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Short communication

Occurrence of an unknown Atlantic eruption in the Chaîne des Puys volcanic field (Massif Central, France)

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ABSTRACT

A volcanic ash layer, called MF1, was recently identified in Holocene sediments from the Gourgon and Molhiac peat bogs (Monts du Forez, French Massif Central). This ash layer consists of colorless shards with a heterogeneous trachytic to rhyolitic composition. The trace elements analyzed by Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) attest to a local origin. Radiocarbon dating of peat samples taken within and below the ash layer indicates the best age at 6339 ± 61 cal yr BP, i.e. an age contemporaneous with the volcanic activity of Montchal, Montcineyre and Pavin volcanoes from the Chaîne des Puys volcanic field. These volcanoes are characterized by basaltic and trachytic products, thus the rhyolitic composition of MF1 tephra suggests that it is likely originated from an unknown eruption. These results again confirm the interest of studying the distal volcanic ash fallouts in order to establish or specify records of past eruptions of volcanic fields. Identification of this new tephra layer also provides an additional tephrochronological marker for Eastern French Massif Central.

1. Introduction

The extent of volcanic ash deposits originating from the Chaîne des Puys volcanic field (Massif Central, France) is not precisely documented. Only rare studies about distal volcanic deposits mention Holocene tephra layers originating from the Chaîne des Puys. They concern mainly on the Puy de la Nugère (13,204–13,476 cal yr BP) tephra which has been found in northern Monts du Forez (Etlicher et al., 1987), the Jura Mountains and the Swiss Plateau (Walter-Simonnet et al., 2008; Cupillard et al., in press), and ash from the Puy Vasset and/or Puy Kilian volcanic eruptions (9200 ± 0.36 yr and 9400 ± 0.20 yr) which has been described in northern Switzerland (Lane et al., 2011). Comparatively, the proximal volcanic deposits surrounding the Chaîne des Puys have been studied in more detail (Baudry and Camus, 1970; Juvigné, 1987; Bastin et al., 1990; Juvigné, 1991; Juvigné et al., 1992; Vernet, 1992; Vernet et al., 1998; Vernet and Raynal, 2000; Miallier et al., 2004; Fourmont et al., 2006; Vernet and Raynal, 2008). In the Clermont-Ferrand basin, 43 ash layers dated between 150 and 80 ky and 75 ash layers between 80 and 40 ky have been observed. 6 other Holocene tephra layers have already been found in the same area. The time interval of activity was variable (Vernet, 1992). The chemical analyses of these proximal deposits were carried out on minerals or bulk rock. Unfortunately, there are no data on glass shards.

This short paper presents the first chemical results characterizing a young unknown centimetric tephra layer, recognized in deposits dated to the Atlantic period, cored in peat-bogs from the Monts du Forez, French Massif Central. The characterization of this new tephra could represent an important and new contribution to the knowledge of the recent past of the Chaîne des Puys eruptive history.

2. Materials and methods

Sediment corings were carried out on the highest land of bog Gourgon (N 45°36′31″.62; E 3°52′59″,75; 1367 m a.s.l.) and Molhiac (N 45°30′09″.00; E 3°51′20″.00; 1130 m a.s.l) peat-bogs in Monts du Forez (Fig. 1) that have been developed on the Velay granitic basement during the Holocene (Ledru et al., 2001; Faure et al., 2009). The cores were taken using a Russian corer of 50 cm length. The total lengths of profiles recovered by this corer are 288 cm for the Gourgon site and 220 cm for the

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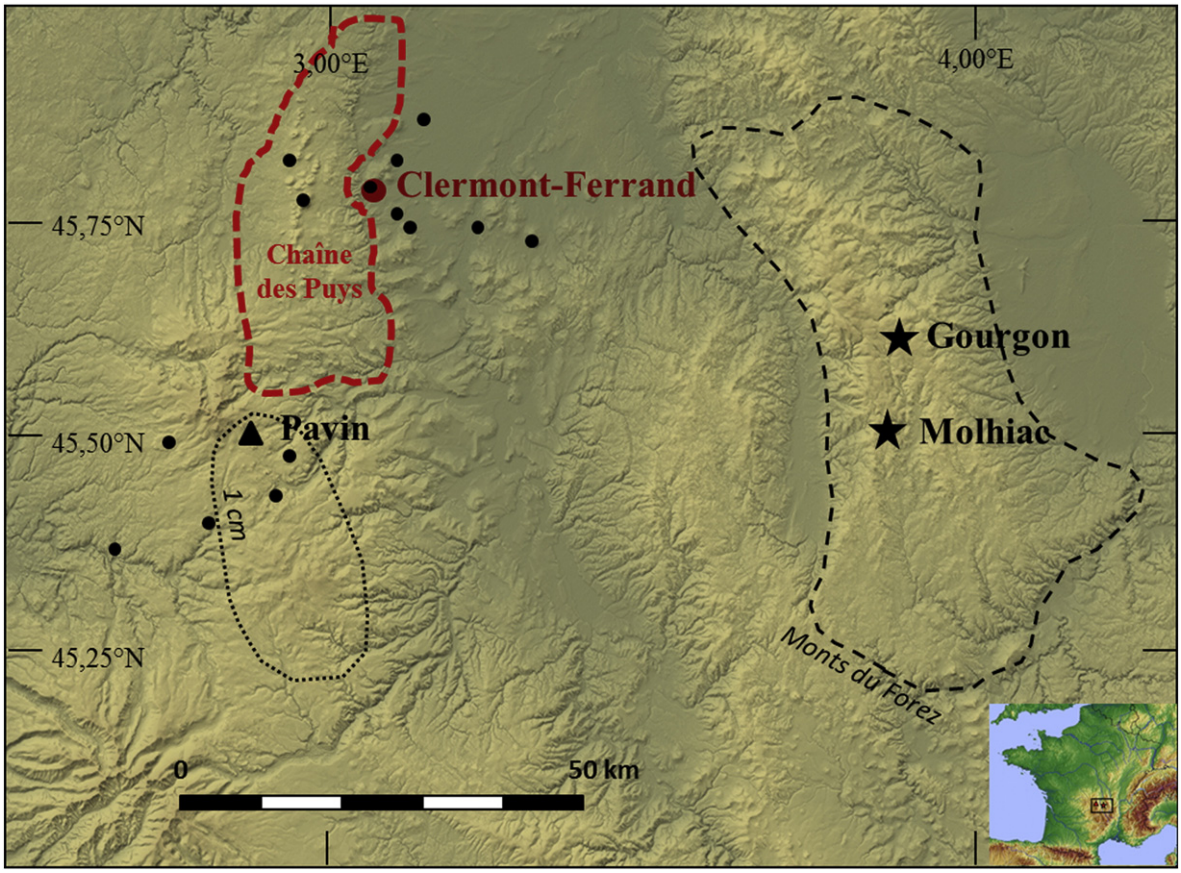

