THE SWABIAN ALB – AN ANTHROPOGENICALLY TRANSFORMED KARST LANDSCAPE

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A CONTRIBUTION IN CELEBRATION OF THE 65TH BIRTHDAY OF ILONA BÁRÁNY-KEVEI – IN COMMEMORATION OF THE JOINT FIELD EXCURSIONS WITH STUDENTS FROM THE UNIVERSITIES OF TÜBINGEN AND SZEGED

Abstract: The Swabian Alb is a secondary mountain range with unique karst forms. The geological history determined the genesis of the forms and the soils. Using current climate data, it is shown that the Swabian Alb could be beech grove mountains. Since pre-historical times, the appearance of the landscape has been steadily influenced anthropogenically, so that the distribution patterns of the soils, their location, and the vegetation have changed. This has essentially shaped the characteristics of the landscape.

THE MOUNTAINS

The Swabian Alb is a 200 km long and ca. 40 km wide karstified secondary mountain range between Lake Constance and the Nördlinger Ries. It is made up of Upper Jurassic rocks (lower bedded limestones of the Oxford–Upper Jurassic Beta and reef facies of the Kimmeridge–Upper Jurassic Delta) and has an altitude of over 1000 m in the southwest and ca. 600 m in the northeast. The northern edge of the SW-NE striking mountain range is an over 400 m high cuesta of the Upper Jurassic. In the south, the strata plunge beneath the molasse of the Alpine foreland.

The karst forms determine the surface forms and a diverse mosaic made up of forests, fields, meadows, and pastures with areas of ecologically valuable semi-dry grassland and juniper heaths characterise the landscape (***Pfeffer, K.-H.*** 2003).

The appearance of the landscape and the ecological environment can be traced back to three causal complexes. The natural potential can be derived from the geological history and the present geographical location. This potential is being temporally and spatially used, burdened, changed, and at times destroyed by man's workings.

THE IMPORTANCE OF THE GEOLOGICAL HISTORY

The geological history began with the sedimentation of limestones and dolomites during the Upper Jurassic, the geomorphological development began

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with the uplifting at the end of the Jurassic. The geological background produced clear spatial patterns in the Swabian Alb. Along the cuesta in the western part of the Alb, a bedded plane (Schichtflächenalb) dominates. This plane follows the strike direction of the Oxford bedded limestones. South of the SW-NE oriented line, the so-called cliff line, which represents the northernmost limit of the Upper Marine Molasse, the spatial plane relief is dominated by karst basins, dolines, and dry valleys, whereas north of the cliff line, in particular domes, as well as karst basins, dolines, and dry valleys make up the forms.

