ACTA UNIVERSITATIS CAROLINAE
2000 GEOGRAPHICA, XXXV, SUPPLEMENTUM, PAG. 85–97

Late Glacial and Holocene Environmental Changes in the Hegau Region, Southwest Germany

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ABSTRACT

Sedimentological and palaeoecological investigations have been carried out to study the impact of early farming activity on the landscape evolution, next to a settlement (dated to ~7250 a BP cal) discovered in 1984 on the footslopes of the 'Hohentwiel' volcano in the Hegau region, SW Germany. The site is surrounded by fens, which are considered to be possible sediment traps and, as such, constitute suitable geoarchives for landscape change.
Sediment cores were investigated from four different locations: the settlement site 'Hilzingen Forsterbahn' (470 m a.s.l.), the fens 'Hilzinger Ried' and 'Heiligenwies' in the vicinity of the settlement site, and the alluvial and fen deposits 'Oberbiber' 5 km distant.
Our study reveals that the action of early neolithic farmers did not lead to significant colluvial deposition in the vicinity of the settlement. During the middle neolithic cultural stages (Hinkelstein and Großgartach), there was evidence of local colluvial sedimentation (settlement vicinity) and increasing minerogenic influx in the fen Heiligenwies. The fen Hilzinger Ried, however, was without any neolithic sedimentation. Only since the Bronze age, can agriculture be considered to have exerted a substantial morphogenetic effect on the landscape, which was documented in the vicinity of the settlement site and also in the two fens. The location Oberbiber, which lies further away, reflected its own fluvial development of a larger alluvial system (80 km^2).

Key words: Late Glacial, the Holocene, Hegau, environmental changes

1. Introduction

Recent climate changes have intensified public and scientific interest on past global changes, especially those during the Quaternary. One area of research is focussed on the Neolithic period, in particular the intensity of human impact by clearing, building of permanent settlements and the establishment of agricultural techniques. One major field of interest concentrates on the question of how to separate man-made changes in the environment from natural changes such as climate variability.

In order to contribute to this scientific goal, geoarchives around a Neolithic settlement in the Hegau region, southwest Germany were investigated in detail. The project is part of the programme "Changes of the Geo-Biosphere during the last 15,000 Years – Continental Sediments as Evidence for Changing Environmental Conditions". The programme itself is a contribution to PAGES (Past Global Changes) and hence, part of the IGBP (International Geo-Biosphere Programme) (cf. Andres 1998).

2. Study area

The study area, west of Lake Constance, has been formed by different geomorphological processes. The geological basis of the region is Molasse sediments that accumulated in the marginal trough of the rising Alps during the Tertiary (Fig. 1). Miocene tuff, basalt and phonolite were deposited as a result of volcanic activities within the Hegau Volcanic province (Schreiner 1995). The volcanic domes visible today are erosion features formed by glacial, periglacial and fluvial activities during the Pleistocene. The Rhine glacier over-deepened and widened the basin of Lake Constance. Typical glacial features such as kettle holes, pro-glacial channels and moraines can be

