONS

The compiled and filtered paleomagnetic dataset obtained from the BSB illustrates the established problem of inclination shallowing in coarse-grained sediments, which is relevant to palaeomagnetic studies of sedimentary rocks that aim to define palaeolatitudes and contribute to paleogeographic reconstructions (e.g. Vaes et al. 2021). Further measurements and sampling of non-glacially influenced sediments from three of the IODP-347 sites (M0060, M0061, and M0062) were able to reconstruct PSV (Snowball et al. 2019, Herrero-Bervera and Snowball 2020). Of course, without independent prior knowledge of the regional Quaternary geology and accepted palaeogeography, conversion of the paleomagnetic data obtained from the glacially influenced sediments in the BSB into paleogeography could lead to the misinterpretation of glaciers located at sea level near the equator. Our investigation of the IODP Expedition 347 paleomagnetic data set shows the importance of sampling paleomagnetically suitable sedimentary rocks for paleogeographic studies and an understanding of the NRM acquisition processes, which also include deposits formed during the Proterozoic and Neoproterozoic (e.g. Evans 2006, Schmidt et al. 2009).

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