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Dry swamp? Researching a peat bog and settlement in Podłęże near Kraków as a contribution to climate reconstruction in the early Subatlantic period

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A Holocene peat bog was excavated during archaeological research of site 17 in Podłęże near Kraków. It was located at the bottom of the valley of the Podłężanka river, a Fore-Carpathian tributary of the Vistula river, with a multiphase prehistoric settlement nearby. Radiocarbon dating of the peat bog deposits was accompanied by analysis of the archaeological remains and pollen analysis. A well, dated dendrochronologically to after 613 BC, allowed the dating of the peat bog to be more precise. Palaeoclimatic data from around Europe indicates that after the episode of sharp cooling and wetting of climate at the beginning of the Subatlantic period (*c.* 850–650 BC), the climate became warmer and drier (*c.* 650–450 BC). The well dug into the peat bog may indicate a temporary lowering of the groundwater level due to improved climate conditions. Therefore, the case may contribute – just like the discoveries from the shores of the Kunickie and Koskowickie Lakes in Silesia and from the Elbe valley in Dresden – to the hypothesis of a warmer climatic event during the early Subatlantic period.

KEY-WORDS: climate, early Subatlantic period, Podłęże, wetland settlement, south Poland

INTRODUCTION

The archaeological and palynological research in Podłęże, Wieliczka district (at the northern margin of the Carpathian foothills, southern Poland) was part of the programme of salvage excavations preceding the construction of the A4 Motorway between Kraków and Bochnia (Fig. 1). The excavations were conducted between 2000–2007 by the Cracow Team for Archaeological Supervision of Motorway Construction (a general partnership formed by the Institute of Archaeology and Ethnology

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of the Polish Academy of Sciences, the Jagiellonian University, and the Archaeological Museum in Kraków) at the behest of the General Directorate of National Roads and Motorways (Dzięgielewski 2010; Dzięgielewski *et al.* 2011).

The site, on two small elevations within the valley of the Podłężanka river (right-bank, Fore-Carpathian tributary of the Vistula), revealed abundant traces of prehistoric occupation (10 settlement phases, from the Neolithic to the modern period). Adjoining the site from the north there was a peat bog, developed on part of the Podłężanka flood plain in the Holocene. The peat bog was partially excavated and several pollen profiles were analysed (Fig. 1B). The close proximity of the site to the peat bog made it possible to perform "in site" palynological investigations in order to trace changes in land-use over time and to identify episodes of abandonment. The palynological profile P3 (Fig. 1B) was derived from samples collected directly from the wall of the archaeological trench in the peat using metal sampling tins (25 × 10 × 10 cm). 1 cm^3 samples of the material were analysed, subjected to maceration with KOH, HCL, $ZnCl_2$, and then to Erdtman's acetolysis (Faegri *et al.* 1989). Tablets with *Lycopodium* spores as indicators (Stockmarr 1971) were added to each sample. The percentage calculations were based on the total pollen sum including trees, shrubs and terrestrial herbs (investigation in progress, for tentative results see Dzięgielewski and Nalepka 2009).

DATING OF THE PEAT BOG

The age of the sediments from the Podłęże peat bog was determined using radiocarbon dating (18 dates; Fig. 2), pollen records, and an analysis of the artefact distribution in the peat deposits. The results, obtained independently from each of the aforementioned methods, were correlated and show no major disturbances in the sedimentation of peat layers, despite the direct proximity of human habitation. The majority of the radiocarbon dates come from profile P3 (Fig. 2). The remaining samples (from the other three profiles) were included in modelling the age-depth relationship by linear interpolation of the dated levels. The age-depth relationship for the bog shows a high degree of conformity for nearly all the dates to a depth of *c.* 125 cm and an age of *c.* 2000 BC (Fig. 2). Thus, the rate of neo-Holocene peat accumulation was determined with reasonable accuracy.

