IME-Site 16: Pré-du-Bois swamp and openfield blockstream formations

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Introduction & study area

The Béage basaltic plateau and its phonolitic summits constitute the southern part of the Mézenc massif (**figure 2**). This volcanic landscape, built during the upper Miocene, is incised by the Loire River and its tributaries: Gage, Orcival and Veyradeyre rivers for example (Defive, 1996 ; Defive *et al.*, 2013). Periglacial geomorphological processes of the Late Pleistocene has been also involved in the erosion of basaltic and phonolitic formations, creating **openfield blockstreams** (Valadas, 1984 ; Etlicher, 2005 ; Defive *et al.*, 2013). New investigations have been initiated to characterise formation pathways and chronologies of these typical landforms (Peignelin, 2014 ; Peignelin *et al.*, 2014 ; Peignelin & Defive, 2015)

This paper focuses on the ***area of Pré-du-Bois*** (1,400 to 1,475 m a.s.l.) at the foot of the Montfol peak (**figure 2**). Two phonolitic blockstreams are present: "Pré-du-Bois bas" and "Pré-du-Bois haut" formations. A ***small swamp***, located at the contact with the "Pré-du-Bois haut" blockstream (1,460 m a.s.l,) has been also studied in order to examine relationships between this wetland and the formation of blockstreams and to reconstruct past landscape changes (Peignelin, 2014 ; Dendievel, 2017). In the surroundings, the soil cover is thin and consists of a brown ochre soil (Dejou & Kessler, 2006). The vegetation is mainly composed of grasslands and moors with heather, dotted with dwarf juniper (*Juniperus communis* ssp. *nana*) and mountain pine (*Pinus uncinata*). Huge conifer plantations (*Abies alba*, *Pinus sylvestris*, *Pseudotsuga menziesii* and *Larix decidua*) are present at the foot of phonolithic mounts.

Methods

GPR (georadar) and ERT (electrical resistivity tomography) cross profiles have been conducted to identify the extension and the depth of the ***Pré-du-Bois blockstreams:*** electrodes were placed with an interval of 2 m to 1 m and results were analysed with *Reflexw* and *Res2Dinv* programmes (Peignelin, 2014 ; Peignelin *et al.*, 2014). Orientations of blocks were measured on field by manual counting and by photo-interpretation. In ***the swamp of Pré-du-Bois***, two cross profiles has been realised thanks to manual tests with graduated threaded rods (**figure 3**). Cores were extracted using a "Russian" manual peat corer (Peignelin, 2014 ; Dendievel, 2017). Magnetic susceptibility was measured in laboratory using a *Bartington* device (resolution= 1cm) and,

after sampling, organic matter content was computed by LOI (loss on ignition). Two AMS radiocarbon dates were obtained on bulk sediments and two others are in progress (**tab. 1**).

Results

Blockstream measurements

Measurements on "Pré-du-Bois bas" and "Pré-du-Bois haut" show a primary orientation of the blocks in the slope direction or in a field of less than 50 degrees with respect to the global block alignment (Peignelin, 2014). The block size progressively decreases in a downstream direction. Ripples and terminal bulges imply creep processes. These formations are prolonged by gullies which are starting points of several streams, including the Gage River (**figure 2**).

According to GPR data, from 0 to 5 m deep, the signal is clear due to the presence of phonolitic blocks; beyond, the signal is scrambled suggesting hydromorphic or clayey levels (**figure 4**). ERT data well match with these results (**figure 4**): the blockstream surface is identify by a thin and resistive layer (3,000 to 10,000 $\Omega.m^{-1}$); up to 5 m in depth, a heterogeneous layer with resistive lens indicates the blockstream extend (200 to 2,000 $\Omega.m^{-1}$) and a very conductive layer (< 100 $\Omega.m^{-1}$) could be a humid and altered matrix at the basis of the blockstream.