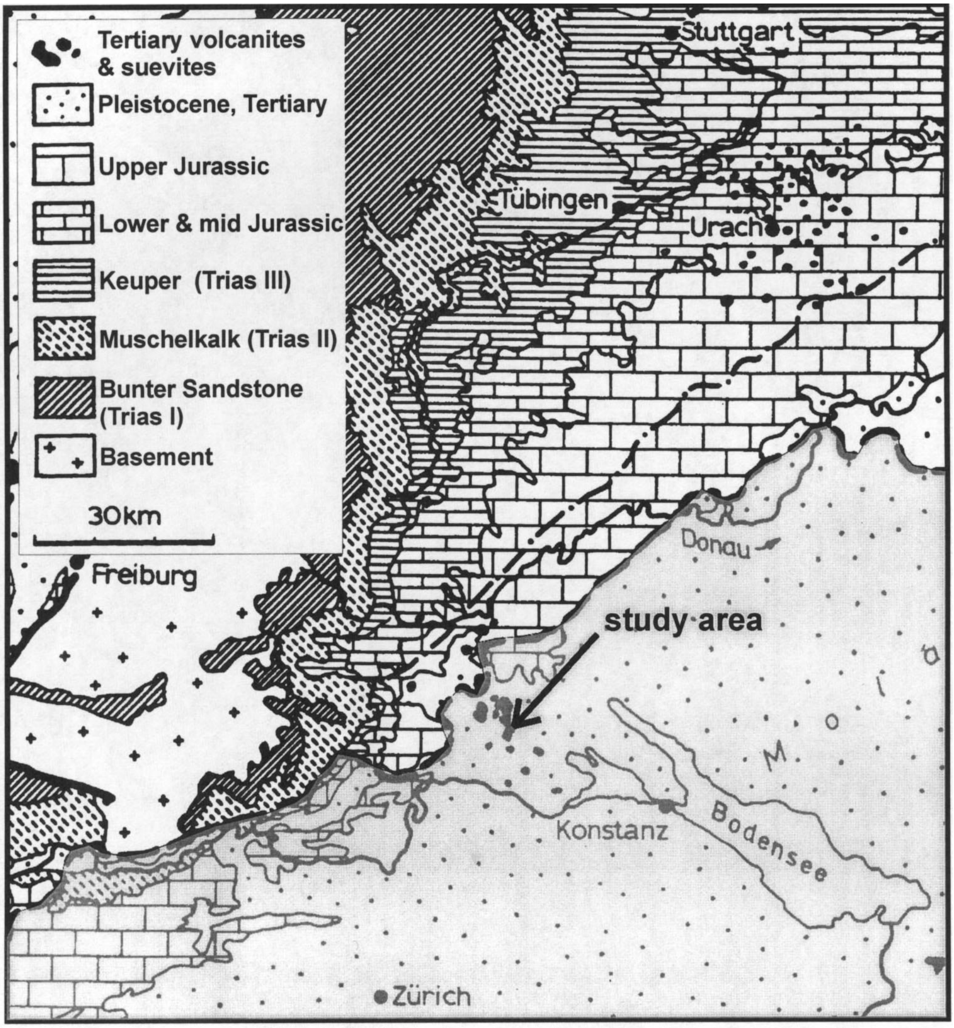

Figure 1: Main geological units of the German Alpine foreland (from Geyer & Gwinner 1991).

found throughout the area. Following the retreat of glacier ice, many small lakes were formed most of which later developed into fens.

During the Holocene, Luvisols and Phaeozem-like soils developed on well drained and moderately tilted slopes, whereas calcaric Regosols covered the steeper slopes (Ehwald 1980; Schlichting 1986; Stahr and Peyer 1997). These soils apparently offered good conditions for early agriculture compared to the loess soil region, for example, the Kraichgau depression between the Odenwald and the Black Forest Mountains (Barsch et al. 1993). In the Hegau region, human activities from Neolithic and earlier periods caused the formation of Cumulic Anthrosols.

An early Neolithic settlement has been excavated on the footslopes of the Hohentwiel Volcano, and dated to 7,250 a BP cal (Fritsch 1998). It is the earliest settlement in southern Germany according to Rösch (1987), and was inhabited until the middle Neolithic period (Hinkelstein- and Grossgartach-cultures), and then again during the early Bronze age (Urnenfeld-culture). There is no archaeological evidence of late Neolithic cultures (Dieckmann 1995). This early settlement, together with the geoarchives of the adjacent fens and alluvial deposits, presented an opportunity to study early human impact on landscape evolution.

3. Methods

After taking sediment and peat cores, sub-samples of the gained sediments were analysed in the geomorphological laboratory of the University of Heidelberg. The investigations included volumetric susceptibility, organic carbon, carbonate and sediment stratigraphy by different methods. By means of the Loss-on-Ignition method, 2cm spaced samples were analysed for organic carbon (430 °C) and carbonate content (925 °C). The residue was interpreted as minerogenic material. Thus, the influx of minerogenic sediment into a fen could be detected, a process probably caused by early farming. Further methods were applied to study palaeo-environmental conditions, such as analyses of pollen (M. Stumböck, Mainz), diatoms (J. Alefs, Munich) and molluscs (H. Rittweger, Waldbrunn). Some samples were radiocarbon dated (B. Kromer, Heidelberg; K. van der Borg, Utrecht).

4. Results

The following four locations were chosen (Fig. 2) out of the total sum of seven sites investigated, in order to obtain an overview on landscape development:

A Neolithic and Bronze age settlement site, ‘Forsterbahn’, including its near surroundings (4.1).

The fen ‘Hilzinger Ried’, close to 4.1, situated in a late glacial lake basin (4.2).

The fen ‘Heiligenwies’, valley bottom 500 m downstream of the settlement site (4.3).

Alluvial deposits ‘Oberbiber’, 5 km distant, valley bottom of the Biber river (4.4).

We present a comprehensive interpretation of our results - detailed discussion is given in various publications (Schulte and Stumböck 2000; Heckmann 2000; Schulte 2000).

