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Absolute paleointensity determinations by using of conventional double-heating and multispecimen approaches on a Pliocene lava flow sequence from the Lesser Caucasus

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ABSTRACT

We report 28 successful Thellier type absolute geomagnetic paleointensity determinations from a Pleistocene lava sequence composed of 39 successive flows in the Djavakheti Highland (Lesser Caucasus, Georgia). Additionally, multispecimen technique provided the estimation of geomagnetic field strength for 12 independent cooling units.

Paleointensity studies were performed using both Thellier type double heating and multispecimen techniques. Samples selection was mainly based on uni-vectorial remanent magnetization, thermal stability and domain size of the samples. Flow-mean Thellier paleointensity values range from 16.3 ± 5.2 to 71.0 ± 0.3 μT, while intensities obtained using multispecimen approach vary from17.2 ± 2.3 to 69.3 ± 7.9 μT.

One of the flows is located near a possible discontinuity in the sequence and yields a rather low Thellier absolute intensity (16.3 ± 5.2) suggesting a transitional regime and the onset of the Matuyama-Olduvai polarity transition, which does not appear on the directional record. Multispecimen paleointensities from the same flow, however, yield higher, close to present day values which makes untenable the hypothesis of occurrence of transitional field. Thus the whole sequence was emplaced in a short time between the Olduvai chron and 1.73 ± 0.03 Ma, as suggested by available radiometric and paleomagnetic data (Caccavari et al., 2014).

1. Introduction

A full description of the fluctuations of the Earth's Magnetic Field (EMF) with time requires knowledge about both its directions and its intensity. For the time previous to direct measurements, this kind of information can only be retrieved through paleomagnetic experiments. However, while paleofield directions are relatively easy to obtain, as they are generally parallel to magnetization directions, determinations of the absolute paleointensity of the EMF are much more complicated, as the magnetization intensity recorded in rocks is only proportional to the field. Because of that, thermal remagnetization experiments are needed to retrieve absolute paleointensity values. However, the absolute intensity over geological periods is a critical parameter to shed light over the history of the geodynamo and the physico-chemical processes taking place in the Earth's liquid core. Because absolute intensities can only be obtained from rocks carrying a thermoremanent magnetization (TRM) and the success rate of paleointensity determinations is rather low due to the occurrence of chemical/mineralogical or physical changes during the experiments (e.g., Kosterov and Prévot, 1998) and the presence of multidomain grains in the analyzed rocks (Shaskanov and Metallova, 1972; Levi, 1977; Bol'shakov and Shcherbakova, 1979; Worm et al., 1988), high quality paleointensity determinations are still scarce and of dissimilar quality, with some 3500 data available worldwide for all geological periods.

Volcanic rocks allow a reliable and instantaneous record of the EMF by means of the acquisition of thermoremanent magnetization

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(TRM) during their cooling down (e.g., Camps et al., 2011; Prévot et al., 1985a and b) and they are a potential source of absolute intensity data. In particular, lava sequences composed by several consecutive flows are considered as an adequate means of studying the variations of the EMF, although the continuity of the record depends on the timing of the successive eruptions. Due to the aforementioned scarcity of data, information about the paleointensity variation of the EMF is specially needed, including more constraints about its behavior during and around polarity transitions. There is now a general agreement among the paleomagnetic community that intensity drops significantly compared to the stable field during the large departures of the geomagnetic field from the axial dipole position (Laj and Channell, 2007). It has also been observed that polarity transitions is first expressed in the intensity record than in the directional one (Valet et al., 1999; Prévot et al., 1985a, b; Riisager et al., 2000). No systematic intensity drops are related, however, to the pre and post transitional regimes. Although some new Pleistocene and Pliocene absolute paleointensity data from Georgia are already available from previous studies (Camps et al., 1996; Gogichaishvili et al., 2000, 2001, 2009; Calvo-Rathert et al., 2011, 2013, 2015), new paleointensity results from this region are still much needed. In 2012 we sampled a radiometrically dated Pleistocene lava flow sequence consisting of 39 consecutive, independent lava flows in the Djavakheti region (Southern Georgia). Directional paleomagnetic results and rock-magnetic data of all flows were reported by Caccavari et al. (2014). All cores of the sequence were sampled with a gasoline-powered portable drill and oriented with both a magnetic and a sun compass. Considering the potential interest of new paleointensity data we have performed a detailed study which includes both Thellier type and multispecimen determinations on rocks from the same lava flows.