Stratigraphy, age and analysis of the PDB core

In the Pré-du-Bois swamp, a 3 meters core – PDB core – was extracted (Dendievel, 2017). From the basal part to 2.5 m, the sediment is composed of minerogenic lacustrine clay (**figure 5**). From 2.5 to 2 m, a *gyttja* layer show an organic enrichment and, after a wooded transition dated to 9,000 cal. BP, several peat layers are recorded. Finally, an organic clay layer is present just before the surface and linked to the current swamp function (**figure 5**). Magnetic susceptibility values decrease from positive to negative values (from basal layers to the surface). However, positive values are again observed in the upper 20 cm, in the clay deposits of the swamp. LOI values also show a shift at this level with a short decrease in the organic matter content (**figure 5**).

Discussion

Blockstreams: formation

The vertical zonation of the geophysical signal (GRP and ERT) underlines the presence of an openwork blockstream formation, 5 to 10 m thick. Its basis is more conductive and could corresponds to humid and altered layers (clay?). Aerial photographs and measurements showed that creeping is the main vehicle involved in the formation of blockstreams, creating riddles and bulges. These data also suggest links between blockstreams and geliflucted blocks formations of the surroundings, as indicating by creeping axes and diverse block alignments or concentration. Thus, several hypothesis are considered (Peignelin, 2014): blockstreams could be a part of wider formations, with a block enrichment partly due to a specific topography (micro-thalwegs and gullies). A leaching of clay and silts is also probable along these lines.). The presence of an ice core between blocks could also have been at the origin of these

formations. This hypothesis is also supported by resistivity values similar to values from rock glaciers, but there is no evidence of a Late Pleistocene ice cover in this area (Etlicher, 2005 ; Define *et al.*, 2013).

Blockstreams: age

According to literature, blockstreams of Pré-du-Bois could have been created in less than 5,000 years of creeping (Harris *et al.*, 1998 ; Bodin, 2011). This very short duration must be tempered because we do not know how many steps were involved and if blockstream's formation was continuous in time.

The presence of a former lake at the location of the PDB core is established on the basis of deep minerogenic lacustrine clay and *gyttja*. According to low organic content and to high magnetic values, this lake could date back to the Late Glacial. Two radiocarbon dates are in progress to confirm this hypothesis (**tab. 1**). After a progressive infilling, it became a fen with peat deposits around 9,000 years cal. BP. All of these sediments were deposited above a bed of blocks, indicating that local blockstreams are necessarily older than these deposits, *e.g.* probably older than the Late Glacial.

Recent changes: formation of a swamp at Pré-du-Bois

The top of the PDB stratigraphy shows an shift around 30 cm, with the replacement of peat by organic clay (**figure 5**). This change, linked to the establishment of the current swamp, was achieved at the end of the Roman period (AD 246-388). An anthropogenic origin could be deduced form numerous drains and ditches dug to bring water and also by the arrangement of an outlet (**figure 6**). The creation of this swamp is probablu due to the need of a long-term source of water for the pastoral practices.

In the near future

To supplement our knowledge concerning the formation of Late Pleistocene and Late Glacial landforms and ecosystems, a complete study of the PDB stratigraphy will be completed. Holocene deposits are also very interesting to have an overview of climate changes and anthropogenic activities at such elevation (1,460 m a.s.l.).

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Figures and tables

Figure 2: Location of the Pré-du-Bois operations at Le Béage in Ardèche (base map from Geoportail-3D ®)

