

Guide to the archives of the Laacher See eruptions

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Late Würmian strata prior to the Laacher See eruptions (W. SCHIRMER)

Amongst the youngest volcanic events in Germany are the eruptions of the Laacher See volcano in the Eastern Eifel volcano field on the Mittelrhein dating into the Allerød interstadial at about 13, 000 cal BP. Recently the Laacher See event could be subdivided into two eruptions of Allerødian age, the older Pellenz eruption and the younger Meile eruption (W. SCHIRMER 1995a,b).

The two eruptions of the Laacher See volcano preserved two sedimentary and palaeobiological archives:

The **Pellenz eruption** preserved strata prior to the middle Allerødian. Generally, it is the humic **Mendig Soil**, a calcaric regosol whose formation was interrupted by the Pellenz eruption. Until now this soil underwent post-eruptive alterations by solutions pervading the tephra from the recent surface (IKINGER 1995, 1996). In small depressions this soil splits up into a more subdivided Late Würmian including the Meiendorf Interstadial - Older Dryas - Bølling Interstadial - Middle Dryas - early Allerød Interstadial (U. SCHIRMER 1995, W. SCHIRMER 1996) (Tab. 1, Fig. 8). They are topped by the middle Allerødian **Mendig palaeobiocoenosis** that indicates the oecological state of the first eruptional moment of the Pellenz eruption.

The **Meile eruption** preserved strata deposited between the Pellenz and the Meile eruption, the so-called **Breisig Interval** topped by the **Breisig Soil** (W. SCHIRMER 1996) with the Allerødian **Breisig palaeobiocoenosis** (WALDMANN 1995, 1996c). The duration of the Breisig Interval can only be estimated by the developmental stage of the Breisig palaeobiocoenosis and may embrace several decades of years.

Moreover, the Mendig flora and the Breisig flora differ in plant composition as well as season. This supports the geological evidence of two different Laacher See eruptions (WALDMANN 1996c).

Thus, both eruptions leave to us the inheritance of two oecological moments of the Allerød landscape with soils, vegetation and fauna.

The **Pellenz** landscape (Fig. 1) exhibits the tephra of the Pellenz eruption with the preserved underlying beds, the Mendig Soil and Flora. In some places the Pellenz tephra is cut by deep channels filled by a reworked second flora (**Barbara Flora**) and reworked tephra rich in silt. From stratigraphical point of view I assume that the Barbara Flora is an equivalent of the Breisig Flora and the reworked tephra belonging to is an equivalent of the Meile tephra.

The **Goldene Meile** exhibits reworked Pellenz tephra followed by the Breisig Soil with the Breisig biocoenosis that has been protected the Meile tephra.

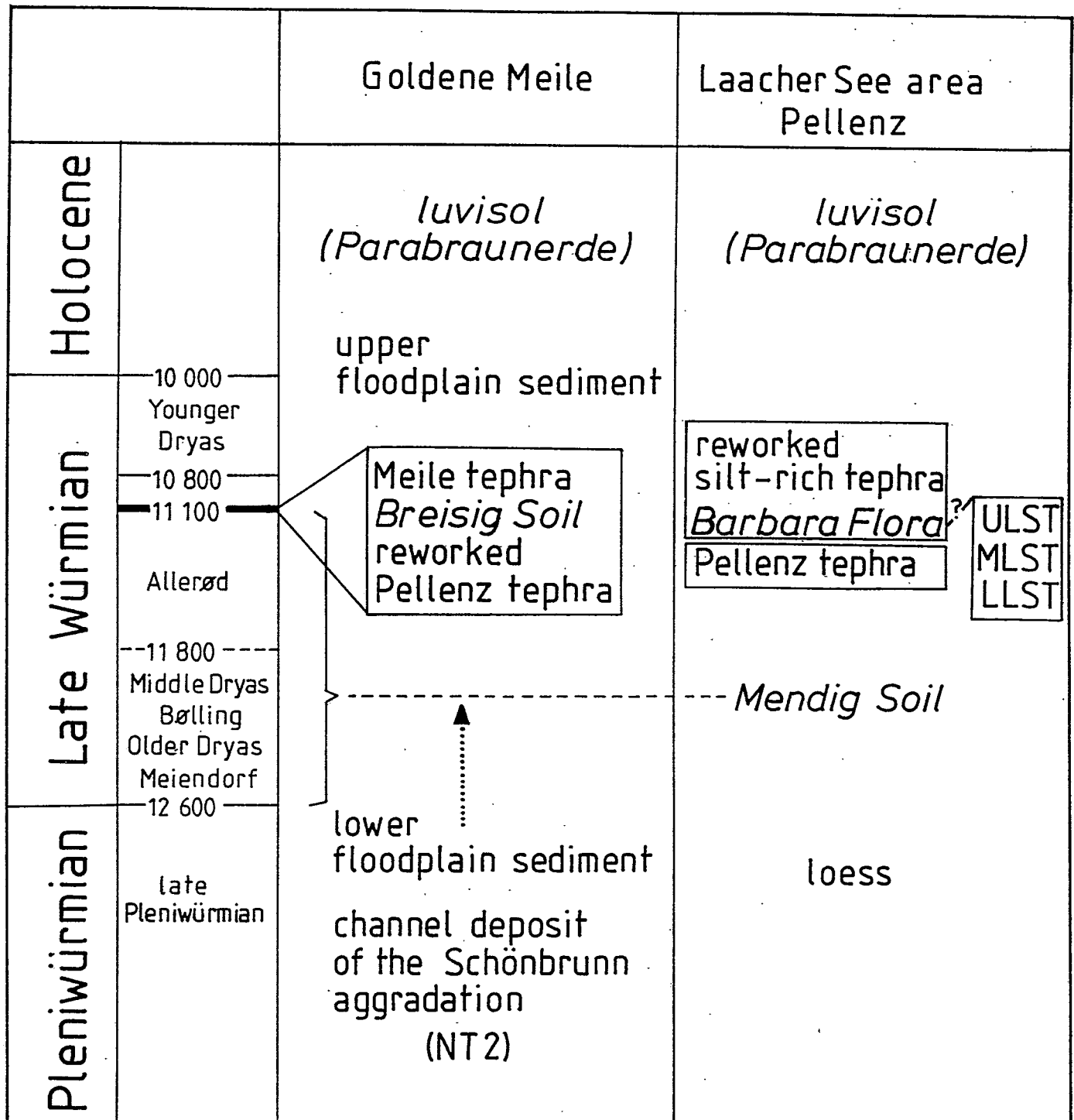


Table 1: Stratigraphy of soils and tephras on top of the Schönbrunner Terrace (NT 2) of the Goldene Meile/Mittelrhein in comparison with that of the Laacher See area

