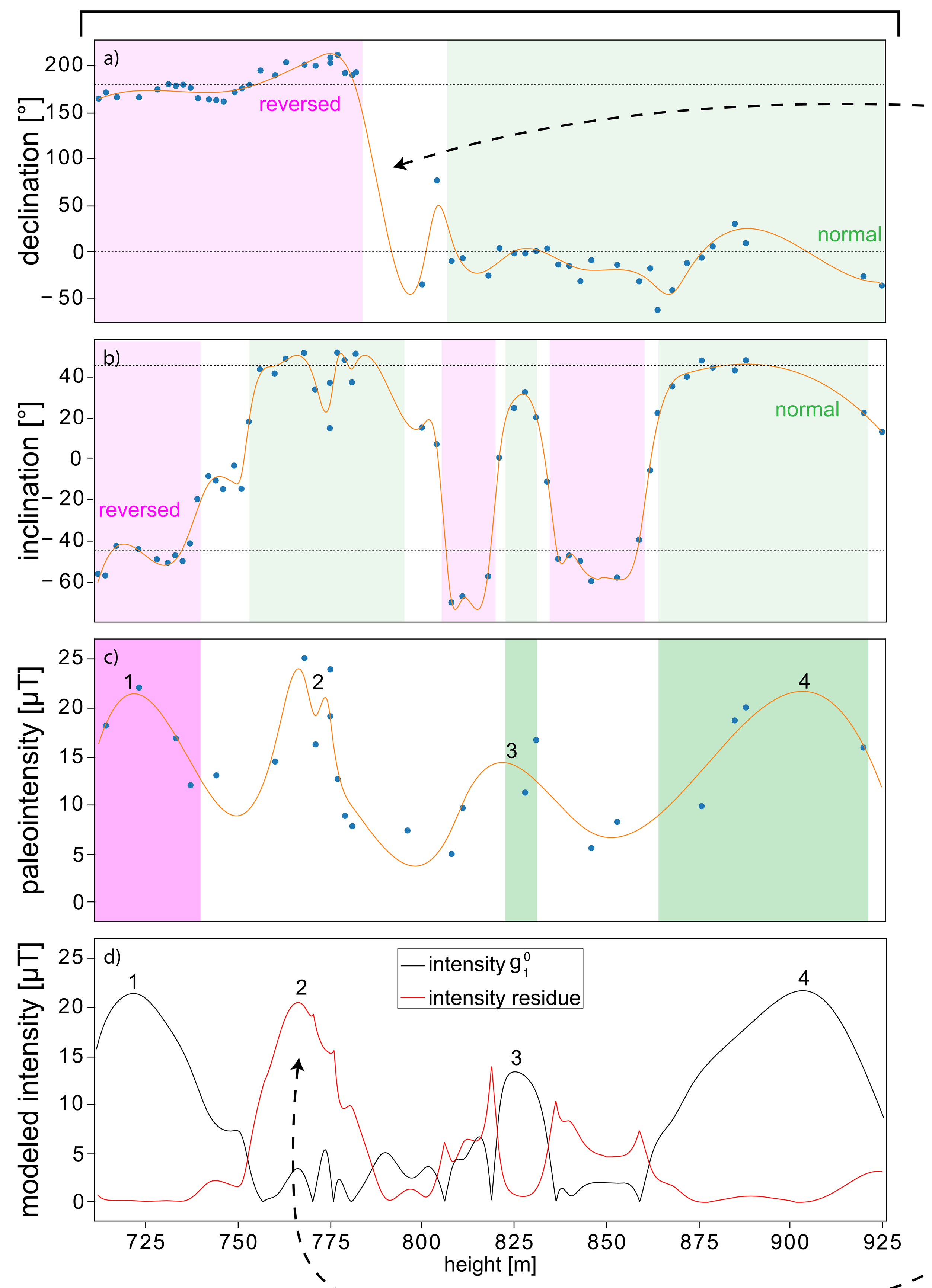
A non-axial dipole intensity peak precursor: case study of a mid-Miocene geomagnetic reversal from lava flows of Gran Canaria

Liz van Grinsven[1], Annemarieke Béguin[2], Klaudia F. Kuiper[3], Lennart V. de Groot[1]