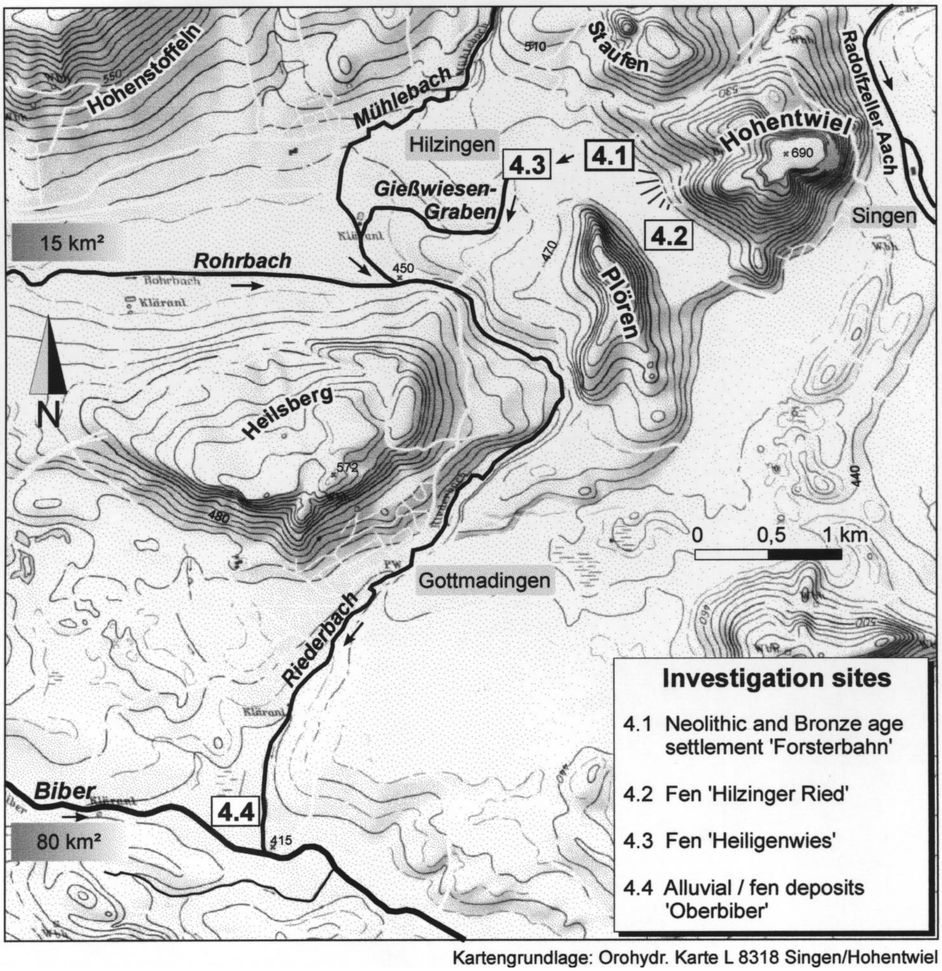

Figure 2: Map of the study area with the prehistoric settlement site, the fens Hilzinger Ried and Heiligenwies and the alluvial deposit Oberbiber (from Heckmann 2000).

4.1. Settlement site Forsterbahn

Combining pedological (Ehrminger 1988), archaeological (Dieckmann 1995; Fritsch 1998) and our sedimentological investigations, the development of this location can be described as follows (Fig. 3). Early Neolithic man established a settlement on a small ridge consisting of gravely and silty deposits covered by a Phaeozem-like soil. In order to build the long wooden houses, the settlers dug 1–1.5 m deep holes for supporting pillars. Hundreds of these hole remnants, filled with organically-rich material, were discovered during the excavation in 1984 (Fritsch 1998). The ridge was eroded gradually during the Neolithic and Bronze Age, and the sediments were trapped in colluvial deposits at the ridge border.

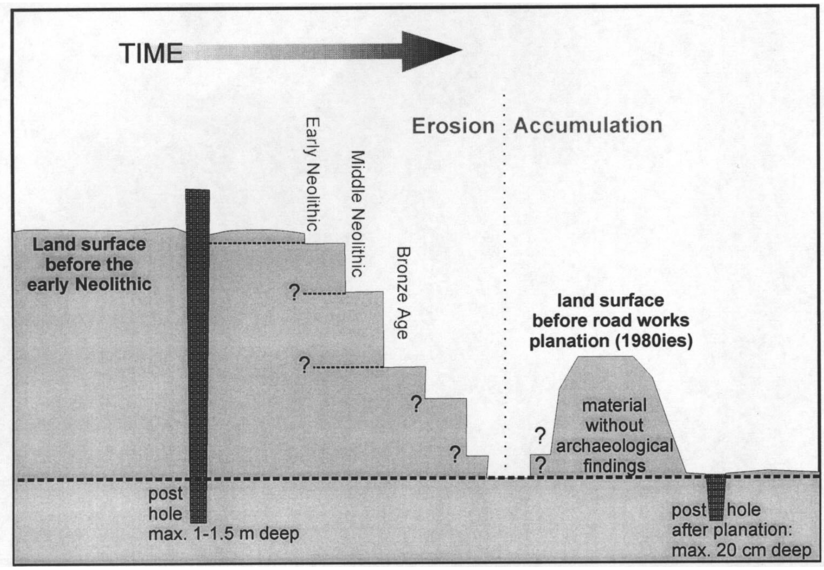

Figure. 3: Periods of erosion and deposition on the prehistoric settlement site.