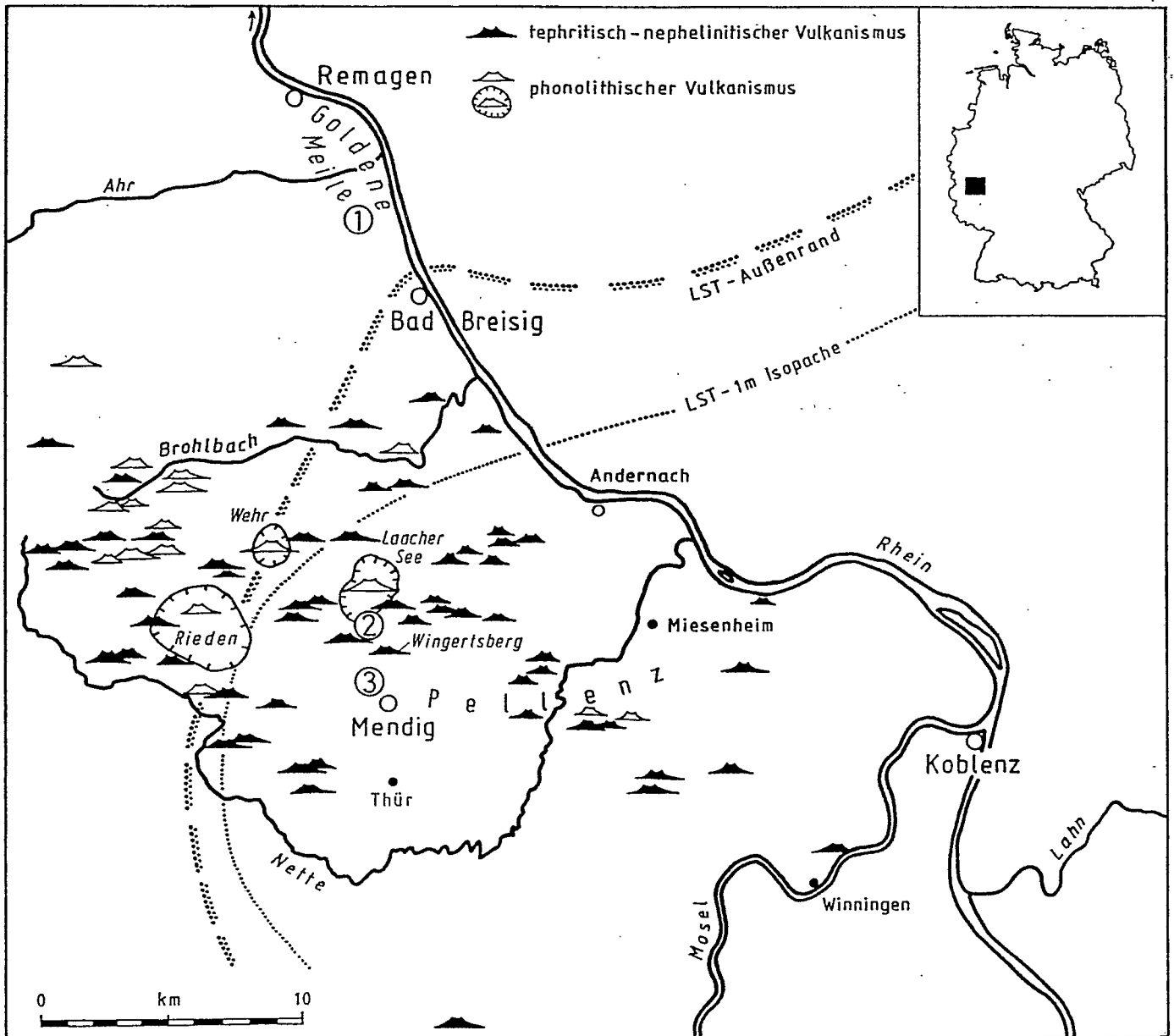


Fig. 1: Map of the Laacher See vulcano area and the Goldene Meile (Golden Mile). LST Außenrand = edge of continuous Laacher See tephra cover after AHRENS (1929: 292) and v. D. BOGAARD & SCHMINCKE (1990). LST-1m-Isopache = 1 m isopach of the Laacher See tephra after v. D. BOGAARD & SCHMINCKE (1984: 935)

The question remains whether the distal Laacher See tephra spreading over central Europe as thin ash layer (v.D. BOGAARD & SCHMINCKE 1985) belongs to the Pellenz or to the Meile tephra.

Field guide

- Stop 1: The Goldene Meile (Golden Mile)
- Stop 2: The Laacher See
- Stop 3: The Pellenz

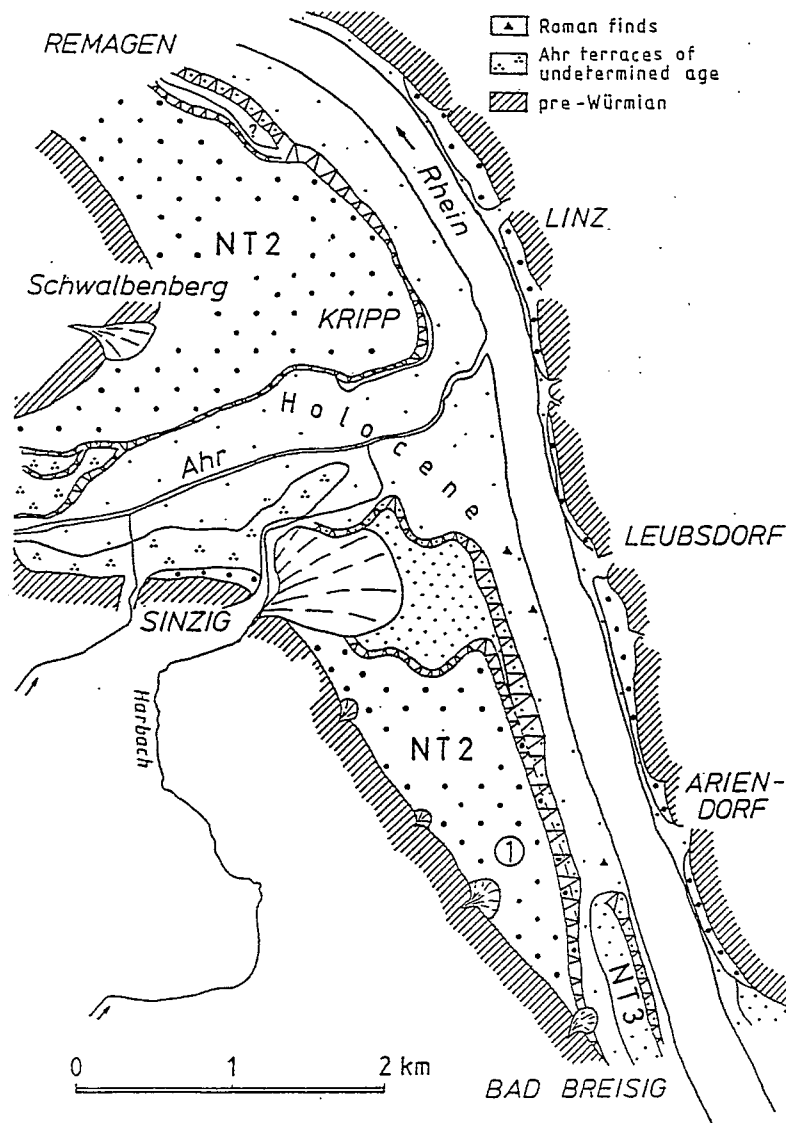


Fig. 2: Terrace map of the Goldene Meile (Golden Mile) (modified after W. SCHIRMER 1995a: 530)

Stop 1: The 'Goldene Meile' Geomorphological and stratigraphical setting (W. SCHIRMER)

It is a fertile basin of a German geographical mile (= 7.4 km) in length, 140 m deep incised into the climatically rougher trough valley of the Rhein. It has been formed at the place where the left tributary, the Ahr, pushed the Rhein towards its eastern valley slope. Protected by the gravel cone of the Ahr river, a small valley bottom - the Goldene Meile - extends on top of the Niederterrassen and a couple of Holocene floodplain terraces (Fig. 2).