Interpreting the geomagnetic record

Despite the large number of reversals in the magnetographic record, the geometry of the Earth's magnetic field and the mechanism(s) driving reversals still remain obscure, because; 1. Available sedimentary records lack temporal resolution for recording the rapid field changes during a reversal. 2. Volcanic data records -that may have the necessary temporal resolution- are dependent on volcanic eruption frequency and much more difficult to find. To further our understanding of magnetic reversals, high quality volcanic records need to be discovered and studied. Here we studied a high quality mid-Miocene geomagnetic reversal from Gran Canaria; We intensively sampled a continuous volanic section (see **Fieldwork**) from which we obtained a full vector geomagnetic record (see **Measurements**).



In the time the declination reverses once the inclination reverses five times.

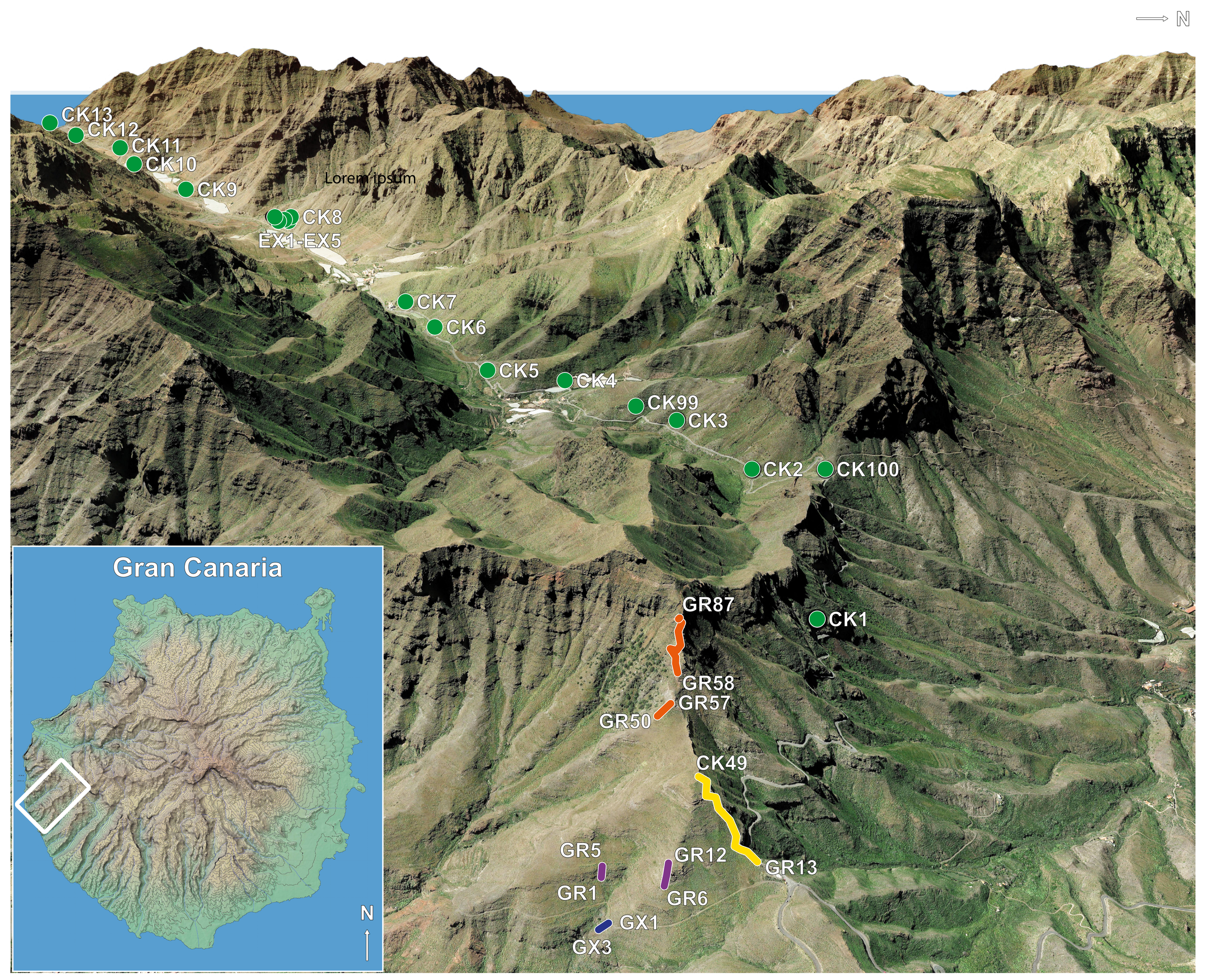
Interpreting the full vector record with a simple spherical harmonic model. To determine the non-axial dipole contribution, we built a simple spherical harmonic model of the measured paleomagnetic record. The top three panels on the figure to the left contain the paleodirection and paleointensity records (blue dots) with a fitted spline (orange line). The bottom panel contains the resulting total intensity of our simple spherical harmonic model in which only the axial dipole component, term g^0_1, was fitted (black line). The bottom panel also contains a red line which is the intensity residue: the measured intensity minus the fitted g^0_1 term.