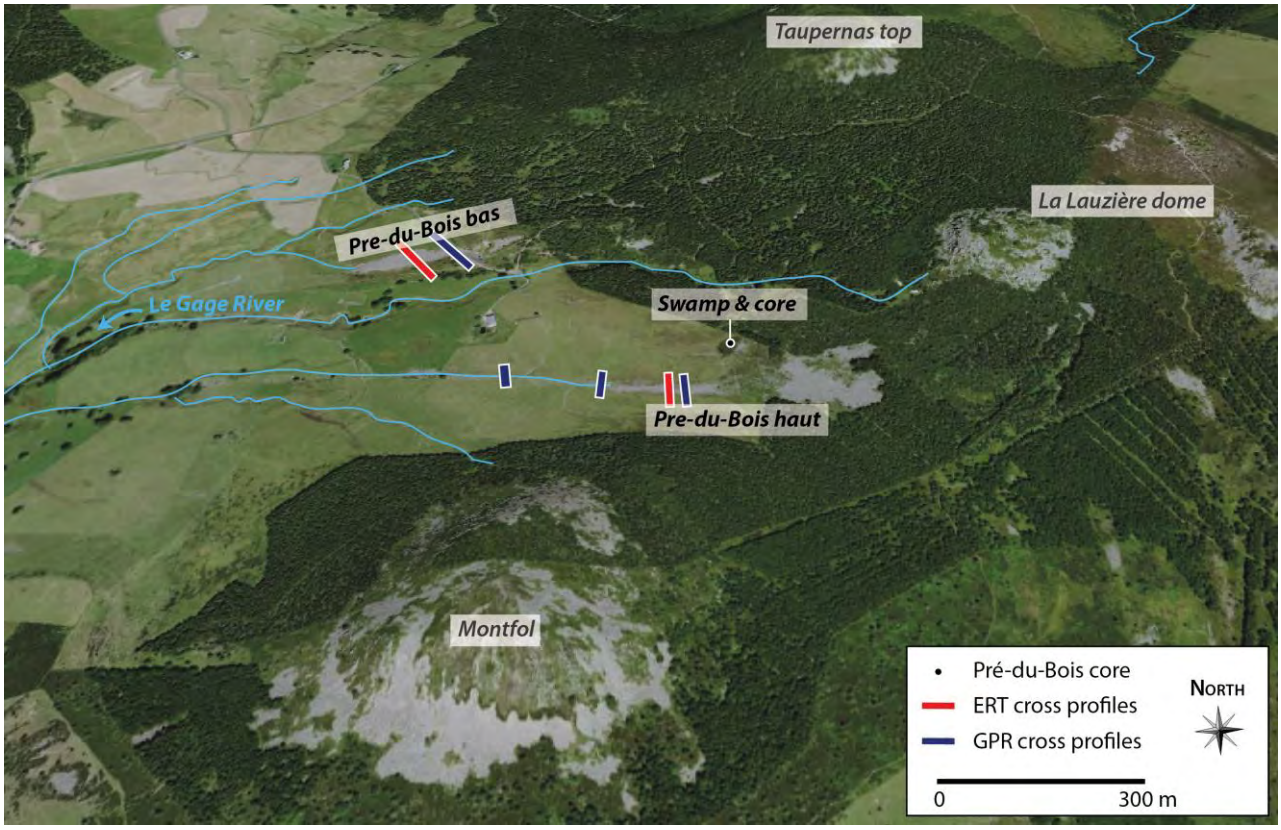


Figure 3: Cross section of the Pré-du-Bois with the location of the PDB Core (unpublished)