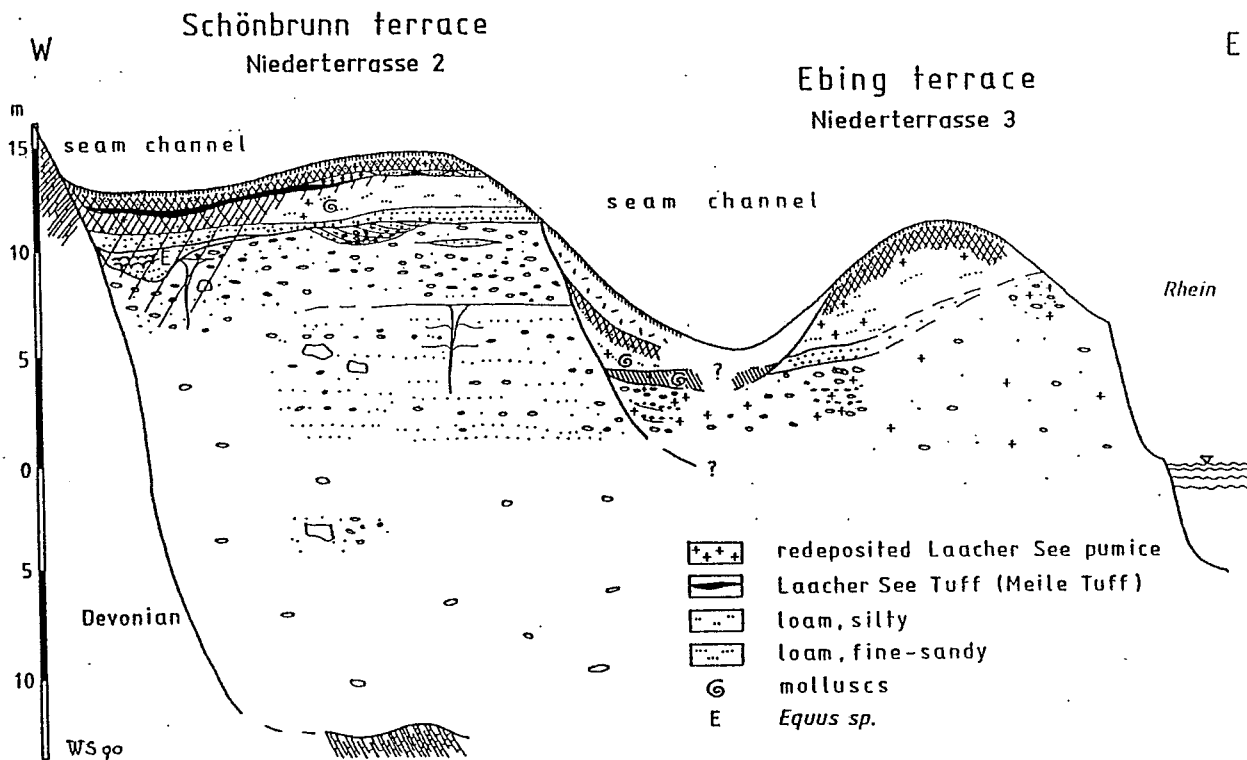


Fig. 3: Cross section of the valley bottom of the Goldene Meile (after W. SCHIRMER 1995a: 533)

As in whole central Europe, three Niederterrassen (NT) (Low Terraces) exist on the Rhein river (W. SCHIRMER 1995c). On the lower Mittelrhein the Maxiwürm Terrace (NT 1) lies on average 16 m above the river level, the Schönbrunn Terrace (NT 2) 14 m, the Ebing Terrace (NT 3) ca. 13 m. The NT 1 has a small sandy flood sediment and is free of loess. The NT 2 has a thick fine-sandy, silty flood sediment. Both the NT 3 channel and flood sediment bear small pebbles and grains of reworked Laacher See pumice from the Mittelrhein basin downstream.

In the Goldene Meile only the Schönbrunn Terrace (NT 2) and the Ebing Terrace (NT 3) are preserved (Fig. 2). On top of the NT 2 there is a flood deposit including clods of reworked Pellenz tephra (Fig. 4). Moreover, particles and burrow fills of Meile silt tephra indicate a certain vertical infill into the underlying flood sediment (W. SCHIRMER 1996). The Breisig Soil is an initial soil only marked by a slightly increased carbon content. It is represented much better by its excellently preserved flora and fauna described by WALDMANN (1996c, see below). The Meile tephra preserving this soil exhibits in its basal layer of a decimeter a silty tephra, generally buff, but banded in different weak colours. Its homogenous structure allows well preservation of the flora and fauna enclosed. The higher silty tephra - up to 4 decimeters thick - is a fine laminated floodplain deposit.

Breisig Soil and Flora as well as Meile tephra are of Allerødian age. They do not overlie the Ebing Terrace of Younger Dryas age. Consequently, the age is post-middle Allerødian and pre-Younger Dryas. According to the trees and well developed flora it should be some decades younger than the Mendig Flora and Pellenz tephra.