The first settlers established an agriculture, but soil erosion and transport seem to have been too weak to form colluvial deposits. A dark colluvial layer, identified by archaeological remains as middle neolithic (Hinkelstein culture), was the first evidence of increased soil erosion on the ridge (centre of the settlement) and sediment displacement at its border (Dieckmann 1995). Due to its black colour, the sediment was interpreted as the eroded and re-deposited humic top horizon of a Phaeozem-like soil. Soil erosion at the settlement site and colluvial deposition continued during the period of middle neolithic Grossgartach culture. Ehrminger (1988) reconstructed the amount of middle-neolithic erosion by about 80 cm in depth.

The following 3,000 years have not been preserved in either archaeological findings or sediments. Not until after the beginning of the Bronze age, during the Urnenfeld culture, did colluvial deposits again accumulate at the ridge border and in other areas investigated. These sediments could be clearly distinguished from older ones by their light brown colour. They represented eroded soil from deeper layers, poor in organic material. Semmel (2000) reports similar differences in colour between colluvium from the Neolithic and Bronze age in the area around Frankfurt.

After the Bronze age, the geodynamic processes on the ridge must have changed from erosion to accumulation, because the former settlement site was covered by younger colluvial sediments. In 1984, road construction removed almost all of these younger deposits.

4.2. Fen Hilzinger Ried

The fen Hilzinger Ried (similar to 4.1) originated from a glacial basin between the tuff mantle of the volcano Hohentwiel and the tuff mountain Plören (Fig. 2). After deglaciation around 15,000 a BP conv (Furrer 1991), the basin was filled by a pro-glacial

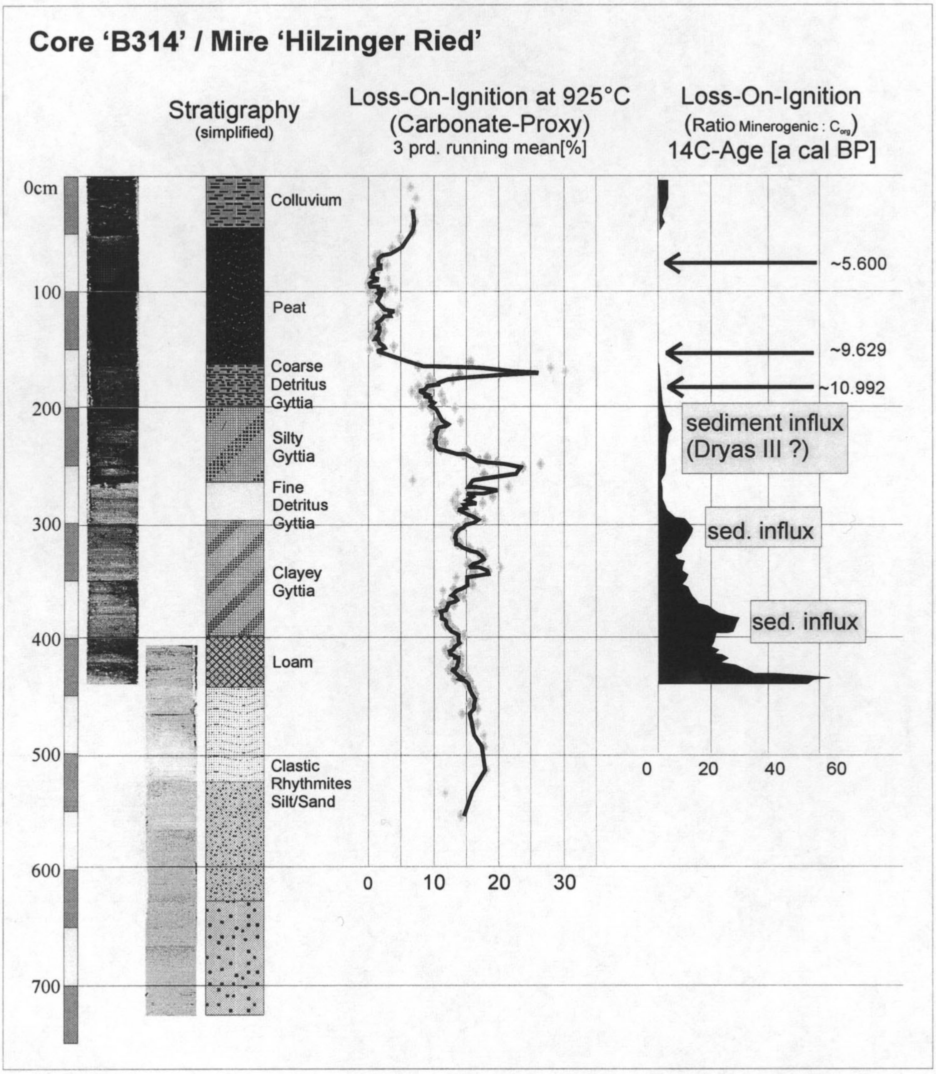

Figure 4: Geoecological parameters from sediments of the fen Hilzinger Ried.

lake with a maximum depth of 5 m. During the final retreat of the glacier from the terminal moraine, the melt waters altered their direction southward. As a result, the influx of fluvioglacial sediments into the basin stopped. This sudden change was preserved in a well defined border between the lower fluvioglacial gravel and lacustrine sand, and the upper layers consisting of silt and clay (Fig. 4). Assuming that the change in drainage occurred 15,000 years ago, the sedimentation rate (until Bølling) may be estimated between 0,5 and 1 mm per year (Heckmann 2000). Similar rates of sedimentation have been reported for Lake Constance (Wessels 1998).