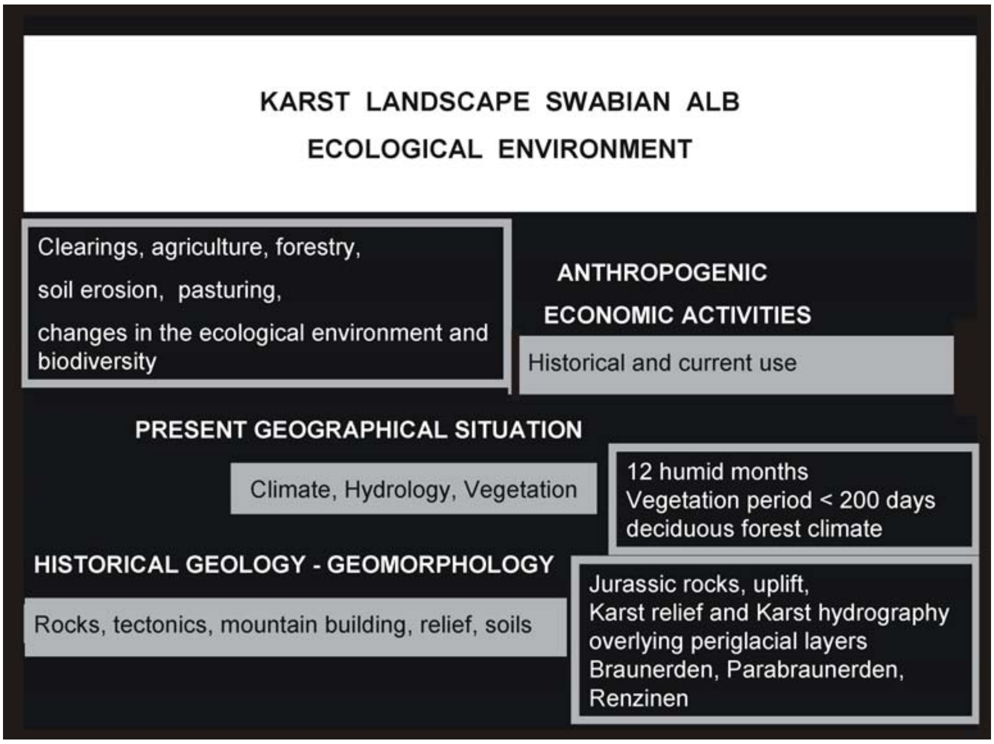

Figure1 Ecological environment

At the end of the Jurassic, the Alb became a denudation area. Without deep-reaching karst hydrography, level relief developed with kaolin clays and iron bean ores. The molasse ocean transgressed over the flat relief until the cliff line. After that, the Alb was a level plane with the lakes of the Upper Freshwater Molasse. North of the cliff line, a denudation relief developed, exposing the reef, while to the south, at first the molasse cover was eroded away. As the Danube and the Neckar-Rhine systems incised their beds, deep reaching karst hydrology developed with the formation of the karst forms. The Quaternary Ice Ages disrupted these processes, permafrost enabled surface flow with valley formation and the uncovering of the reef domes. Blown in loess and periglacial mud covered and partially filled the depressions. At the end of the permafrost phase, there was a resurge in the karst hydrology, the valleys became dry again and the periglacial cover over well-developed karst pipes eroded, dolines developed in the cover due to erosion. Instable, rupturing cavities were counterdrawn on the surface as collapse dolina (***Geyer, O. H. – Gwinner, M. P.*** 1991, ***Pfeffer, K-H.*** 1990).