Fig. 1. Map of the Massif Central showing the location of the Chaîne des Puys Volcanic Field and Pavin volcano (black triangle) and the location of the Gourgon and Molhiac sites (black stars) in Monts du Forez (area demarcated by black dashes). The 1 cm isopach of the Pavin eruption is marked with a dotted line. Black points are the main proximal tephrostratigraphy studies (Juvigné and Gewelt, 1987; Juvigné et al., 1992; 1994; Vernet et al., 1998; Vernet and Raynal, 2000; Fourmont et al., 2006; Boivin et al., 2009).

Molhiac site. The sediment profiles of the sequences are mainly composed of brown peat that was more or less decayed. Volumetric magnetic susceptibility measurements were performed at 0.5 cm intervals using a MS2-E1 surface scanning sensor from Bartington Instruments. X-Ray Fluorescence analyses were also performed at the same interval in the Edytem Laboratory (Savoie University, France) (operating conditions: voltage of 10 and 30 KeV, 750 mA beam current).

Tephra samples were wet sieved and separated into a 45 μm fraction. The >45 μm fraction was treated with a 10% solution of H_2O_2 to remove organic material and with a 10% solution of acetic acid to remove carbonates. Particles were separated using the density separation method to isolate glass shards (Blockley et al., 2005). The separation was carried out with a density of 2 and 2.55 because the density of glass shards is in this interval. The grain-size of the biggest glass shards observed is less than 200 μm. Electron probe microanalysis (EPMA) of glasses was obtained on a WDS Cameca SX100 at Laboratoire Magmas et Volcans (LMV), Clermont-Ferrand. The instrument was calibrated on natural glass (A99). The analytic conditions are similar to standard analysis (Oladottir et al., 2011): 15 kV accelerating voltage and 4 nA beam current (10 nA used for mineral analysis) to reduce Na loss and 4 μm beam diameter, in agreement with Hunt and Hill (2001) and Kuehn et al. (2011). The counting time was 10 s for Na, Ca, Ti and Si; 20 s for Mg and Al; 30 s for MN and finally 40 s for Fe and K. Trace element analyses on single glass shards have been carried out by Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS) in the same laboratory but only on glass shards from the tephra observed at Gourgon. The international glass standard BCR-2G (Colombia River Basalt; Wilson, 1997) was used for calibration using a similar procedure as described by Mason et al. (2008), Tomlinson et al. (2010), Oladottir et al. (2011) and Sigmarsson et al. (2013).

Two peat samples were prepared for AMS radiocarbon dating carried out in Radiocarbon Dating Laboratory, University of Lyon (France), in order to determine the age of the volcanic deposit. In the Gourgon sequence peat was sampled 2.5 cm below the tephra layer, whereas in the Molhiac sequence the tephra containing peaty layer was directly dated (Fig. 2). The ^{14}C ages were calibrated using the INTCAL 13 calibration curve after Reimer et al. (2013) and the CALIB 7.0 software (Stuiver and Reimer, 1993).

3. Results

The tephra layer has a thickness of 2–3 cm in both sites. It can be clearly detected by magnetic susceptibility measurements and X-Ray Fluorescence analyses. These methods are frequently used to detect volcanic deposits in sedimentary records (Gehrels et al., 2008; Walter-Simonnet et al., 2008). In the cores sampled at Gourgon and Molhiac, the presence of the two tephra layers induces a peak of intensity in magnetic susceptibility measurement and an increase of the relative Zr content (Fig. 2).

The chemical analyses of these volcanic deposits show a heterogeneous rhyolitic composition with a wide range in silica content (from 65.74 to 78.21 wt.%), especially for the Gourgon site (Table 1, Fig. 3). Chondrite-normalized REE diagrams of glass shards from the Gourgon site show a negative Eu anomaly (Fig. 4A) which is characteristic of rhyolitic compositions in any origin and in any geological context (Pearce