During the Bølling, increasingly organic relics were deposited in the shallow lake. There were two phases of increased influx of minerogenic sediment during that chronozone, revealed by Loss-on-ignition (LOI) analysis. Reforestation - initially with birch, later with pine forests - started during the Bølling, as found, for example, by Lang (1994) in the western Lake Constance area, and Beck (1998) in a fen a few km north of the study area. It continued, reaching a maximum in the Allerød chronozone.

In the second half of the Allerød, the lake level reached a minimum. There was even sedimentation and pollen analysis evidence of the lake drying up, the basin being overgrown by macrophytes.

During the Younger Dryas, the area was dominated by pine forests. This observation is consistent with studies from Nussbaumer Seen, on the northern Swiss Plateau (Rösch 1995), the Buchensee (Bertsch 1961), and the Biber valley 5 km south of the study area (Schulte & Stumböck 2000), the latter illustrated in 4.4. In spite of the relatively dense pine forest and evidence of a dry climate during the Younger Dryas, an increased influx of minerogenic sediment into the lake was interpreted as an indicator for an erosional phase during that chronozone. At least 50 cm have accumulated over 1,100 years (sedimentation rate of ~0.45 mm/year).

The lake level seemed to rise again during the Preboreal. In the Boreal chronozone, peat growth started with the water table rising at times above the surface. This Boreal water table rise has been documented in many lakes in the vicinity of the study area, for example, in Le Locle lake (Swiss Jura) between 10,200 and 8,900 a BP cal (Magny & Schoellammer 1999), in the French Alps (transgression phase Joux), in the Swiss Plateau and the Swiss Alps (Magny and Richoz 1998).

Interpolation of the radiocarbon datings of peat deposited since the Boreal, leads to a growth rate of 0.26 mm/100 a, which seems to be too small compared to other studies. Together with the stratigraphy of some cores, a hiatus in the peat stratigraphy of the Hilzinger Ried is suspected, probably caused by temporary regression phases.

However, peat growth continued throughout the Atlantic chronozone. The area affected by peat growth was even larger than the former lake, which points to a rise in the ground water table. Radiocarbon datings from the peat base (Boreal), show that there was no lake when the Neolithic settlers arrived, maybe there were only small patches of open water. Consequently, fish, the remains of which were found in Neolithic 'waste dumps' discovered on the settlement site (Fritsch 1998), must have been caught in creeks or been 'imported' from somewhere else in the lake rich landscape.

There was no sedimentary evidence of soil erosion during the Neolithic in the Hilzinger Ried sediments, although the basin was looked at as an ideal trap for eroded sediment at the beginning of our studies. Eroded soil was possibly accumulated somewhere between the Neolithic 'fields' and the basin, maybe in the colluvial deposits at the border of the ridge at the transition to the Hilzinger Ried basin.

The middle Holocene elm decline was documented in the sediments of Hilzinger Ried. Extrapolation of radiocarbon datings tentatively suggest an age somewhere between 6,000 and 4,500 a BP cal, as found in studies from Lobsigensee, Switzerland (6,000 a BP cal; Ammann 1989), Nussbaumer Seen, Switzerland (decline of elm and lime between 6,000 and 4,000 yrs BP; Rösch 1995) and Wallisellen-Langachermoos (elm decline over approx. 2,000 years; Haas 1996). Parallel to the elm decline, there was a increase in pollen, evidencing a growth in land use. This constellation is also reported in several other publications (e.g. Lang 1994; Burga and Perret 1998). Corresponding archaeological evidence from the late Neolithic has not yet been found in the closer neighbourhood of the study area, however.

The formation of colluvia further away from the settlement site did not start before the early Bronze age (Urnenfeld-culture). Peat growth ends about 2,700 a BP cal, when colluvial deposits accumulated at the margins of the basin, reaching a total thickness of approximately 1 m to date. Concurrent with the onset of the Bronze Age colluvial deposition, an erosional phase could be documented in several cores from valley bottoms throughout the study area. The erosional phase fitted to a time frame of 3,050 – 2,450 a BP cal (Schulte and Stumböck 2000).

4.3. Fen Heiligenwies

The fen Heiligenwies is situated in the valley bottom, 500 m downstream of 4.1 (Fig. 2). In contrast to the results of the settlement site (no evidence of significant soil erosion during early Neolithic), these sediments already showed a distinct increase of minerogenic influx into that small basin at 7,550 a BP cal (Fig. 5), that is, 300 a before the dated commencement of settlement (7,250 a BP cal). This is likely due to a problem in the interpolation of datings, otherwise the land use would have begun earlier than the dated commencement of settlement. To date, there is no evidence for a culture older than the early Neolithic.