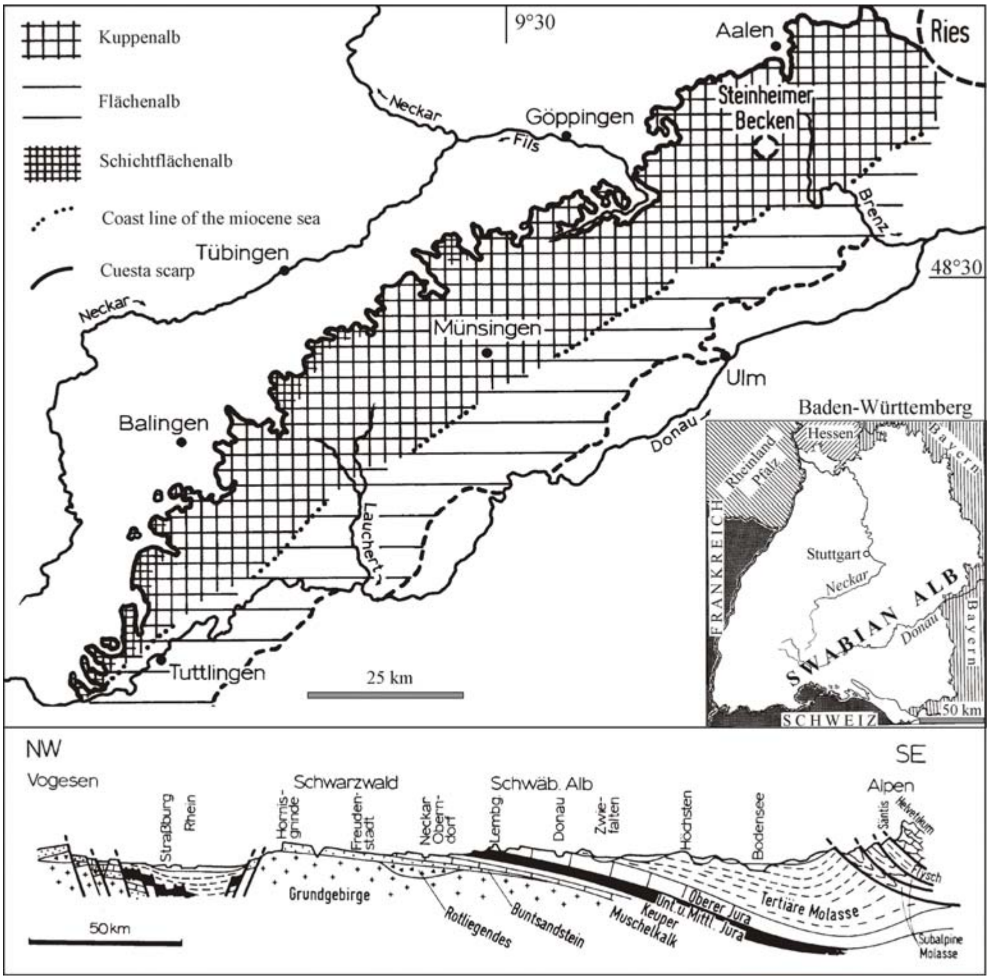

Figure 2 Spatial pattern of the Swabian Alb landscapes (***Geyer, O. F. – Gwinner, M. P.*** 1991. p. 316), geological cross-section from the Upper Rhine Graben to the Alps (***Geyer, O. F. – Gwinner, M. P.*** 1991. p. 7)

Since the end of the Ice Ages, parabraunerden developed in the loess-containing periglacial layers, which merged into terra fusca soils over the outcropping limestone or limey base layers.

The soils range from rendzinas to braunerden and parabraunerden (***Pfeffer, K.-H.*** 2004).