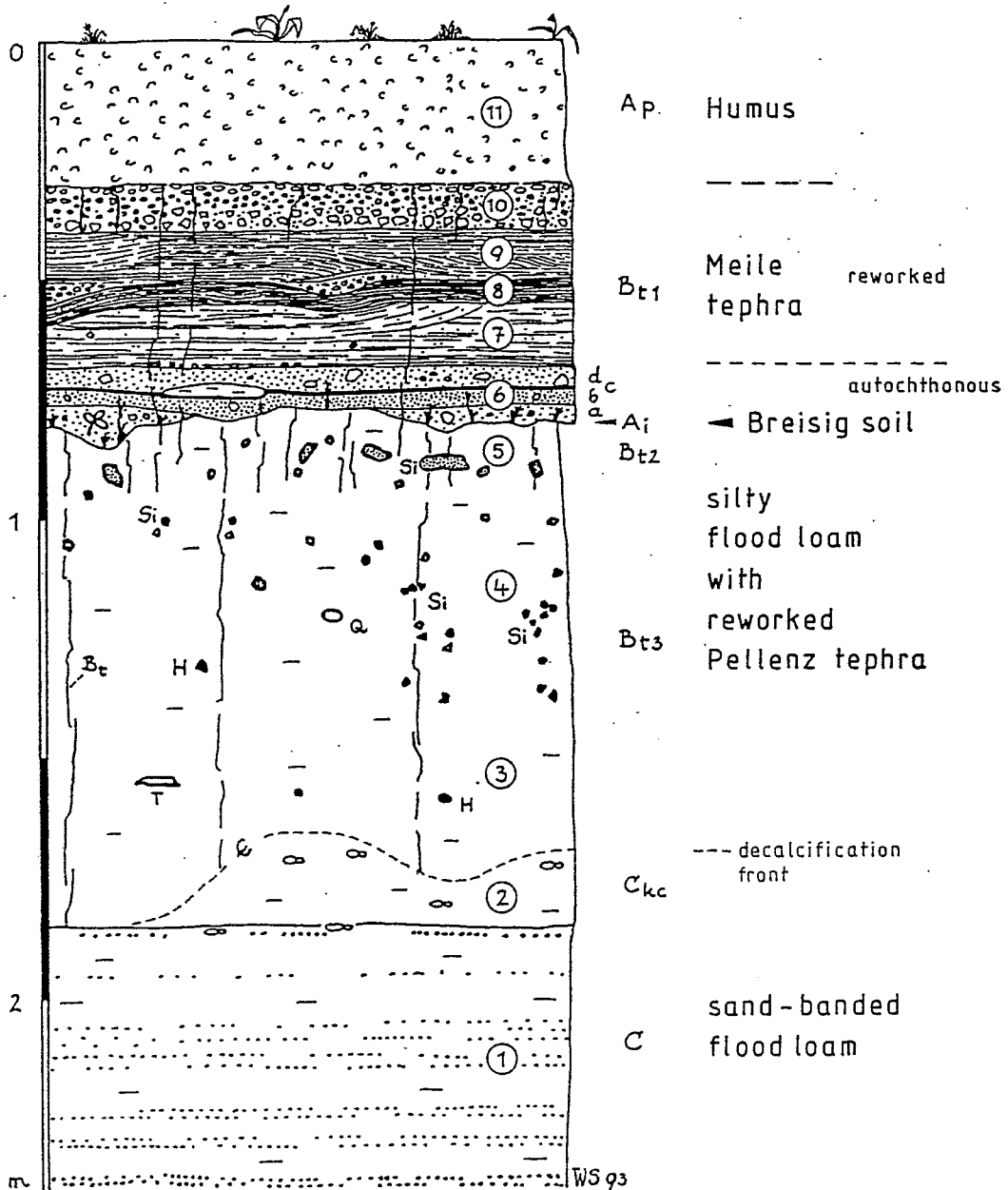


Fig. 4: Section Goldene Meile 9-5 (gravel pit SCHMICKLER). Floodplain deposits and Laacher See pyroclastic deposits overlying the late Pleniwürmian Schönbrunn Terrace (Low Terrace 2) of the Rhein. 1 = sand-banded flood loam, 2 = silty flood loam, 3 = silty flood loam decalcified, 4 = silty flood loam with reworked Pellenz tephra and some amounts of infilled Meile tephra, 5 = Breisig Soil, 6-10: Meile tephra, 11: humus topsoil. E = decalcification front, H = pores filled with redbrown clay, Q = Paleozoic quartzite pebble, Si = clods of silt tuff and pumice grains, T = slate slab (modified after W. SCHIRMER 1995b: 91)

Breisig palaeobiocenosis (G. WALDMANN)

Tephrobiology: new methods to reconstruct the pumice-covered Middle Rhenish landscapes of the Laacher See volcano 13,000 cal BP

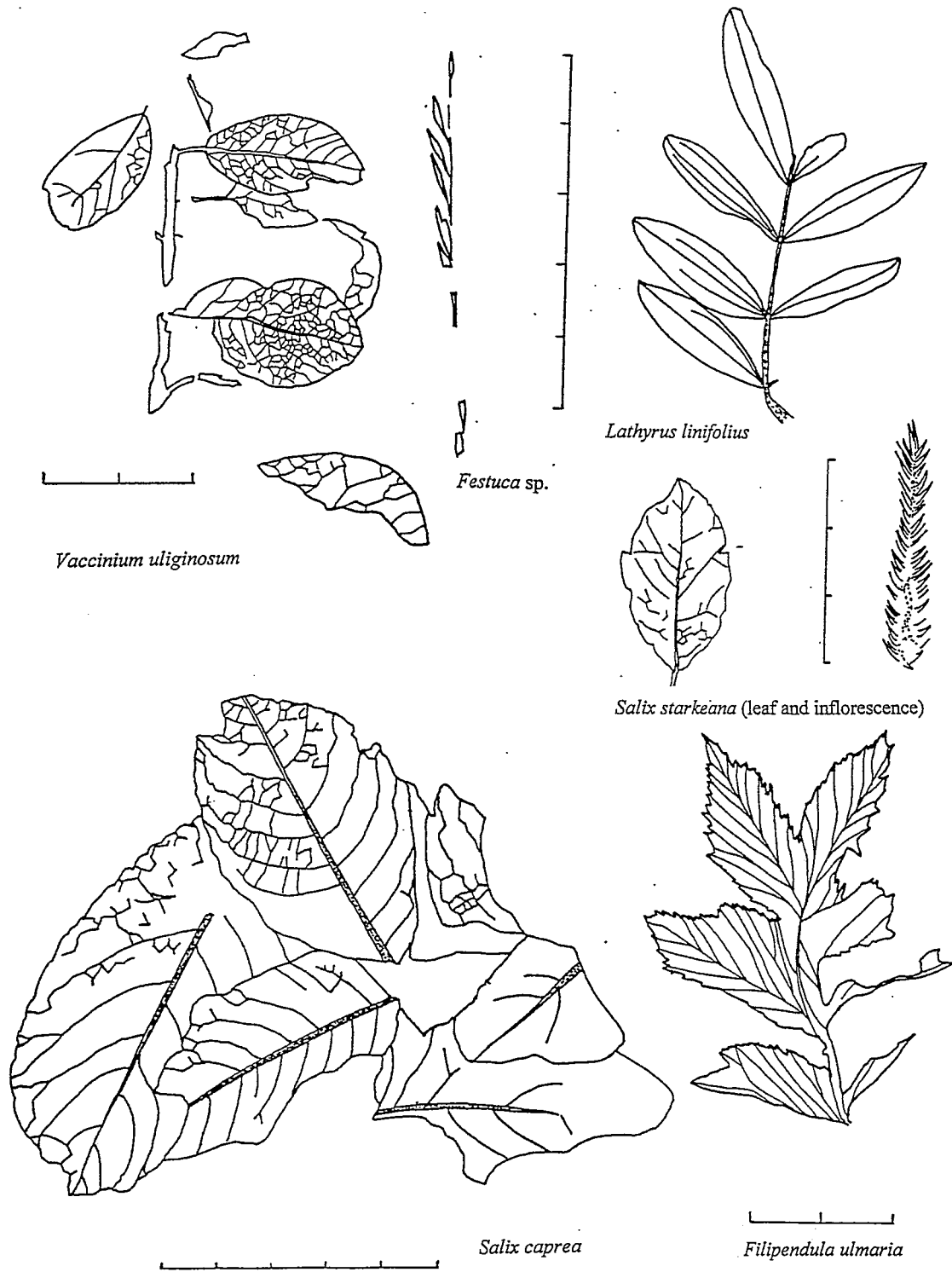


Fig. 5: Tephrofossils from Mendig and Thür (Mendig Soil) (WALDMANN 1996c)

The unique source of information from volcanogenic thanatocoenoses has been used only sparingly as a way of reconstructing the paleoecology of a region.