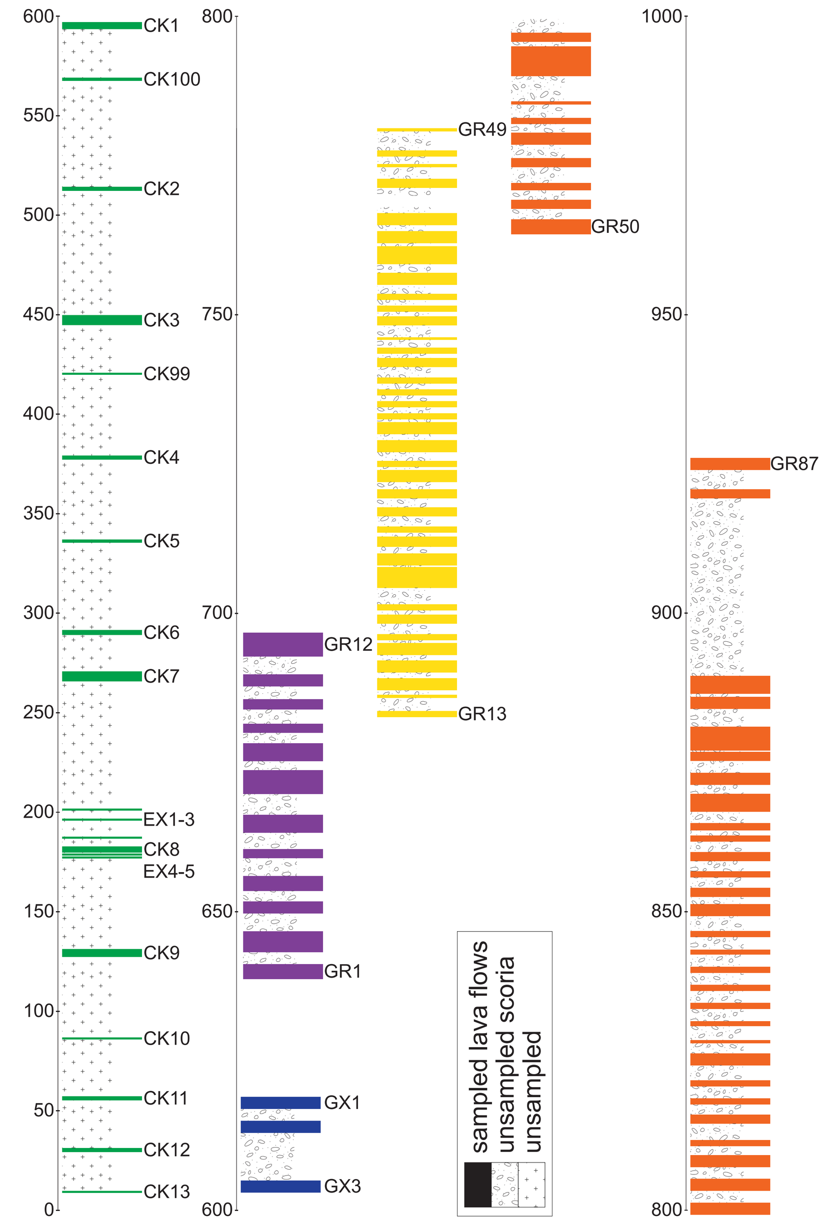
A 20+ μT intensity peak which cannot be attributed to the axial dipole term.