2. Geological setting and age of the sequence

The study area is located in the Djhavakheti Highland (Fig. 1), a volcanic region extending over the central part of the Lesser Caucasus mountain system in Georgia. The Caucasus Mountain Range is part of the Alpine-Himalayan orogenic belt, which is the largest continental collision zone in the world. The recent geodynamics of the Caucasus region is determined by its position between the converging Eurasian and Arabian plates and characterised by the complexity of its active tectonics. Three main directions of active faults compatible with the nearly N-S compression produced by the convergence of the Arabian and Eurasian plates can be distinguished in Georgia (Adamia et al., 2008). The first group of structures is characterised by a WNW-ESE or W-E strike and represented by compressional structures like reverse faults, thrusts and nappes. Two other groups of structures are characterised by either a NE-SW or a NW-SE strike. They are mainly extensional structures but have a considerable strike-slip component (Adamia et al., 2011).

The Caucasus region is also characterised by an important and continuous volcanic activity, at least from the Jurassic and lasting until present (e.g., Rebaï et al., 1993). The subaerial volcanism of the Djavakheti Highland and some other areas of Georgia is most likely related to processes of W–E extension causing emergence

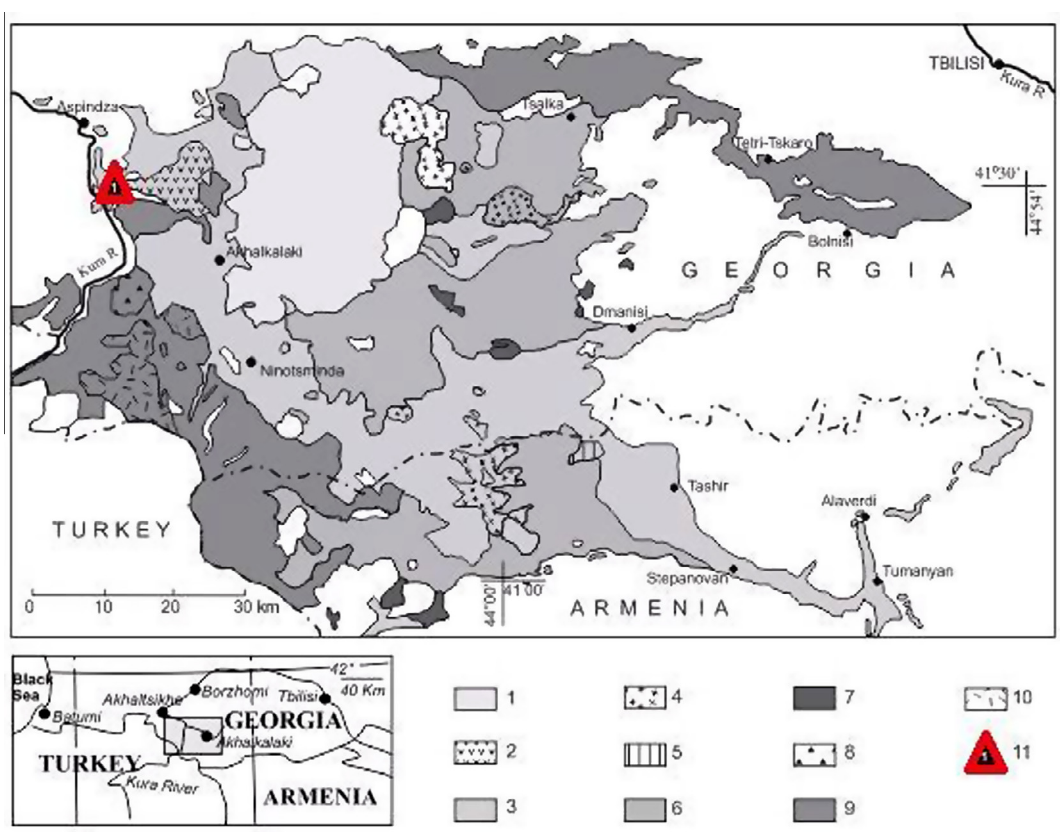

Fig. 1. Schematic geological map (modified from Lebedev and Dudauri, 2008; Calvo-Rathert et al., 2013) of the Pliocene-Quaternary volcanism in the DjavakhetiHigland showing the Saro lava flow sequence sampled in the present study. 1: Quaternary volcanics of the Samsari ridge (800–0 ka); 2: Basic lavas (1.75–1.55 Ma); 3: Basic lavas (2.15–1.95 Ma). 4: Dacitic lavas of the Djavakheti ridge (2.25 Ma); 5: Hyalodacite (2.5 Ma); 6: Basic lavas (2.65–2.45 Ma); 7: Rhyolites and dacites of the Chikiani, Agvorik and Busistsikhe volcanoes (2.85–2.6 Ma); 8: Dacites (3.15–3.11 Ma) of the Kumurdo lava flow (a) and Amiranisgora volcano (b); 9: Basic lavas (3.22–3.04 Ma); 10: Basic lavas (3.75–3.55 Ma); 11: Sampled lava flow sequence in Saro.