The Breisig flora in the Goldene Meile was discovered in April 1990 by W. SCHIRMER. First exploratory excavations began in June with full-scale work commencing in September of that year. Today, 50 square metres of pumice-covered landscape have been surveyed and 6 tons of tephra analyzed for their fossil contents (WALDMANN 1994, 1995a,b, 1996a,b,c).

Examination of the Breisig material and a fresh look at botanical and zoological tephrafossils held in museums confirm the field-geological evidence of W. SCHIRMER (1995a,b) that the Laacher See volcano erupted not once, but at least twice during the Allerødian interstadial. The first eruption, the Pellenz eruption, and the second, the Meile eruption, are separated by some decades called the Breisig Interval. Using evidence from the tephra fossils, the Pellenz eruption appears to have taken place at the end of June or early July, commencing during daylight hours. The Meile eruption probably took place on the 20th of May (plus/minus seven days), with initial ash-fall probably starting during the night.

The profile of the Goldene Meile contains remnants of two lahar incidents, the Pellenz lahar and the Meile lahar, which accompanied each eruption. Until now, tephra from the Laacher See volcano was viewed as being a singular isochrono-stratigraphical marker horizon within a number of late glacial profiles. The tephrobiological analysis gives additional support to revise this, and to have wider implications for the periodization of the Allerødian in central Europe.

Various Laacher See pyroclastics have long been used industrially. Trass quarrying began in Neolithic times and has continued to the present without interruption. Pumice has been used since the Middle Ages, if not earlier. Both activities have led to the exposure and discovery of botanical and zoological fossils as well as human artifacts during the Allerødian interstadial.

The first tephrobiological collection dates from 1790. Botanical macrorests were the basis for the first attempt in 1863 to date the last activity of the Laacher See volcano. For a century, the flora conserved in LST has been considered to be post-glacial. A systematic search and archeological catalogue of has yet to be undertaken.

The study of the leaf imprints of deciduous trees and weedy plants from tephra has been confined to the Eifel area and has not been employed in palaeo-ecological surveys even in Germany.

In identifying fossils, I assumed that a comparison with specimen found today in Northern Europe was appropriate. Botanical and zoological collections were compiled from two field trips to Sweden and Norway at different times of the year.

Utilizing the indicator values of plants in Central Europe of ELLENBERG ET AL. (1992) for the analysis of the fossil record and contemporary specimen, the following profile for the Allerødian Mittelrhein area was generated: the region was densely forested before the Pellenz eruption. Although all vegetation was destroyed by this eruption, it regenerated during the Breisig Interval, at least in the vicinity of the Rhine river to a species-enriched, possibly denser flood plain forest. Towards the end of the Breisig Interval, the relative irradiance intensity of the ground seems to have decreased, which indicates denser forestation. Flora recovered from the Pellenz tephra of the Neuwied Basin contains 60% of warmth indicators, whereas the Meile tephra contains 80% of warmth indicators. This seems to indicate a continuous rise in

temperature in the Mittelrhein area during the Breisig Interval. This is born out in the composition of plant species. Cold indicators seem to have vanished towards the end of the Breisig Interval. At this time, the vegetation displays a significantly more atlantic character than at the time of the Pellenz eruption. The carbonate content should have more than doubled according to the indicator values; likewise an increase in nitrogen supply is indicated.

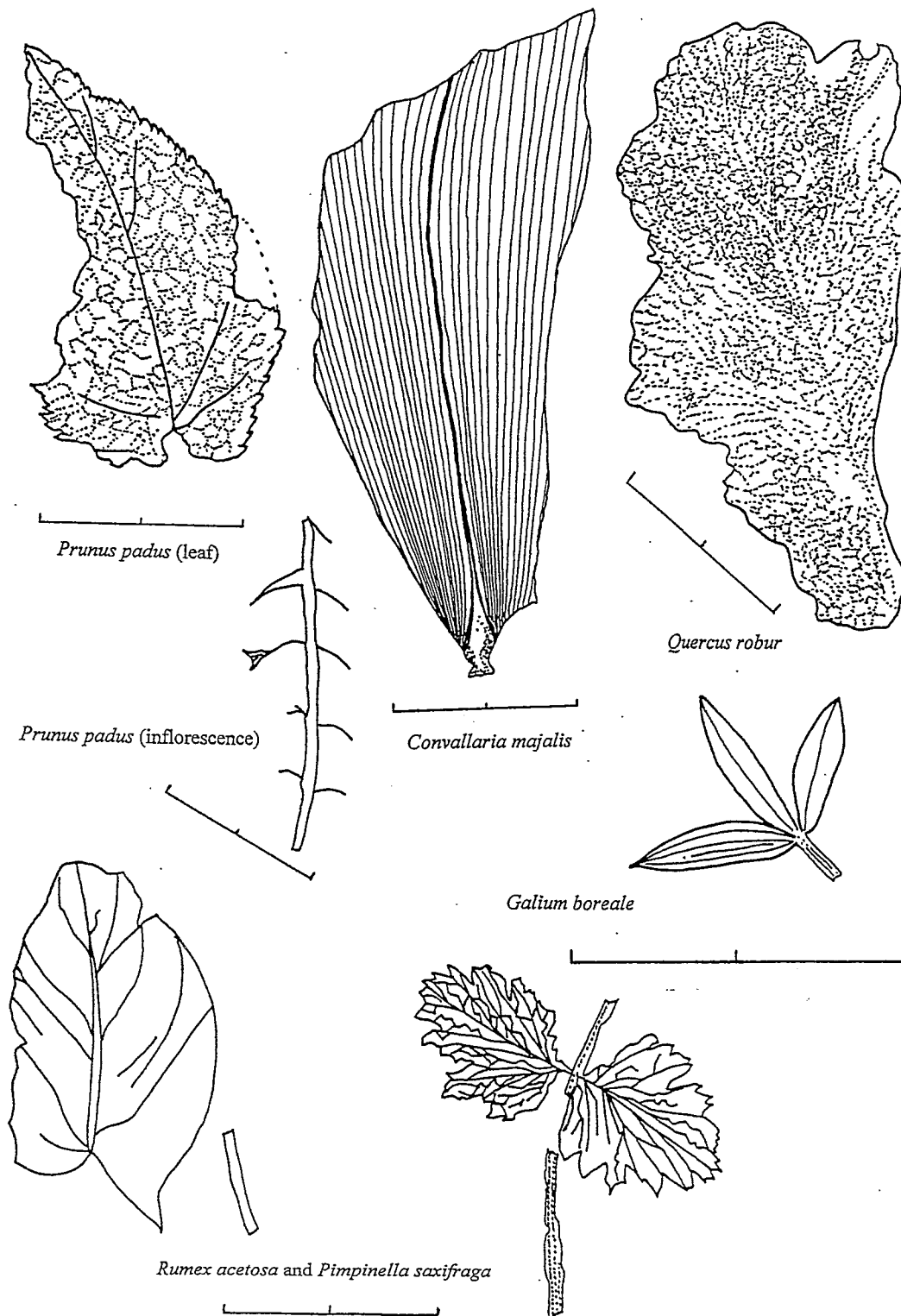


Fig. 6: Tephrofossils from Sinzig and Bad Breisig (Breisig Soil) (WALDMANN 1996c)