Observations on reversals based on our geomagnetic record. We can observe from the paleodirections in our geomagnetic record, with a declination which reverses once in the time the inclination reverses five times, that the geomagnetic field has a complex field geometry during a reversal. It is also generally accepted that during a reversal the axial dipole component is weak and therefore the non-axial dipole components are more dominant, however, it is a new observation that the non-axial dipole and higher order pole contributions can increase in strength to a size that is comparable to the intensity of the axial-dipole field.

Fieldwork

Sample location Gran Canaria. The sampled section on Gran Canaria was deposited by a 2000m high shield volcano [1] during the short-lasting shield building phase of the island, around 14.5-14.0 Ma [2]. The reversal in this section was previously discovered by Leonhardt et al. 2002 [3].



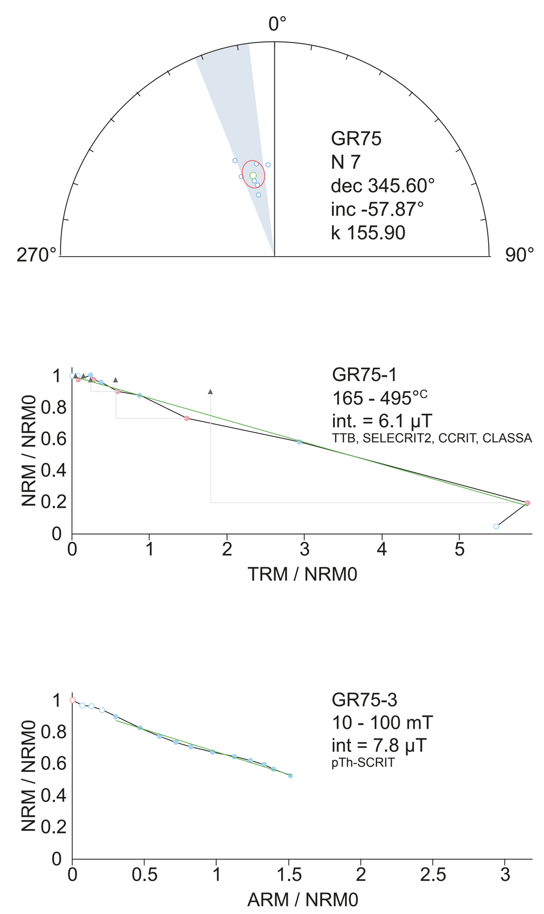


Sampled cooling units from sea level. The first 600m from sea level was sampled every ~50 altimeters. Between 600-925m every cooling unit was sampled.

