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Palaeoenvironmental and chronological investigations of the Magdalenian sites of Goyet Cave and Trou de Chaleux (Belgium), via stable isotope and radiocarbon analyses of horse skeletal remains

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ABSTRACT

Trou de Chaleux and Goyet are caves situated less than 30 km apart in Belgium that contain stratified Magdalenian artefacts and butchered faunal remains. Published radiocarbon dates suggest that both sites were contemporaneously occupied during to the Late-glacial interstadial. It has previously been suggested that the Trou de Chaleux Late-glacial faunal remains might be slightly older than those at Goyet Cave, and that Trou de Chaleux has two phases of occupation during the Late-glacial interstadial. However, the limited number of radiocarbon dates currently available makes it impossible to determine whether the sites are truly contemporaneous, and the assessment of their absolute chronologies is complicated by a plateau in the calibration curve. In this paper, bone collagen $\delta^{13}C$ and $\delta^{15}N$ signatures of horse bones from the two sites are used to reconstruct local palaeoenvironments. We hypothesise that if occupations at the two sites were contemporaneous, the horse collagen $\delta^{13}C$ and $\delta^{15}N$ isotope signatures from both sites will be similar, since comparable carbon and nitrogen isotopic values would reflect similar diets, ecologies and environments. To provide clear dating parameters, new AMS radiocarbon determinations are also presented. Results show that horse collagen $\delta^{13}C$ and $\delta^{15}N$ isotope signatures at the two sites are different, indicating that the populations were not subject to similar diets, ecologies and environments. The new radiocarbon dates confirm that the horse bones from Trou de Chaleux date to the Late-glacial interstadial, but they also show that in Goyet Cave Horizons 1 and 2, older horse remains dating to ca. 32 000–27 000 ^{14}C yr BP are mixed with Late-glacial horse remains. The $\delta^{15}N$ values of the Goyet Cave horse bones radiocarbon dated to the Pleniglacial are substantially higher than those that have Late-glacial radiocarbon dates. Therefore, we now hypothesise that the majority of the horse bones isotopically analysed from Goyet Cave Horizon 1 are Pleniglacial in age. Statistical analysis of the radiocarbon dates indicates that the Late-glacial occupation at the two sites was contemporaneous, and that while there may appear to be two phases of occupation at Trou de Chaleux, this may be an artefact of the radiocarbon calibration curve.

1. Introduction

The Magdalenian sites of Trou de Chaleux and Goyet cave are situated less than 30 km apart in the Namur Province of Belgium (Figs. 1 and 2). Published radiocarbon dates suggest that both sites were occupied just prior to and during the Late-glacial interstadial (Greenland interstadial 1; Svensson et al., 2006). Conventional and accelerator mass spectrometry (AMS) radiocarbon dates on bones of various species from Trou de Chaleux have yielded radiocarbon ages ranging from 12 990 ± 140 to 12 370 ± 170 uncalibrated ^{14}C yr BP (Uncalibrated radiocarbon dates henceforth are referred to as ^{14}C yr BP). Of these, two cut-marked horse bones have been dated to 12 880 BP ± 100 and 12 790 ± 100 ^{14}C yr BP (Hedges et al., 1993; Charles, 1998). AMS dates on bones of various species from Goyet Cave Horizon 1 have primarily produced Late-glacial ages ranging from approximately 12 775 ± 50 to 12 560 ± 50 ^{14}C yr BP, but there is also a bone of Pleniglacial age: 27 230 ± 260 ^{14}C yr BP (Germonpré, 1997). Of these, two horse bones have been dated to 12 770 ± 90 and 12 560 ± 50 ^{14}C yr BP (Germonpré, 1997). A single AMS date on a fox bone from Goyet Cave Horizon 2 has been dated to 12 380 ± 60 ^{14}C yr BP (Dalen, 2007). Based on the probability distributions of the calibrated AMS radiocarbon dates from the two sites, Germonpré (1997) postulated that the Trou de Chaleux Late-glacial faunal remains might pre-date those from Goyet Cave by a slight margin. However, the limited number of radiocarbon dates

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Fig. 1. Location of study region. Map generated from ESRI map data using ArcGIS v.9.1.

and the presence of a radiocarbon plateau during the Late-glacial, make it difficult to establish the precise temporal relationship between the Late-glacial phases at the two sites.

By themselves, conventional and AMS radiocarbon dates provide a means of dating archaeologically derived samples, whether they be samples from carbonised botanical material or from human or animal bone. However, in any such analysis, the dates are only as reliable as the archaeological stratigraphy from which they were obtained, and in many instances, there is an inherent difficulty in establishing the integrity of those deposits, particularly when one is dealing with older excavations. Stable isotopes are capable of providing very sensitive measures of climatic and environmental variation, which are particularly informative at points in time where there have been shifts in local and global climate. The analysis of the isotopes from bone is a nuanced method that has the potential to contribute a great deal to interpretations of site formation processes, and establishing the contemporaneity of samples from potentially mixed deposits.