Another clue to dating the peat bog came from household pits dug into the peat in the vicinity of the settlement (Fig. 1B). Radiocarbon dates from their fills (800–400 BC, 2δ confidence level) allowed them to be linked with the Lusatian culture settlement from the Early Iron Age (Dzięgielewski 2010: 154–160). The most interesting discovery was a well (feature 655) with one oak plank surviving from its boarding (Fig. 3). The plank was dated dendrochronologically to 613 BC (+ *c.* 10 years for the sapwood). The level from which the well was dug was identified (the upcast when digging the

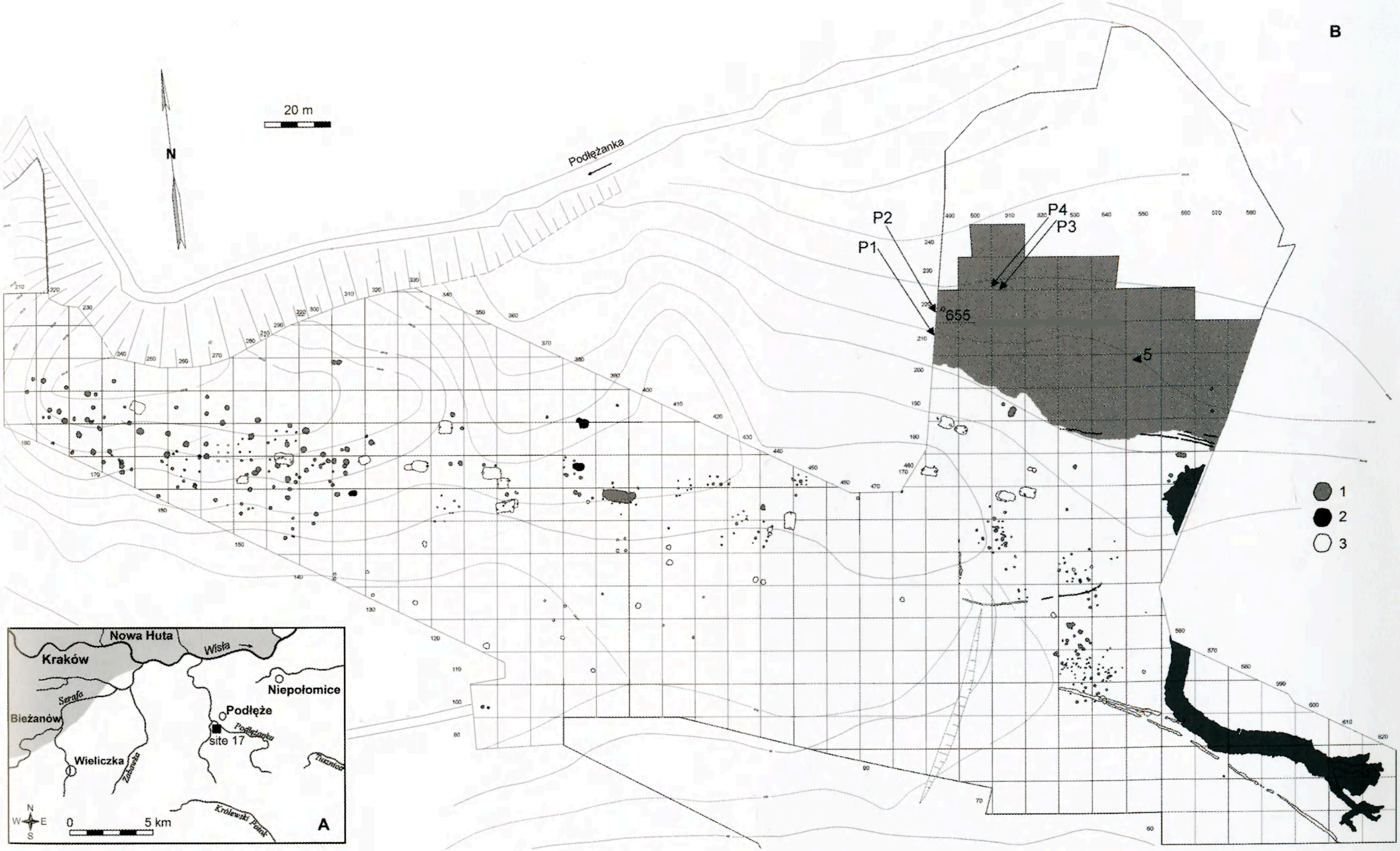

Fig. 1. Podłęże, Niepołomice commune, Wieliczka district. A. Location of the site. B. Plan of the central and northern parts of site 17; features dated to the first millennium BC (1 – Lusatian culture, 7^{th}–5^{th} century BC; 2 – Pomeranian culture, 5^{th}–4^{th} century BC; 3 – La Tène culture, 3^{rd}–2^{nd} century BC), location of the peat bog (grey colour), and pollen profiles (P1-4) as well as single ^{14}C sample (5) are marked