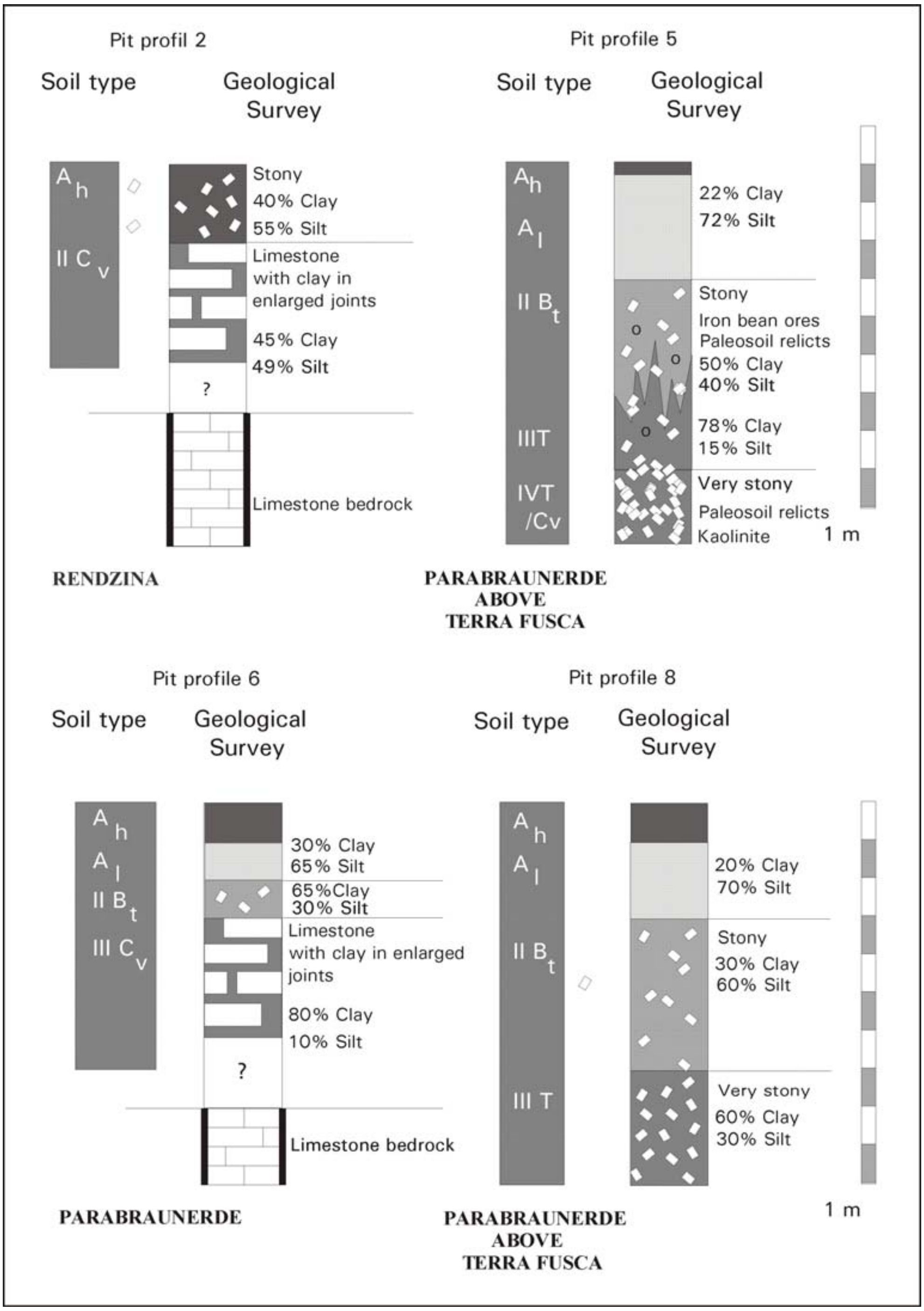

Figure 3 Geology of the near surface underground and typical soils

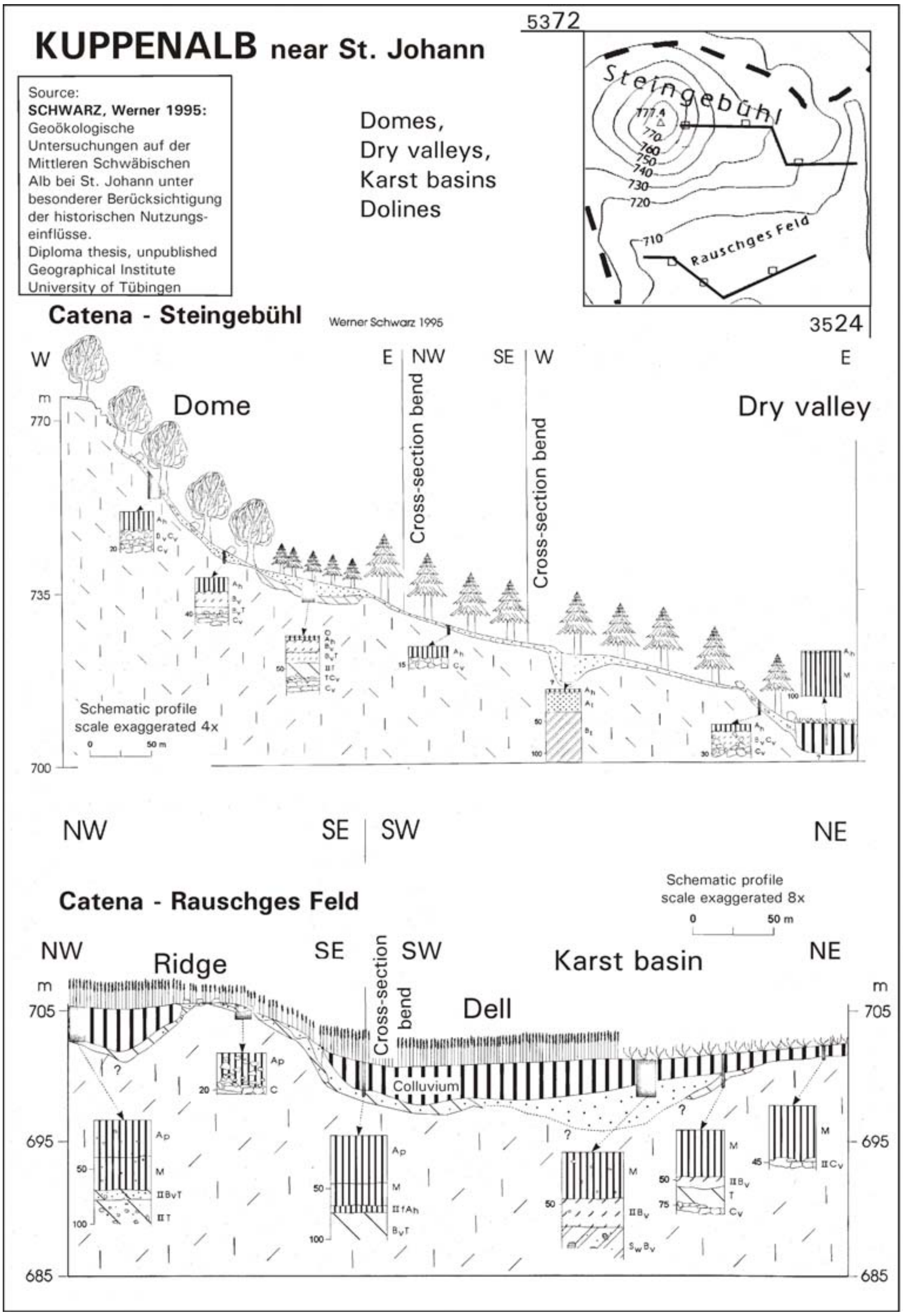

Figure 4 Catena: dome, dry valley and karst basin

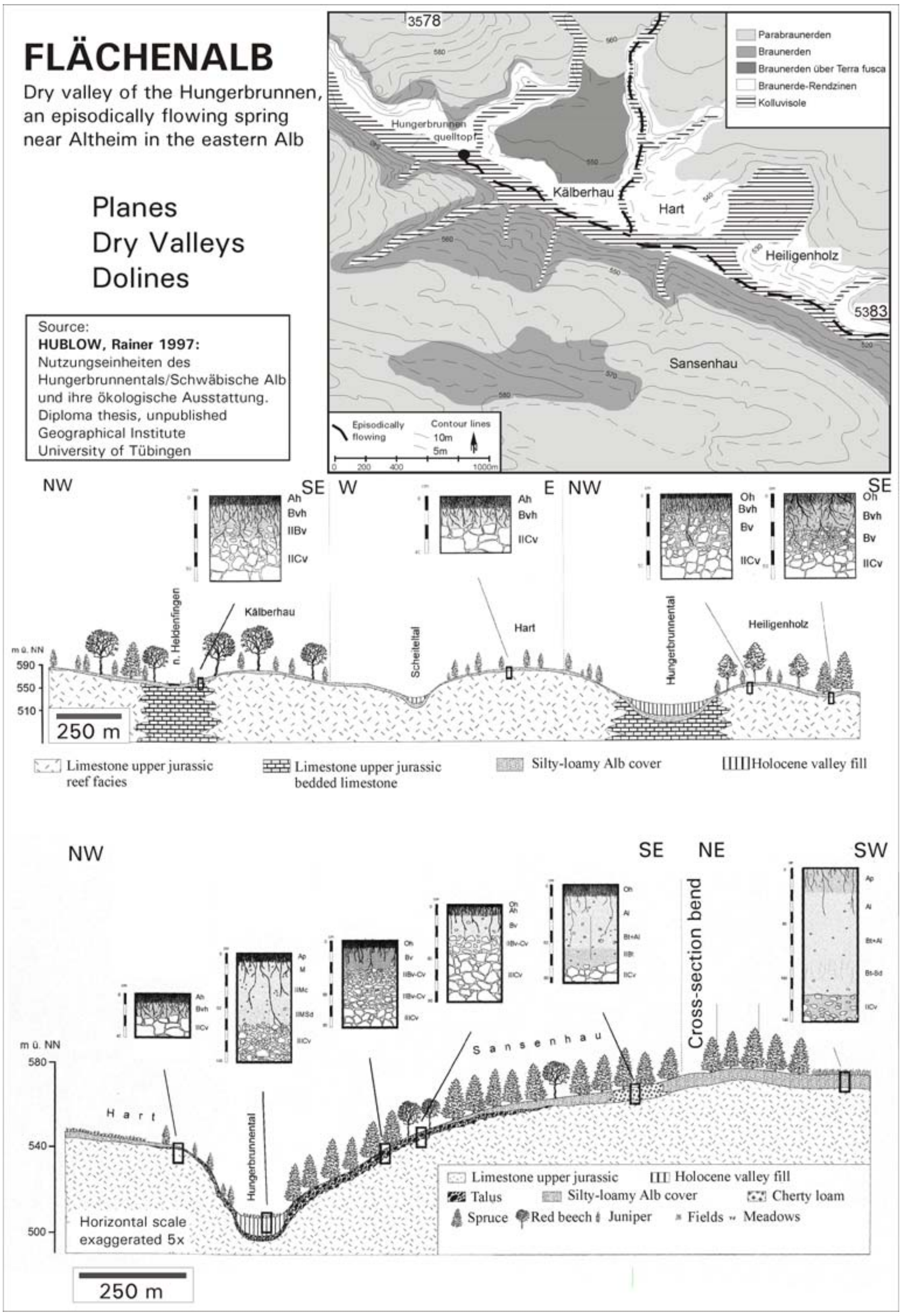

Figure 5 Catena: plane and dry valley

In Germany, the assignment of soil types and the designation of the soil horizon are determined according to the “Bodenkundlichen Kartieranleitung” (***AG Boden*** 2005), which is required for official soil maps.

The soil horizons: **A** horizon is generally the uppermost horizon, $\mathbf{A_p}$ is a plough horizon, $\mathbf{A_h}$ is a mineral horizon containing decomposing organic matter. $\mathbf{A_l}$ a horizon, who had lost some of its original substance through the downward transport of clay particles, **B** horizon is enriched in clay ($\mathbf{B_t}$) or loam ($\mathbf{B_v}$). **C** horizon is the parent part of the profile. **M** is the sign for Kolluvium, it is an anthropogenic slope-wash deposit. Roman numbers show the change in geological strata.

In comparison to the FAO classification the soils belong to the following Reference Soil Groups: Rendzina – Leptosole; Braunerden – Cambisole; Parabraunerden – Luvisole; Kolluvisole – Anthrosole / Fluvisole; Terra fusca – Chromic Cambisol.

INFLUENCE OF THE GEOGRAPHICAL LOCATION

Due to the location of the Swabian Alb in the western part of Central Europe, it has year-round humid conditions and seasonal temperature variations.

The mean annual temperature is 6-7ºC, the monthly mean temperature for January is -2 to -3ºC and the monthly mean temperature for July, 15-16ºC. The mean number of days with a daily mean temperature of at least 10ºC is 120-140 days and the vegetation period is over 200 days.