Distribution of shrubs and trees in the Neuwied Basin during the Alleroedian based on macrofossils within Laacher See Tephra

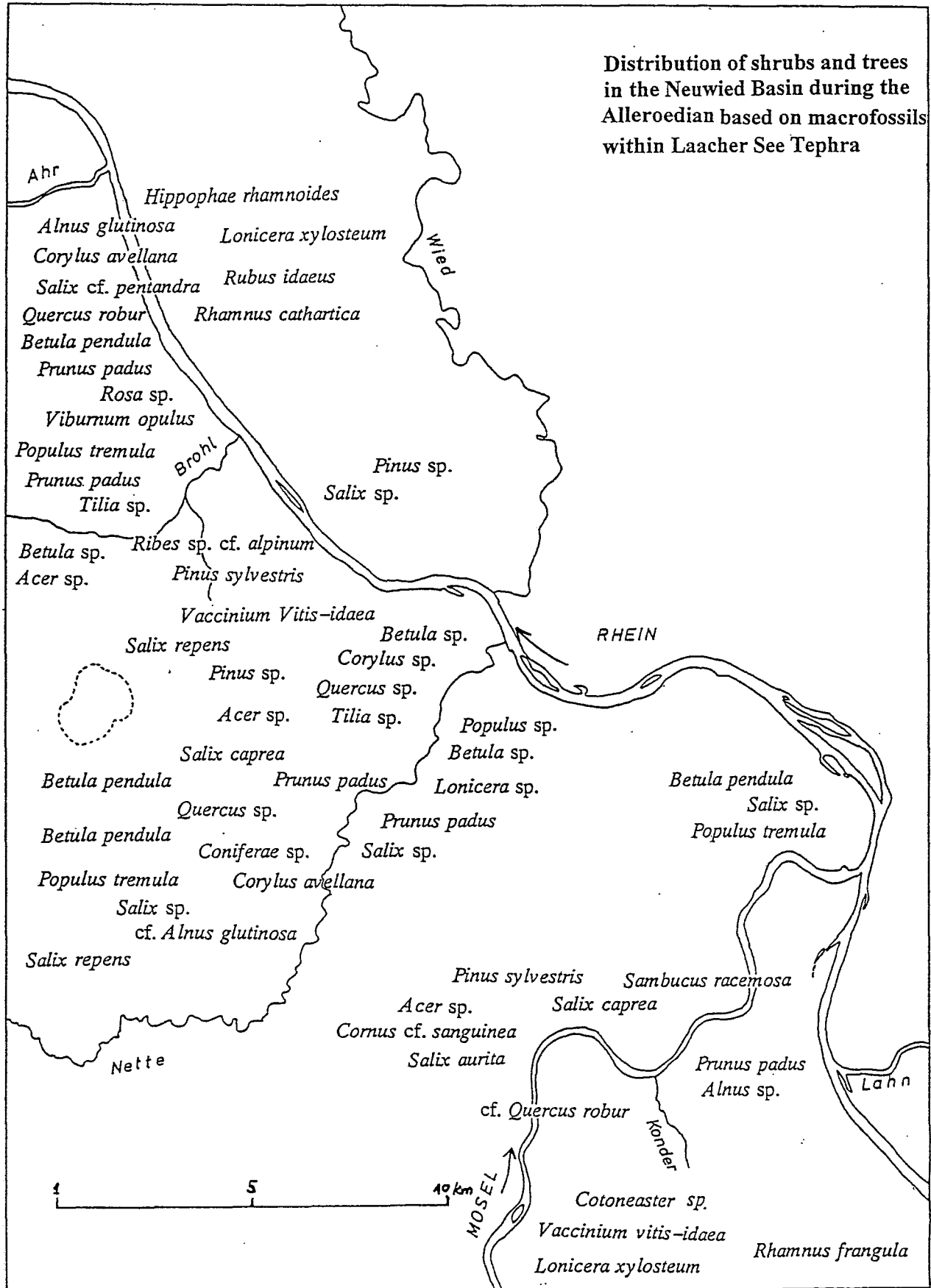


Fig. 7

An almost species-identical flora in Uppland/Central Sweden today suggests that the present climatic conditions there are comparable to the Mittelrhein area in the Allerødian interstadial. The average temperature throughout the year is 5.5 °C in Ultuna (near Uppsala) whereas today's average temperature at Laach is 8.2 °C. This suggests a general rise in temperature of 2.7 °C in the Mittelrhein area between the Allerødian and present day.

The recent comparison site Ultuna is characterized by hemiboreal mixed forests, containing, among others *Acer platanoides*, *Quercus robur*, *Populus tremula*, *Betula* spp., *Rhamnus cathartica*, *Tilia cordata*, *Salix* spp., *Ulmus glabra*, *Corylus avellana*, *Lonicera xylosteum* and *Pinus sylvestris*.

From my own observation, plant successions in the Neuwied Basin and the Goldene Meile during the Breisig Interval may be comparable to successions after recent tephra incidences in North America and Northern Japan.

No human artifacts from the time of the Breisig Interval have yet been found. This indicates a disruption of human habitation in the Laacher See area during that time. Due to continuous post-eruptive lahar incidents, which persisted over several decades, the Middle and Lower Rhineland area, despite of the richness of floral species, became unsuitable for human settlement. I have witnessed a similar population shift of aboriginal people in lahar areas of the Philippines in recent times.