During the middle Neolithic periods, Hinkelstein and Großgartach, increasing soil erosion resulted in colluvial deposits reflected in mineral contents up to a maximum of 15 %. The subsequent decrease in minerogenic influx can be explained by the abandonment of the settlement for about 3,000 years, resulting in stabilising environmental conditions. This explanation is supported by the absence of late Neolithic archaeological findings (Dieckmann 1995; Fritsch 1998).

The sediment system was activated again during the Bronze age (3,500 a BP cal) with the establishment of the Urnenfeld-culture. This is not a local phenomenon as colluvial deposits are documented near the settlement (4.1), the Hilzinger Ried fen (4.2) and in the fen Heiligenwies as well. A gravely layer and a colluvium embedded in the peat could be correlated to a phase of increased fluvial activity about 2,716 – 2,468 a BP cal (SCHULTE & STUMBÖCK 2000).

For this period, with the increase in fluvial activity, it appeared difficult to separate the magnitude of human impact on soil erosion and river degradation from that effected by worse climatic conditions. Forest devastation, by cutting and fire or intensive agriculture, may have resulted in increasing overland flow and erosion, leading to higher fluvial dynamics. However, the evidence of dated stratigraphic unconformities in several other cores from a bigger area, which is not presented here, emphasises the possibility that worse climatic conditions were responsible for the increase in sediment dynamics.

4.4. Alluvial deposit Oberbiber

The area is situated at a distance of 5 km from the settlement site (4.1), close to the confluence of the creeks Biber and Riederbach (Fig. 2). The alluvial deposits

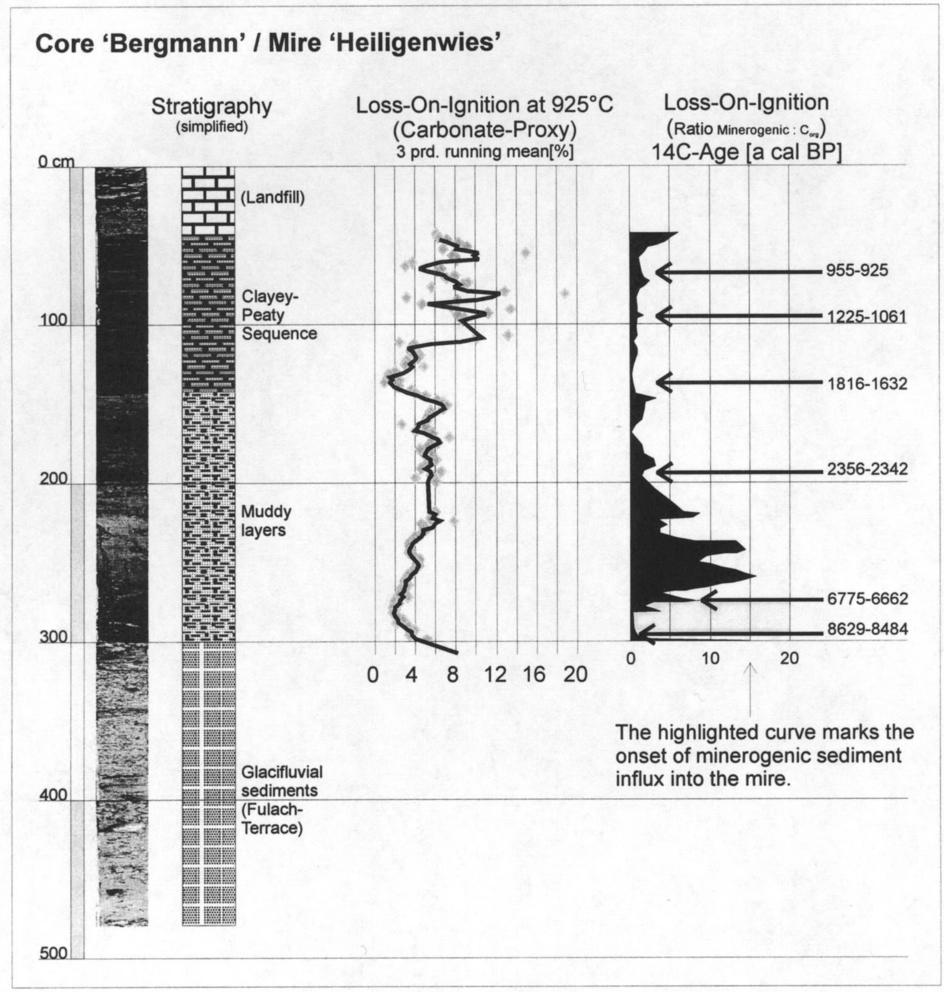

Figure 5: Geoecological parameters from sediments of the fen Heiligenwies.

accumulated at the earliest from the Late Glacial period up to historical times. Pollen analyses were conducted in order to get an overview about the local and regional vegetation development (Fig. 6).