The annual precipitation in the lee side of the Black Forest is between 750 and 1000 mm (***Borcherdt, H.*** 1991), whereby karst water balances show a discharge of between 40 and 58% of the amount of precipitation, depending on the height of precipitation and evaporation. Thus, the karst water in the springs along the edge of the karst and at the level of the Danube River is a large water resource (***Geyer, O. F. – Gwinner, M. P.*** 1991, ***Köberle, G.*** 2003, ***Pfeffer, K.-H.*** 1990).

Ecologically, the climate parameters, together with the local site factors, indicate a forest climate with beech dominance. Pollen analyses validate forest stands after the Ice Ages, not steppenheide grasslands. Signs of anthropogenic changes do not appear until the Bronze Age (***Smettan, H.*** 1993).

ANTHROPOGENIC CHANGES IN THE ECOSYSTEM

In the Swabian Alb, Celtic viereckschanzen (rectangular ditched enclosures) and Hallstatt culture burial mounds, tumuli, indicate signs of dense prehistoric settlements. Their spatial patterns correlate with the distribution of iron bean ore and hard crustal ore, whereby current research has proven prehistoric iron ore smelting in the Alb (***Pankau, C.*** 2005). This is also mirrored in the carbonized particles in the pollen analyses, as charcoal is essential as an energy source for iron ore smelting (***Smettan, H.*** 1993).

The use of the forest and the transformation into farm fields is shown in the percentage in tree pollen. After the height of the forestry use, with the formation of the coppices (Niederwald) in the Alemannic Age, came a period of forest recovery in the early Middles Ages. As of the ninth century, clearings with traces of field-pasture farming are identifiable (***Smettan, H.*** 1993).

The clearing of parts of the forests and the following agricultural use with intensive sheep pasturing essentially changed these locations due to soil erosion and changes in plant communities.

Only domes and valley slopes with northern orientation show complete soil profiles under forest cover with multi-layered loess-containing debris. On the level planes, the uppermost profile areas are often capped. In S-SW orientations with rendzina soils, domes and slopes exhibit only a thin cover of virgin soil, whereas bordering flat drag slopes, dry valley floors, and karst forms are covered with meter-thick washed-out soil material. Field terraces with locally accumulated soil material show proof of the connection of soil erosion to clearing and agricultural use as well as the traces of civilisation in the colluvial beds (***Pfeffer, K.-H.*** 2004).

The dolines in depressions were completely covered by the washed-out soil material. To a high percentage, the doline forms presently recognizable in the landscape of the Swabian Alb are forms that originated through erosion and transport of the fine material through karst hydrographically conducting joints in the covered subsoil or also through collapses in the subsoil counterdrawn in the covered soils under the colluvium (landfall) (***Pfeffer, K.-H.*** 1990, 2003).

The dolines are indicators for places, where surface water or the interflow flowing at the periglacial boundary layers rapidly flows into the underground karst system. Dolines are very important with regards to the potential hazards for karst water due to surface pollutants.

The erosion of the periglacial cover layers with the soil material on slopes and of the limestone rock, now only covered by a thin layer of virgin soil, have changed the locations. This has had an impact upon the land use. Agriculture dominates on the flatter lower slopes of the domes, in the dry valleys, the karst basins, and on the Schichtflächenalb and the Flächenalb south of the cliff. The dry valley slopes that are not oriented south-southwest and the steep slopes of the domes are covered with forests. On the south-west oriented slopes, the thin soil cover with its low water storage capacity only enabled pasture use and out of the combination of dry sites and sheep pastures, slope locations with semi-dry grassland developed. These are designated as juniper heaths because of the isolated juniper bushes. A multitude of red listed endangered fauna and flora can be found here.

