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CONCLUSIONS

The main conclusions, specific to each research topic and to each peat sequence, have been mentioned in the appropriate chapters. Here, methodological considerations and a comprehensive overview of the conclusions on solar forcing of climatic change and on human impact on the vegetation in the Giant Mountains are summarized.

Methodology

Since pollen analysis was pioneered, the palynological method has been settled and improved to achieve higher accuracy in palaeoenvironmental reconstructions. In this respect, it might be useful to stress some considerations made in the course of the present work. High-resolution analysis of different proxy data and their combination provided detailed information on vegetation dynamics, climate change and human impact. Such an approach is particularly useful in Europe, where the general lines of vegetation development and climatic change are already known, and where it is necessary to refine the analysis to understand the decade-to-century-scale changes and local variability. This last factor, local variability of phenomena, is of a crucial importance in understanding the agents of climate change. The different sensitivity of areas to climatic agents (for example the effect of the ocean, cloud cover, or changes in atmospheric circulation) will trigger peculiar reactions in regional and local vegetation. The particular characteristics of such reactions will allow a reconstruction of the modality of change in climate.

Together with a higher detail in palaeoecological reconstructions, a precise and accurate calendar time control has been essential. Only with a precise chronology of events can a single event be recognised in different sequences and discriminated from other events occurring close in time. This will allow a clear progression to be made in assessing the causes of climatic change. Radiocarbon dating is the main method for providing a time-control in palaeoecological research. While the introduction of AMS ^{14}C dating represented a major improvement as it allows dating very small samples, it is still crucial to provide selected hand-picked material. A sample constituted of clean above-ground remains which has the same age as the level to be dated will provide a more accurate estimation of the age than a bulk sample. This recommendation is particularly valid when dating in the proximity of a wiggle in the radiocarbon calibration curve and when applying the wiggle-match dating strategy. In this case, an appropriate selection of the material will yield a better reconstruction of the wiggle in the set of radiocarbon dates. The application of the wiggle-match dating strategy is crucial to achieve an optimal time-control in periods of $\Delta^{14}C$ fluctuations.

Furthermore this strategy also makes it possible to correlate $\Delta^{14}C$ fluctuations directly with evidence for climatic change in the same core. In this respect, wiggle-match dating makes the palaeoecological investigation of solar forcing on climatic change realistic: the time-control limitation reported by Chambers *et al.* (1999) for detecting solar forcing in proxy climate records is largely resolved with the application of this strategy.

The analysis of microfossils other than pollen (i.e. fungal spores, algae, thecamoebae and other animal remains) can add useful information for the reconstruction of local conditions such as, amongst others, the degree of humidity and trophic conditions. Unfortunately, the systematic position and the ecological requirements of some of these microfossils are not yet known. Nevertheless, a more general use of these "extra fossils" would rapidly increase the amount of available information and enlarge the value of their contribution to palaeoecological reconstructions.

Solar forcing of climate change

Increasing evidence is found for solar activity to be an agent of climate change. In this study, strong support was found for the hypothesis of solar forcing of climate change as recorded in the peat bog at Pančavská Louka around 850 cal BC. The results are based on visual comparison and cross-correlation of the curve of residual $\Delta^{14}C$ and those of climate indicators. They indicate a reaction of regional and local vegetation corresponding to the sharp increase of $\Delta^{14}C$ at ca. 850 cal BC. However, further investigation is necessary on the mechanisms amplifying changes in solar activity and on the role of the atmosphere and the ocean. Moreover, further, well-documented evidence is necessary from locations at many latitudes and time-spans. The creation of a network of research sites can provide data on the worldwide variability of the effects of solar activity forcing. In particular, evidence has to be collected of solar forcing of climate during intervals of sharp changes in $\Delta^{14}C$ (1300-1800 AD, 850 BC, 4000-3000 BC, 7500 BC, 8300 BC, 9300 BC). Some of these periods are characterised by well known climatic changes: Allerød – Younger Dryas transition, Younger Dryas–Holocene transition, Pre-Boreal Oscillation, Little Ice Age (compare Renssen *et al.*, 2000).

Human impact in the Giant Mountains area

The palaeoecological reconstruction of human impact on the vegetation in the Giant Mountains area during the last 4000 years corresponds relatively well with the archaeological data and historical sources. Until ca. the sixth century AD, no human impact was recorded in the vicinity of the Giant Mountains, and only long distance transport of Cerealia type pollen grains occurred. In the Černá Hora sequence, deforestation is recorded during the seventh to the beginning of the tenth century AD, possibly due to Slavic settlements in the nearby lowlands. Human impact increased in all the three sequences during the eleventh - twelfth century AD. In the records of Pančavská Louka and Úpská Rašelina a vegetation recovery is recorded in ca. the fifteenth and sixteenth centuries. The vegetation recovery at Úpská Rašelina continued until the end of the seventeenth century.
Uncertainties in calibrating the palynological record with human impact made it difficult to clearly quantify the degree of colonisation and the territorial limit of human influence. This is especially true in mountain environments, where, due to a

steep temperature gradient, different vegetation zones are situated relatively close to each other. Therefore, pollen from different ecosystems and altitudes is easily transported and deposited in bogs. Furthermore, the possible extent and impact of human altitudinal expansion depends on the type of activity (hunting, mining and agriculture). In this respect, further palaeoecological analysis, combined with archaeological survey in the Giant Mountains, could help completing the picture of past exploitation of the area.

This research served to reconstruct, by means of different techniques and tools, past environmental changes. The results achieved on the main research objective, the climate change at ca. 850 cal BC and, in general, the investigation of vegetation and human impact, demonstrate the potential of the integration of palaeoecology with aspects of climatology, isotope physics, archaeology and historical sources.

References

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