GEOMAGNETIC FIELD VARIATIONS AS DETERMINED FROM BULGARIAN ARCHAEOmAGNETIC DATA

PART I: THE LAST 2000 YEARS AD.

MARY KOVACHEVA and ALEKO TOSHKOV
Geophysical Institute, Bulgarian Academy of Sciences, 1113 Sofia

(Received 26 May 1994)

Abstract. The archaeomagnetic determinations obtained from the collections of archaeological materials, dated in the last 2000 years are summarized. The review describes the materials used, the methodology applied, the local database organization, the principles of data processing and smoothing procedures. Errors evaluation at different levels of analysis of the experimental results are described. Special attention is paid to the archaeointensity determinations. Some rock magnetic properties studied in connection with the difficulties in the Thellier method are summarised. The curves of geomagnetic field elements variations for the last 2000 years for Bulgaria are shown. The Bauer plots, VGP path and VDM curve are also discussed, the latter confirming the general decrease in the strength of the geomagnetic field from the beginning of this era to the present. Westward drift of the geomagnetic field non-dipole part cannot be considered proved yet for the time interval 7th to 13th Centuries AD from the Bulgarian directional data.

Key words: geomagnetism, secular variations, archaeomagnetism, VDM, VGP, palaeointensity

1. Introduction

Archaeomagnetic techniques have proved to be the best method for revealing geomagnetic field variations during the historical past. The importance of the knowledge about such long period variations is obvious and can be explored on the basis of data sets, spanning long time, obtained for any particular territory. Archaeomagnetism is primarily based on the determination of the palaeodirection and palaeointensity of the geomagnetic field using baked clays from dated archaeological sites. These clays usually carry a stable natural remanent magnetization (NRM) that is almost entirely a thermoremanent (TRM), which has "fossilized" the direction and intensity of the ancient geomagnetic field at the time and in the place of its last firing. The existence of abundant ancient civilizations within the territory of Bulgaria has facilitated the development of this branch of geomagnetism in this country and the results of such a research comprise both directional and intensity observations. Up to now there have been three major stages in the accumulation of such a data set. At the first stage (Kovacheva, 1980) hand drawn apparent variation curves of declination (D), inclination (I) and the ratio of observed to present day field strengths \(F_a/F_0\) were made. These were based on hundred years among site's averages for the last 8000 years. The archaeointensities were normalized to the present intensity at the site and equal weight was given to each individual result. This basic data set also includ-
ed dated sites from the South-eastern part of former Yugoslavia (Kovacheva et al., 1974). At the second stage (Kovacheva and Kanarchev, 1986) the intensity results were normalized to the present dipole intensity for the corresponding latitude (Creer et al., 1983) and a separate weight was attached to each individual result. The revised archaeointensities were then processed over the same 8000-year period and the experimental imprecision was taken into account during the curve smoothing. In 1991, the third stage involved organizing all of the Bulgarian archaeomagnetic results into a database (Toshkov and Kovacheva, 1992) in which archaeointensities were given absolute values. This database included those presented in Table 1 of Kovacheva (1992) with several corrections due to newly determined sample archaeointensities or site directions and intensity.

The objective of this present review is to summarize all the work done with these collections, to explain the processing of the data for the last 2000 years and to analyse some geophysical implications of the curves obtained for this period. Special attention is paid to the difficulties encountered in palaeointensity determination.

The geomagnetic field variations established for the preceding 6000 years will be the subject of a subsequent paper.

2. Methodology

An archaeomagnetic study includes three major parts: field work, laboratory procedures (including measurements) and elaboration of the data. The terminology used here is that a “sample” is each independently oriented piece of baked clay (Tarling, 1983; Kovacheva, 1989; Sternberg, 1989) and that an arbitrary number of specimens may be cut from it.

2.1. Field work

Samples for archaeomagnetic study in the Sofia laboratory were collected by hand and were chiefly of two types: (i) oriented samples from furnaces, ovens or natural burnt clays, and (ii) unoriented brick samples, mostly from the more recent past. Initially orientation was always registered by a magnetic compass on a horizontal surface made with gypsum but, during the last 12 years, a sun compass was also used. The palaeodeclination results of the oldest collections were corrected by the local contemporary declination.

2.2. Laboratory procedures and measurements

The more fragile samples (usually the oriented ones) were usually consolidated using water glass impregnation and a number of 24 or 20 mm edge cubic specimens were then cut from each of the oriented samples, retaining their original field orientation, or following the long edge of the brick (Figure 1a, b). The magnetic remanence of the older collections was measured using the classic Dolginov astatic magnetometer (sensitivity of 1.5 mA m$^{-1}$/div). Later collections