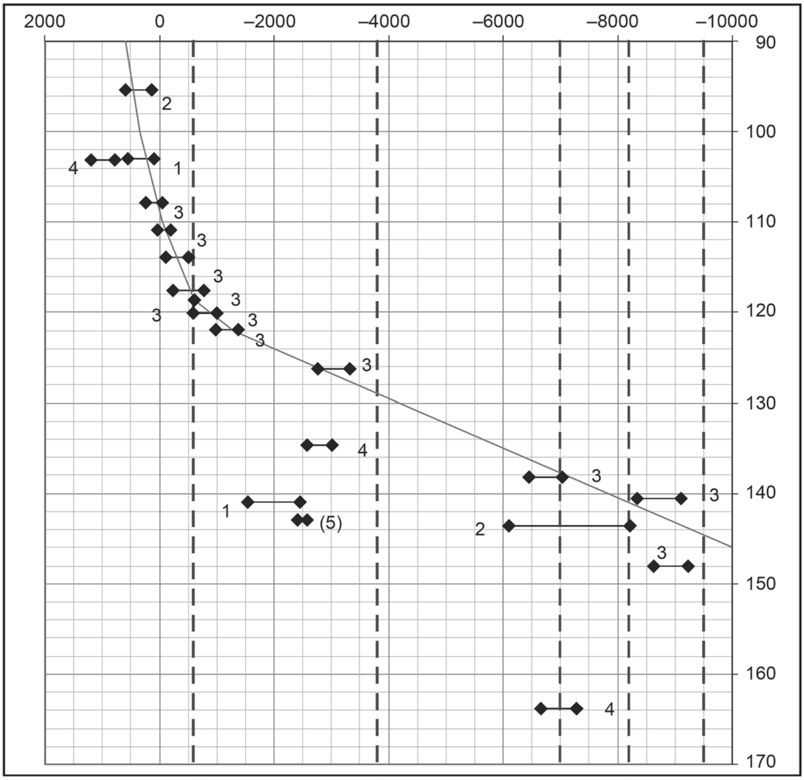

Fig. 2. Age-depth diagram for the Podłęże profiles. Horizontal axis – age AD/BC; vertical axis – depth (according to Profile 1); numerals 1–5 indicate the profile (P1-5 according to Fig. 1) from which the radiocarbon dates were obtained. All determinations were calibrated with the INTCAL09 curve and show 2δ confidence level (95%). Extrapolation of the model to 10,000 BC uses only the dates from Profile 3. Vertical dashed line – borders of Mangerud's chronozones after Walanus and Nalepka 2010. Radiocarbon dating was undertaken at *IGSB* Minsk, Belarus (P1-2 profiles); *Ki* Kiev, Ukraine (P4 profile), *MKL* Skała, Poland (P3 profile and the dendro date) and *Poz* Poznań, Poland (P5 sample) laboratories.

well formed a mound at contemporary ground level – Fig. 3), and allowed a particularly precise dating of the profile's central part (Fig. 2).

The fact that around 600 BC, a well more than 1 metre deep (as well as other features) was dug into the bottom of a river valley within the developing peat bog, testifies to the lowering of groundwater level, temporarily opening this part of the valley up to economic exploitation. Both before this period and especially after it, the profiles from Podłęże show an intensive accumulation of organic material (Fig. 2). It seems that this brief change in water regime could not have been caused by local hydrological factors. Rather, the deforestation of the surrounding area during the Lusatian culture