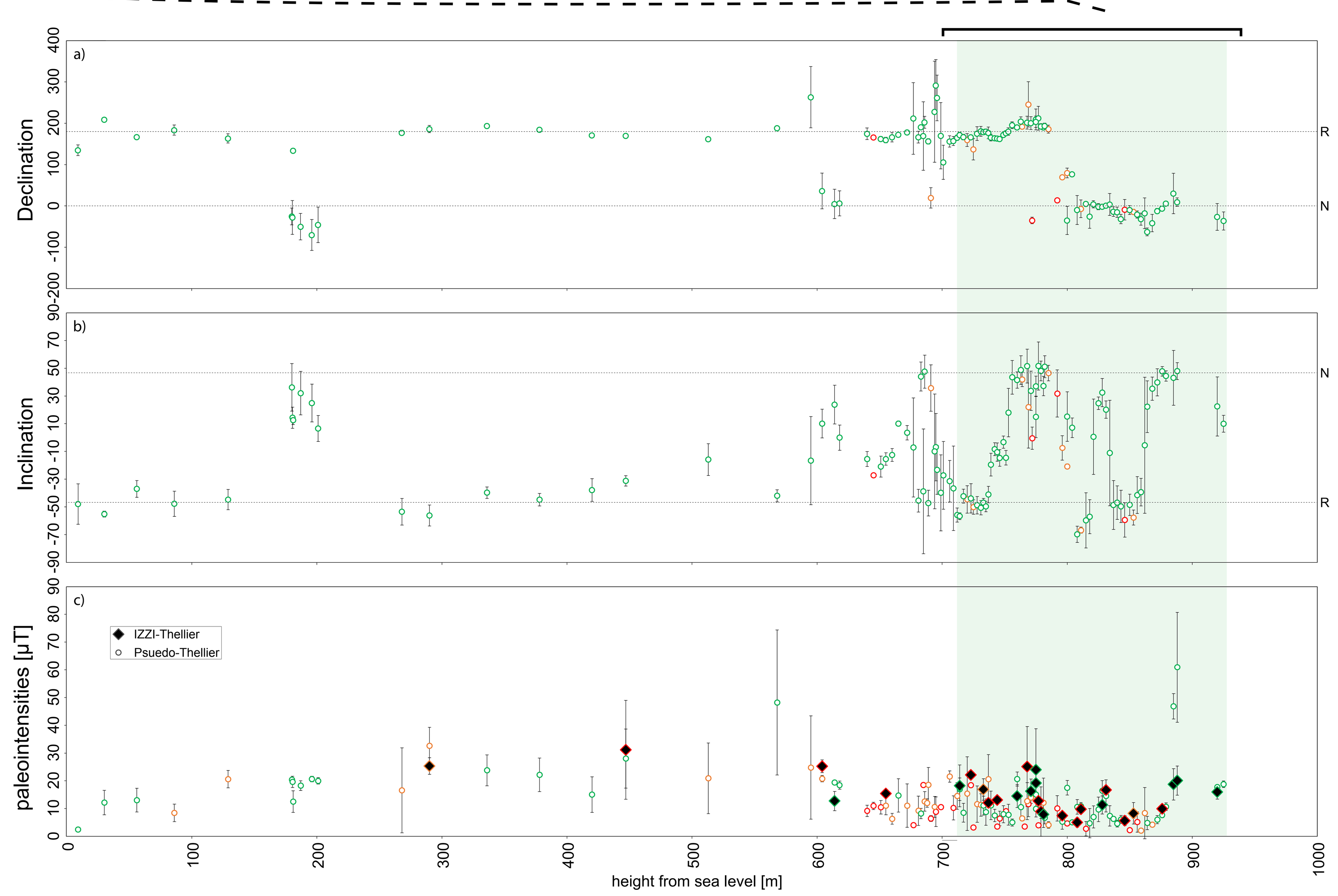
Measurements

All cooling units were measured intensively. A rock magnetic analysis for each cooling unit was obtained with a VSM and a susceptibility measurement. Directions for each cooling unit were obtained with both thermal and alternating field demagnetization experiments. The paleointensity record was measured with an IZZI-Thellier and Pseudo-Thellier experiment.

Example. paleodirection of a cooling unit and an IZZI- and pseudo-Thellier measurement.



The full paleomagnetic record of our Gran Canaria section. The highest data resolution was obtained in the green shaded area, for both paleodirection and paleointensity data.



green: 5 or more, orange: 2-3, red: 1-2 successful measurements per cooling unit

References

1 van den Bogaard, Paul, and Hans-Ulrich Schmincke. "Chronostratigraphy of Gran Canaria." Proceedings of the Ocean Drilling Program: Scientific Results. Vol. 157. No. Chapter 11. 1998.

2 Troll, Valentin R., and Juan Carlos Carracedo. The geology of the Canary Islands. Elsevier, 2016.

3 Leonhardt, Roman, et al. "A reversal of the Earth's magnetic field recorded in mid-Miocene lava flows of Gran Canaria: Paleodirections." Journal of Geophysical Resea rch: Solid Earth107.B1 (2002a): EPM-7.

Contact details

[1]Paleomagnetic laboratory Fort Hoofddijk, Utrecht University, Budapestlaan 17, 3584 CD, Utrecht, the Netherlands

[2]Department of Geoscience and Petroleum, Norwegian University of Science and Technology, 7491 Trondheim, Norway

[3]Department of Earth Sciences, Free University Amsterdam, De Boelelaan 1085 1081HV Amsterdam

Correspondence to: Liz van Grinsven (l.b.vangrinsven@uu.nl)