List of identified species excavated as macroremnants within the Allerødian Laacher See tephra (systematic after OBERDORFER, 1994)

Species from the Goldene Meile near Sinzig and Bad Breisig

| | |
|--|--|
| <i>Achillea millefolium</i> L. | <i>Peucedanum palustre</i> (L.) MOENCH. |
| <i>Alnus glutinosa</i> (L.) GAERTN. | <i>Pimpinella saxifraga</i> L. |
| <i>Bellis perennis</i> L. | <i>Plantago lanceolata</i> L. |
| <i>Betula pendula</i> ROTH | <i>Poaceae</i> sp. |
| <i>Campanula glomerata</i> L. | <i>Polygonatum odoratum</i> (MILL.) DRUCE |
| <i>Campanula</i> cf. <i>rapunculoides</i> L. | <i>Populus tremula</i> L. |
| <i>Cardamine pratensis</i> agg. L. | <i>Primula veris</i> L. |
| <i>Carex</i> cf. <i>acutiformis</i> ERH. | <i>Prunus padus</i> L. |
| <i>Centaurea</i> cf. <i>jacea</i> L. | <i>Quercus robur</i> L. |
| cf. <i>Chaerophyllum bulbosum</i> L. | <i>Ranunculus</i> cf. <i>acris</i> L. |
| <i>Convallaria majalis</i> L. | <i>Ranunculus</i> cf. <i>auricomus</i> L. |
| <i>Corylus avellana</i> L. | <i>Ranunculus</i> cf. <i>repens</i> L. |
| <i>Equisetum</i> cf. <i>fluviatile</i> L. | <i>Ranunculus</i> cf. <i>sceleratus</i> L. |
| <i>Filipendula ulmaria</i> (L.) MAXIM. | <i>Rhamnus cathartica</i> L. |
| <i>Galium aparine</i> L. | <i>Rosa</i> cf. <i>canina</i> L. |
| <i>Galium boreale</i> L. | <i>Rubus idaeus</i> L. |
| <i>Galium</i> cf. <i>uliginosum</i> L. | <i>Rumex acetosa</i> L. |
| <i>Geum urbanum</i> L. | <i>Rumex aquaticus</i> L. |
| <i>Glechoma hederacea</i> L. | <i>Salix pentandra</i> L. |
| <i>Glyceria</i> cf. <i>maxima</i> (HARTM.) HOLMBG. | <i>Scrophularia nodosa</i> L. |
| <i>Hippophae rhamnoides</i> L. | <i>Stachys</i> cf. <i>silvatica</i> L. |
| <i>Hypericum</i> cf. <i>maculatum</i> CRANTZ | <i>Symphytum</i> sp. |
| <i>Knautia arvensis</i> (L.) COULTER | <i>Thalictrum flavum</i> L. |
| <i>Lamium album</i> L. | <i>Valeriana dioica</i> L. |
| <i>Lonicera xylosteum</i> L. | <i>Verbascum nigrum</i> L. |
| <i>Lysimachia nummularia</i> L. | <i>Veronica chamaedrys</i> L. |
| <i>Lysimachia vulgaris</i> L. | <i>Viburnum opulus</i> L. |

Lythrum salicaria L.
Malva cf. *alcea* L.
Melandrium rubrum (WEIGEL) GARCKE

Vicia cf. *cracca* L.
Viola cf. *reichenbachiana* JORD.

Species from Thür, Mendig and the Nette valley

Alnus glutinosa L.
Arctostaphylos uva-ursi (L.) SPRENG.
Betula sp.
Bryophyta sp.
Corylus avellana L.
Festuca sp.
Filipendula ulmaria (L.) MAXIM.
Galium sp.
Geranium cf. *sylvaticum* L.
Lathyrus linifolius (REICH.) BOSSL.

Poaceae sp.
Populus tremula L.
Rumex sp.
Salix caprea L.
Salix starkeana WILLD.
Scrophularia sp.
Ulmus sp.
Vaccinium uliginosum L.
Viburnum opulus L.

Species of the Brohl valley

Acer cf. *platanoides* L.
Achillea millefolium L.
Alnus incana (L.) MOENCH
Anthyllis vulneraria L.
Artemisia cf. *campestris* L.
Betula pendula ROTH
Betula pubescens EHRH.
Carex cf. *acuta* (*Carex gracilis* CURT.)
Carex pseudocyperus L.
Centaurea jacea L.
Centaurea scabiosa L.
Cornus sanguinea L.
Eupatorium cannabinum L.
Galium aparine L.
Galium boreale L.
Galium mollugo L.
Galium odoratum (L.) SCOP.
Galium verum L.
Heracleum sphondylium L.
Hypericum montanum L.
Inula salicina L.
Knautia arvensis (L.) COULTER
Lathyrus linifolius (REICH.) BOSSL.
Leontodon hispidus L.
Lycopus europaeus L.
Phragmites australis (CAV.) TRIN.
Onopordion acanthium L.

Pinus silvestris L.
Plantago major L.
Poaceae sp.
Populus tremula L.
Potentilla argentea L.
Prunus avium L.
Prunus padus L.
Quercus cf. *robur* L.
Ranunculus acris L.
Ribes cf. *alpinum* L.
Rhamnus cathartica L.
Rosa sp.
cf. *Rubus idaeus* L.
Rumex sp.
Salix caprea L.
Salix cf. *pentandra* L.
Salix repens L.
Scrophularia sp.
Sparganium erectum L.
Stachys cf. *silvatica* L.
Tilia cf. *cordata* L.
Typha latifolia L.
Urtica dioica L.
Valeriana officinalis L.
Verbascum nigrum L.
Viburnum opulus L.
Vicia cracca L.

Species of the upper Mosel valley at Winningen and Merl

Acer sp.
Alnus sp.
Betula pendula ROTH
Betula pubescens ROTH
Cotoneaster sp.
Frangula alnus MILL.
Lonicera xylosteum L.
Picea abies (L.) H. KARSTEN
Populus tremula L.

Prunus avium L.
Prunus padus L.
Prunus spinosa L.
Sambucus racemosa L.
Salix aurita L.
Salix caprea L.
Salix cinerea L.
Quercus cf. *robur* L.
Vaccinium vitis-idaea L.

Species of the Mainzer Sand area in Mainz

Calamagrostis epigeios (L.) ROTH

Pinus silvestris L.

Stop 2: Laacher See (W. SCHIRMER)

The Laacher See is a crater lake of barely 2.5 km diameter. Its level is at 224 m, its base at -50 m a. s. l. The eruption happened around 11,000 yr BP, resp. 13,000 y cal BP, during the Allerødian interstadial, in midst of a couple of young Pleistocene scoria cones the relics of which are surrounding the present lake basin. The eruption obviously used the place of an older crater belonging to the framing young Pleistocene volcanism. The form of the lake of two intermittent circles (Fig. 1) indicates a change of the vent. The southern crater was used during the Lower Laacher See tephra, the northern since the Middle Laacher See tephra (SCHMINCKE ET AL. 1990). Recent activity is restricted to weak gas production close to the eastern bank of the lake (CO₂ derivable from the earth mantle due to high ³He/⁴He ratio; SCHMINCKE ET AL. 1990: 155). Before 1852 the lake was larger. In the 12th and 19th century monks of the cloister Maria Laach lowered the lake level by more then 6 m, draining it by a tunnel at its southern bank in order to yield more arable land (FRECHEN 1976: 154).