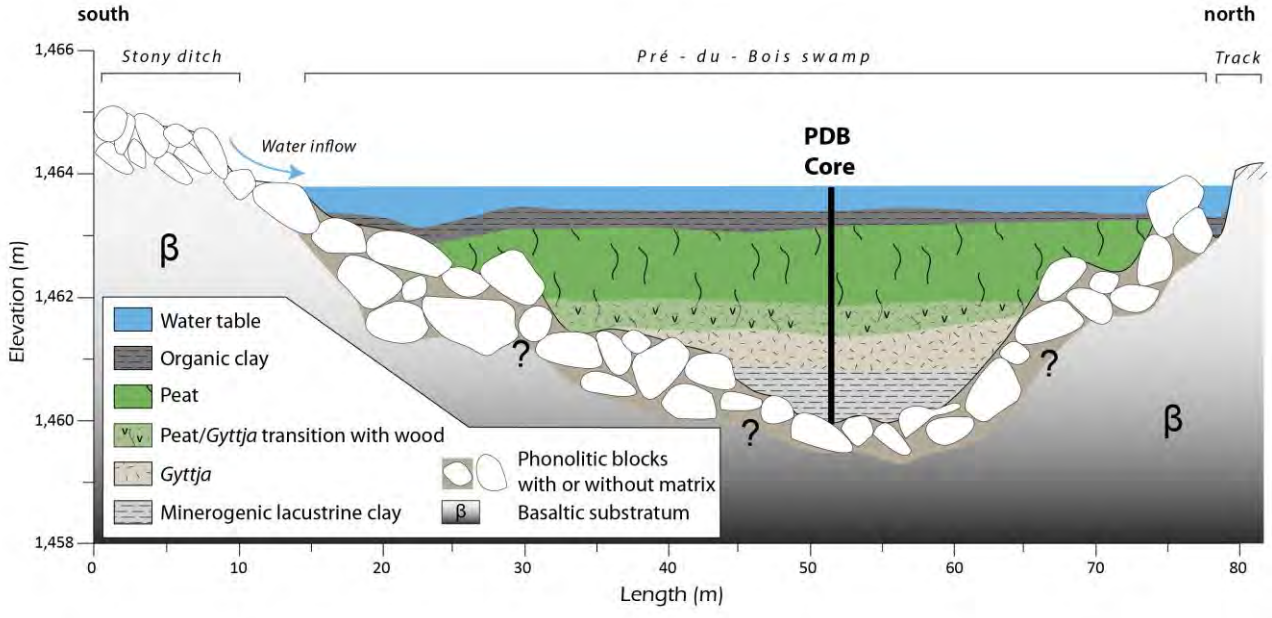


Table 1: Radiocarbon dates obtained of the stratigraphy of the Pré-du-Bois swamp (after Peignelin, 2014 and Dendievel, 2017)

Depth (cm)	Material	Lab code	Measured Age (1 σ; BP)	Calibrated Age (2 σ)		References
36 – 37	Peat	Lyon-12473 (SacA43637)	1,730 ± 30 BP	1,704 –1,562 cal. BP	246 – 388 cal. AD	Dendievel, 2017
162	Gyttja	Beta-369315	8,040 ± 40 BP	9,085 –8,728 cal. BP	7,135 – 6,778 cal. BC	Peignelin, 2014
209	*Wood*	*In progress: Center of Radiocarbon Dating of Lyon and Artemis program*				
289	*Bulk sediment*	*In progress: Center of Radiocarbon Dating of Lyon and Artemis program*				

Figure 4: Geophysical cross-profiles from the Pré-du-Bois bas blockstream (after Peignelin et al., 2014)