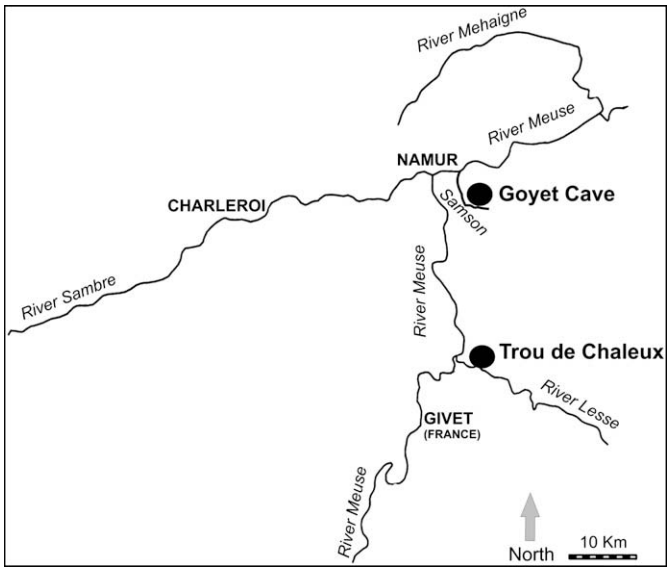

Fig. 2. Location of Trou de Chaleux and Goyet Cave.

This paper investigates the local palaeoenvironment of the two sites via the bone collagen $\delta^{13}C$ and $\delta^{15}N$ signatures of horses from Trou de Chaleux and Goyet Cave Horizons 1 and 2. We hypothesise that given the proximity and similar environmental contexts of Goyet cave and Trou de Chaleux, horse collagen $\delta^{13}C$ and $\delta^{15}N$ isotope signatures from the two sites will be similar if their occupations were contemporaneous, since the carbon and nitrogen isotopic values will reflect similar diets, ecologies and palaeoenvironments. Further AMS radiocarbon dating of horse bones from both sites allows us to assess whether the Trou de Chaleux Late-glacial faunal remains are contemporary with those at Goyet Cave Horizons 1 and 2, and to clarify whether there are distinct phases during the Late-glacial.

1.1. Sites and samples

Trou de Chaleux is situated at an altitude of 115 m in a carboniferous limestone cliff in the valley of the River Lesse, a tributary of the Meuse River, and sits 15 m above the river (Otte, 1994) (Fig. 2). One major bone horizon in the cave, containing a wealth of Magdalenian artefacts, was excavated by Dupont between 1864 and 1865 (Dupont, 1873). Excavations were undertaken on the terrace outside the cave during the mid 1980s (Otte, 1994). Extensive evidence for butchery can be seen, with cut marks on 27% of the horse bones, and it is also notable that the majority of all horse bones were broken, most probably for marrow and grease extraction (Charles, 1998). The published radiocarbon dates for Trou de Chaleux are listed in Table 1.

Goyet is a series of caves located at an altitude of 130 m in a carboniferous limestone cliff, about 15 m above the nearby River Samson. As with the River Lesse, the Samson is a tributary of the Meuse (Fig. 2). Goyet was excavated by Dupont in 1868 and 1869 (Dupont, 1869a,b, 1873). Recently, further small-scale excavations have been carried out (Otte, 1979). Goyet Cave contains five horizons; the youngest two near the cave entrance contained Magdalenian artefacts. The upper bone horizon is separated from the second horizon by a sterile deposit 10–15 cm thick, and the second horizon is separated from the third by a sterile deposit of 10–30 cm (Dupont, unpublished notes, 1906). Magdalenian artefacts found at Goyet Cave include bone needles, a biserial bone harpoon, a necklace composed of 26 teeth and two bone fragments, a necklace composed of 180 trace fossils of *Turitella* shells, a "bâton de commandement", and fragments of ochre (Dewez, 1987; Dupont, 1873; van Wetter, 1920). The presence of badger and domesticated pig in these upper layers show that some mixing with later and possibly earlier material has occurred (Germonpré, 2001). AMS dates on bones from Horizon 3 indicate a Pleniglacial age for these deposits (Germonpré and Hämäläinen, 2007) (Table 1). Evidence for butchery can be seen at Goyet, with cut marks on 4.5% of the horse bones in Horizon 1 (Germonpré, unpublished data) and 4.4% on the horse bones in Horizon 2 (Soenen, 2006). As at Trou de Chaleux, most of the horse bones from Goyet are broken. Only fauna from