The hauyn-phonolitic magma has its chamber at a depth of 2-5 km. About 5 km³ dry rock mass has been thrown out spreading over central Europe (SCHMINCKE ET AL. 1990). The eruption is mostly of Plinian type and therefore estimated to have happened within a few days. As I found recently, the Laacher See eruption took place by two events, the second being separated from the first by a time-lag of some years or a few decades of years resulting in the following stratigraphical sequence of the Laacher See eruption:

| | | |
|----------------------|---|-----------------------------|
| Meile tephra | } | middle Allerød Period |
| Breisig interruption | | |
| Pellenz tephra | | |
| Mendig Soil | | Meiendorf to Allerød Period |

The first event produced the major part of the Laacher See tephra, the Pellenz tephra, named after its thickest occurrence in the Pellenz (Fig. 1). The second, the Meile event, produced a much smaller tephra amount well exposed in the Goldene Meile, burying there the Breisig flora (see Stop 1). The Meile tephra may correspond to the highest part of the Upper Laacher See tephra of Schmincke's subdivision or it succeeds it.

Stop 3: The Pellenz

Geomorphological and stratigraphical setting (W. SCHIRMER)

The Pellenz is the most vivid part of the tectonic Mittelrhein Basin, a volcanic landscape surmounted by big volcanic scoria cones of Late Pleistocene age. The small basins in between are drained by the Nette river and tributaries (Fig. 1). The subsided tectonic Mittelrhein Basin exhibits above Devonian slate a depositional stack ranging from marine Lower Oligocene through terrestrial Pliocene with hiatuses. Hence follows a terrace stair case of the Rhein and Mosel terraces. The terrace landscape is interfingered and capped by Middle to Late Pleistocene volcanic lava flows and tephra. Finally, the whole landscape is covered by a several meter thick veneer of the Allerødian Laacher See tephra (LST) thinning off the vent from 50 to 4 m (V. D. BOGAARD 1995). In a small lake basin of the locality Miesenheim-„Auf der Holl“ (Fig. 1) the Mendig Soil buried by the LST splits up into a detailed lake deposit stratigraphy (Fig. 8) that embraces a fairly complete early Late Würmian (U. SCHIRMER 1995). Thus, it yields evidence that the Mendig Soil has formed since the beginning of the Late Würmian (W. SCHIRMER 1996). In some places the LST is cut on its top by channels deeply incised and filled

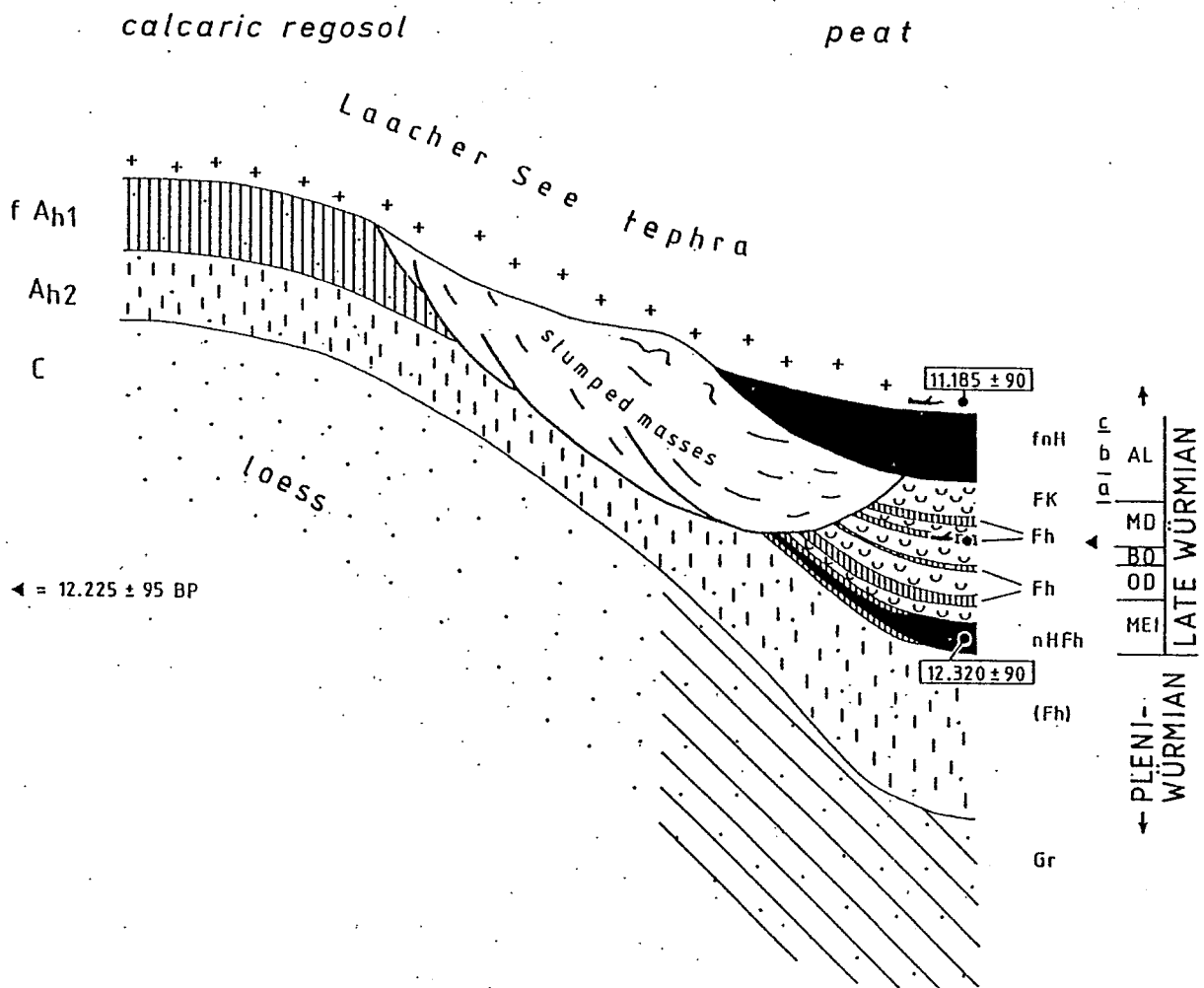


Fig. 8: Section Miesenheim - „Auf der Holl“. Transition from lake sediments (right) to the Mendig Soil (left) (modified from W. SCHIRMER 1996: 54)

with reworked tephra and the reworked Barbara Flora close to its base (Fig. 9) - a presumable equivalent of the Breisig Flora.

The Mendig-Barbara quarry (W. SCHIRMER)

In the Mendig-Barbara quarry thick columnar tephrite is exploited in the depth, pumice tephra in a higher floor. The rough section of the quarry is the following:

- 6 m Channel fill incised into the ULST: Reworked and well-bedded buff silty tephra and green sandy tephra. In the lower part full of leaf imprints; mould of a log of 12 cm in diameter and more than 1 m long (**Barbara Flora**).
- 2 m ULST = Upper Laacher See tephra
- 12 m MLST + LLST = Middle + Lower Laacher See tephra
- 0.6 m BLST = Basal Laacher See tephra: Greenish fine-grained ash with big boulders of tephrite and Tertiary clay. In the basal part plant imprints (**Mendig Flora**)
- 0.35 m humic **Mendig Soil**, calcaric regosol, developed on loess
- 1.7 m loess and loess derivatives (Upper Würmian)
- 2.0 m stream gravel and solifluctive loess
- 5.0 m agglomerated volcanic scoria
- Base: Mendig lava flow (columnar tephrite) (Würmian)