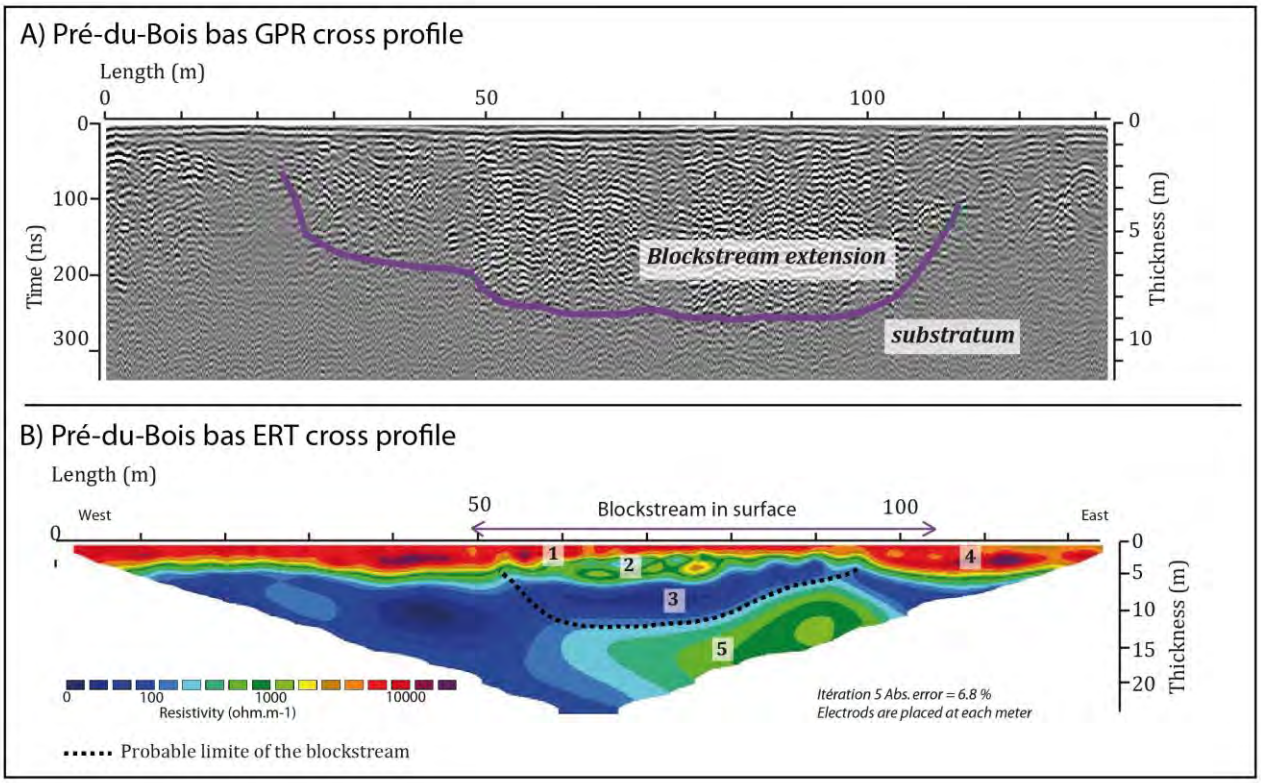


Figure 5: Chrono-stratigraphy, magnetic and organic data from the PDB core (after Dendievel, 2017)

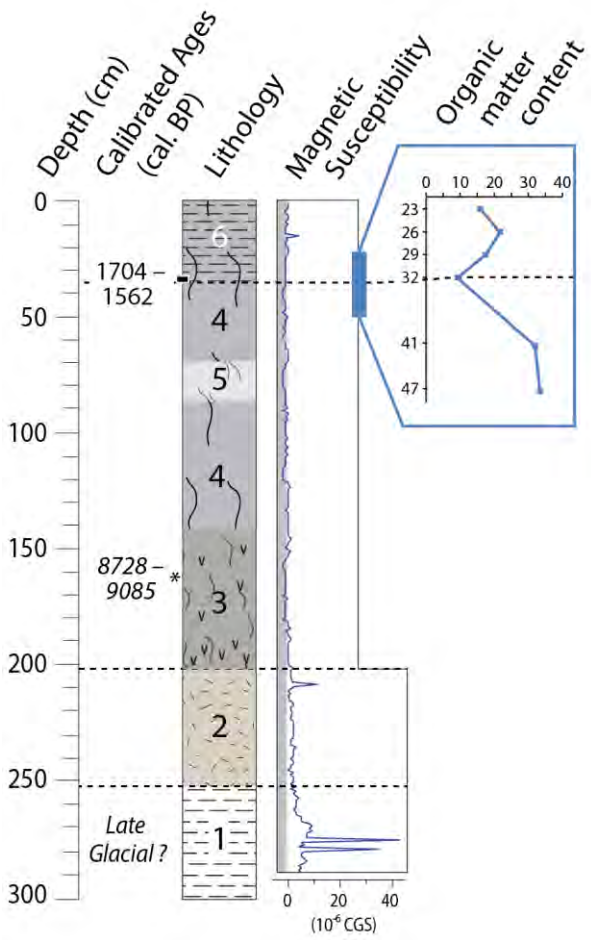


Figure 6: The Pré-du-Bois swamp and adjacent anthropogenic structures (after Dendievel, 2017)