The lowest parts of the core (520–372 cm) showed gravel followed by loam and clay during the Bølling and Allerød. An open pioneer vegetation dominates developed soils with herbs such as Artemisia, Poaceae and Thalictrum and shrubs such as Hippophae, Pinus (mugo) and Betula. Trees other than Pinus sylvestris were absent, because the unfavourable climatic conditions during the ice-age restricted the occurrence of further tree species to southern Europe (Kral 1979). Oberbiber itself was a lake covered with water plants (Sparganium). Later, the basin was filled to such an extent that a fen developed with abundant Cyperaceae.

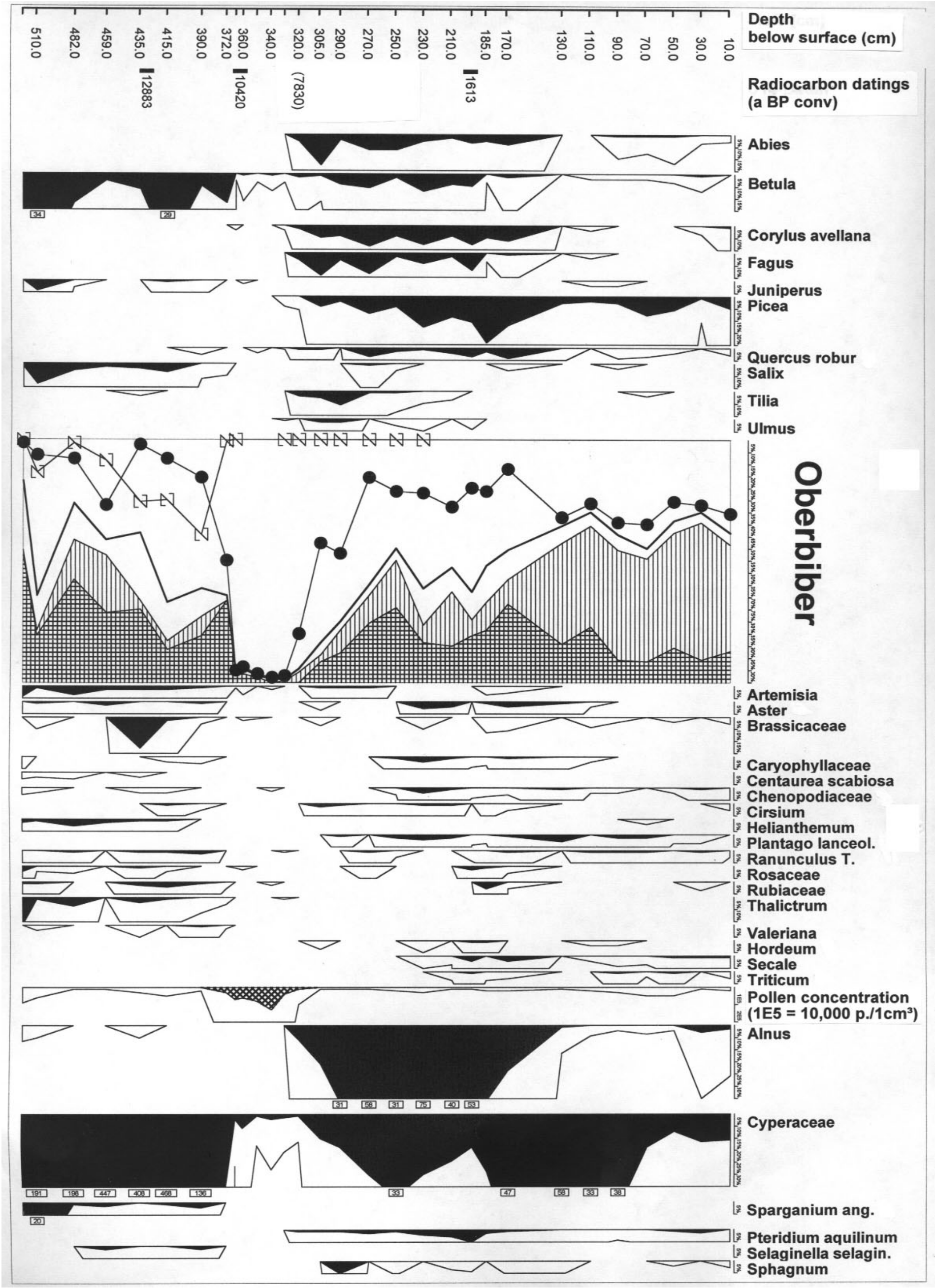

Figure 6: Simplified percentage pollen diagram from the alluvial deposit Oberbiber. 100 % includes all pollen types from Abies to Triticum. Excluded are all types from Alnus to Sphagnum. The main diagram shows following types: ∑ – Pinus; z – Hippophae; hatched area – Asteraceae; squared area – Poaceae; the bold continuous line divides arboreal from non arboreal pollen types.