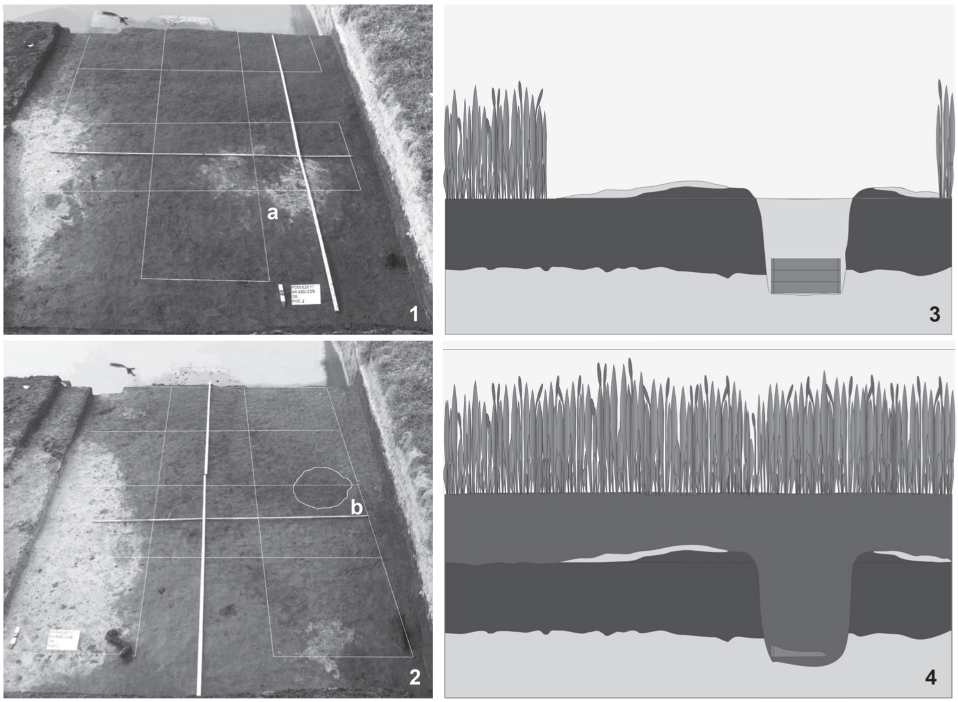

Fig. 3. The well from Podłęże: 1 – mound of excavated earth (a); 2 – outline of the well (b); 3 – reconstructed situation soon after the well was dug; 4 – reconstructed situation after the well was covered with younger peat deposits.

occupation in the Hallstatt period would have resulted in the rising of the water level. No forms of hydrotechnical activity (e.g. river engineering) are known from this period that could have caused such fluctuations in groundwater level. Thus, the reasons should be sought in global paleoenvironmental changes.

PODŁĘŻE AND THE CLIMATE IN THE EARLY SUBATLANTIC PERIOD

There is increasing palaeoclimatic evidence from the northern hemisphere indicating that the distinctly wet and cold swing at the beginning of the Subatlantic period was followed by a warmer and drier episode (Fig. 4: 1–2) (e.g. Klimenko 2004: 14; Tinner *et al.* 2003: 1455–1456, Fig. 5B). Even if this succession is in little doubt, the causes and chronology of the two episodes are still a matter for debate. According to some scholars, especially those who support correlating solar activity fluctuations with climate changes (e.g. van Geel and Renssen 1998; Speranza *et al.* 2002), the colder oscillation may be connected with a distinct increase in the radiocarbon concentra-

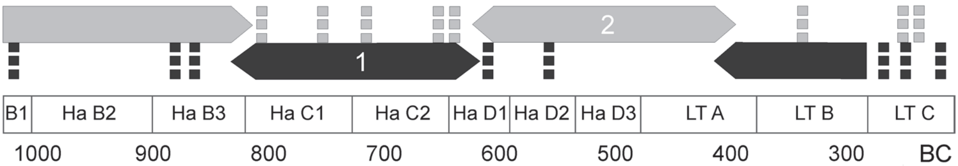

Fig. 4. Proposed synchronisation of climate oscillations and archaeological periodization in Europe in the first millennium BC (grey bars – dry and warm periods; black bars – cold and wet periods (increased frequency of extreme events). 1 – initial, cold and wet Subatlantic swing; 2 – the ensuing warmer oscillation (after Dzięgielewski 2012).

tion in the atmosphere (solar activity proxy) recorded from *c.* 850 to 750 BC. In their opinion, the warmer occurred in Europe between 650 and 450 BC (Maise 1999: 220; Tinner *et al.* 2003, Fig. 5B). On the other hand, some studies suggest these episodes occurred approximately 200 years later (Klimenko 2004: 14; compare with the dating of the Mangerud's chronozones: Walanus and Nalepka 2010).

With the evidence for dry conditions during the 7th/6th century BC transition, Podłęże supports the first of the above possibilities. Together with the discoveries made at the Late Bronze Age and Early Iron Age settlements at the shores of the Kunickie and Koskowickie Lakes in Silesia (Mierzwiński 1992) and in the Elbe valley near Dresden (Gühne and Simon 1986), Podłęże offers a further archaeological contribution in support of claims for a warmer climate oscillation in the early Subatlantic period (Fig. 4: 1). Despite the substantial number of similar cases in Europe, long reported in the archaeological literature (compare Smolla 1954; Dzięgielewski 2012), they are (with no good reason, in our opinion) still rather rarely used as proxy data for reconstructing the climate in the period of time discussed (e.g. Lamb 1982; Dergachev *et al.* 2007).

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