The layers between 372 and 330 cm consisted of mud and peat, reconstructed as a time span from the Younger Dryas possibly up to the Preboreal. During the Younger Dryas, the vegetation was absolutely dominated by Pinus sylvestris with just a few other species. This condition continued until the Preboreal as shown in pollen diagrams from adjacent Switzerland (Ammann 1989). During this time period, the fen Oberbiber was at least partly covered with forest. This was preserved in the abundant pollen of Pinus sylvestris with very few Cyperaceae, and the complete absence of water plants. Apparently the Boreal was not preserved in the sediments, because of the lack of Corylus, which was common during this period.

The radiocarbon dating at 320 cm relates to the early Atlantic. Yet the very high Pinus pollen content, and the low percentages of other arboreal pollen types are not usual in the German alpine foreland during the Atlantic, as demonstrated by other pollen diagrams (Lang 1994). Thus, this dating does not seem to be reliable. The logical conclusion is that a large hiatus of several thousand years, possibly combined with sediment turbulences, determine this segment. It is likely that fluvial dynamics of the adjacent creek, Biber, may have caused this discordance.

The layers above 320 cm consisted of clay and loam, and have accumulated mainly within historical times. The main vegetation types were forest with Abies, Fagus, Corylus and Picea, and meadows and pastures (e.g. Poaceae, Asteraceae, Plantago) respectively. The presence of cereals (Hordeum, Secale, Triticum) documented an agriculture. The location, Oberbiber, was covered by forest composed of Alnus, replacing the former Pinus sylvestris indicating higher soil moisture content. In the uppermost decimetres, Alnus largely diminished and Cyperaceae spread again. This may have been caused by cutting and burning, so diminishing the local and regional forest cover. The increasing overland flow resulted in water logged sediments.

5. Conclusions

From our investigations we may conclude that the early neolithic human impact caused only slight soil erosion and displacement, and did not exert a morphogenetic effect. The hypothesis that the first neolithic settlers in the Hegau region caused an extensive change in the landscape, even in the near vicinity of their clearings, cannot be confirmed.

During the middle neolithic cultures, Hinkelstein and Großgartach, soil erosion increased and local colluvial deposits accumulated up to a thickness of 70 cm in the vicinity of the former settlement site, this amount decreasing with increasing distance from the settlement.

During the early Bronze Age, there was a significant increase in soil erosion, sediment transport and formation of colluvium, and a greater area was affected. It is known from archaeological investigations that the human impact during the Bronze Age affected larger areas and that new farming techniques promoted soil erosion. Thus it seems difficult to evaluate and delineate the significance of climate/weather conditions and human impact on landscape change.

Therefore, the investigations in the Hegau region should be intensified with respect to other fen locations. As geoarchives, these fens contain substantially more information that should facilitate a more precise reconstruction of palaeoenvironmental change with a higher time resolution.

Acknowledgements

The authors would like to thank the German Science Foundation (DFG, Bonn) for financial support. We are especially thankful to following persons for their valuable contributions. S. Depprich, E. Diermayer, A. Dittfurth, T. Heckmann, H. Kerkhof, M. Lechner, G. Schukraft, F. Wellenreuther, H. Wieczorrek and M. Zeh (University of Heidelberg), J. Alefs (University of Munich), H. Rittweger (University of Frankfurt), B. Kromer (University of Heidelberg) and K. van der Borg (R. J. Van de Graaff Laboratory, University of Utrecht).

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POZDNĚ GLACIÁLNÍ A HOLOCÉNNÍ ENVIRONMENTÁLNÍ ZMĚNY V OBLASTI HEGAN V JIHOZÁPADNÍM NĚMECKU

Résumé

Současné klimatické změny zvýšily zájem o výzkum globálních změn v minulosti, a to zejména během kvartéru. Autoři se zaměřují na období neolitu, zvláště na rozsah vlivu člověka odlesňováním, výstavbou stálých sídel a zaváděním zemědělských technik a na možnosti rozlišení antropogenních a klimatických změn přírodního prostředí. Byl proveden sedimentologický a paleoekologický výzkum impaktu raného farmářství na krajinu na čtyřech různých stanovištích v blízkosti sídliště (datovaného na 7250 před současností) při úpatí vulkánu „Hohentwiel“ v regionu Hegau na JZ Německa. V práci je ukázáno, že činnost raně neolitických farmářů nevedla v okolí sídlišť k podstatné koluviální sedimentaci. Tato sedimentace se v blízkých močálech projevila až v průběhu středně neolitických kulturních stadií (Hinkelstein a Grossgartach) na lokalitách „Hilzingen Forsterbahn“ a „Heiligenwies“. Zemědělství lze považovat za významné pro morfologické změny krajiny teprve od doby bronzové, což bylo zjištěno jak v sedimentech močálů, tak v okolí sídlišť. V bronzové době bylo takto ovlivňováno již rozsáhlé území, zvýšila se eroze půdy a transport sedimentů. Od tohoto období je proto velmi obtížné odlišit změny krajiny vlivem činnosti člověka a variabilitou podnebí.