The use of this landscape, which had resulted through cultivation prevalent since the Middle Ages, underwent a large change with the onset of industrialisation and a sharp decline in sheep pasturing. Former pastures and terraced fields on dome slopes were afforested with spruce trees. The juniper heaths, as relicts of the intensive sheep pasturing, are only preserved in the landscape insularly. These stands, ecologically valuable and characteristic for the landscape, are now protected under the nature conservation programs of Baden-Württemberg (***Beinlich, B. – Plachter, H.*** 1995). To preserve these stands, support programs are needed, in particular sheep pasturing, since without this, a succession will occur on the dry, but not nutrient-poor locations and after ca. 20-25 years the juniper heaths will transform into forests.

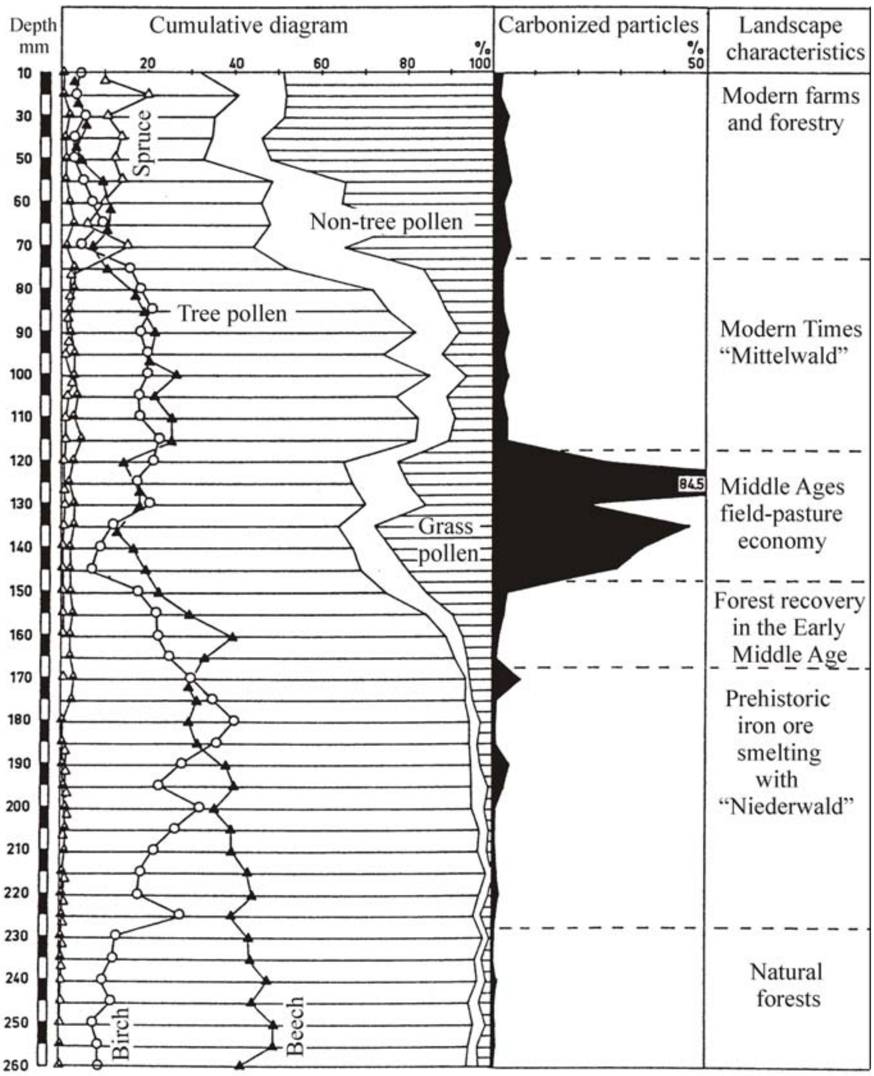

Figure 6 Pollen profiles and vegetation development since the Ice Ages (***Smettan, H.*** 1993. p. 344)

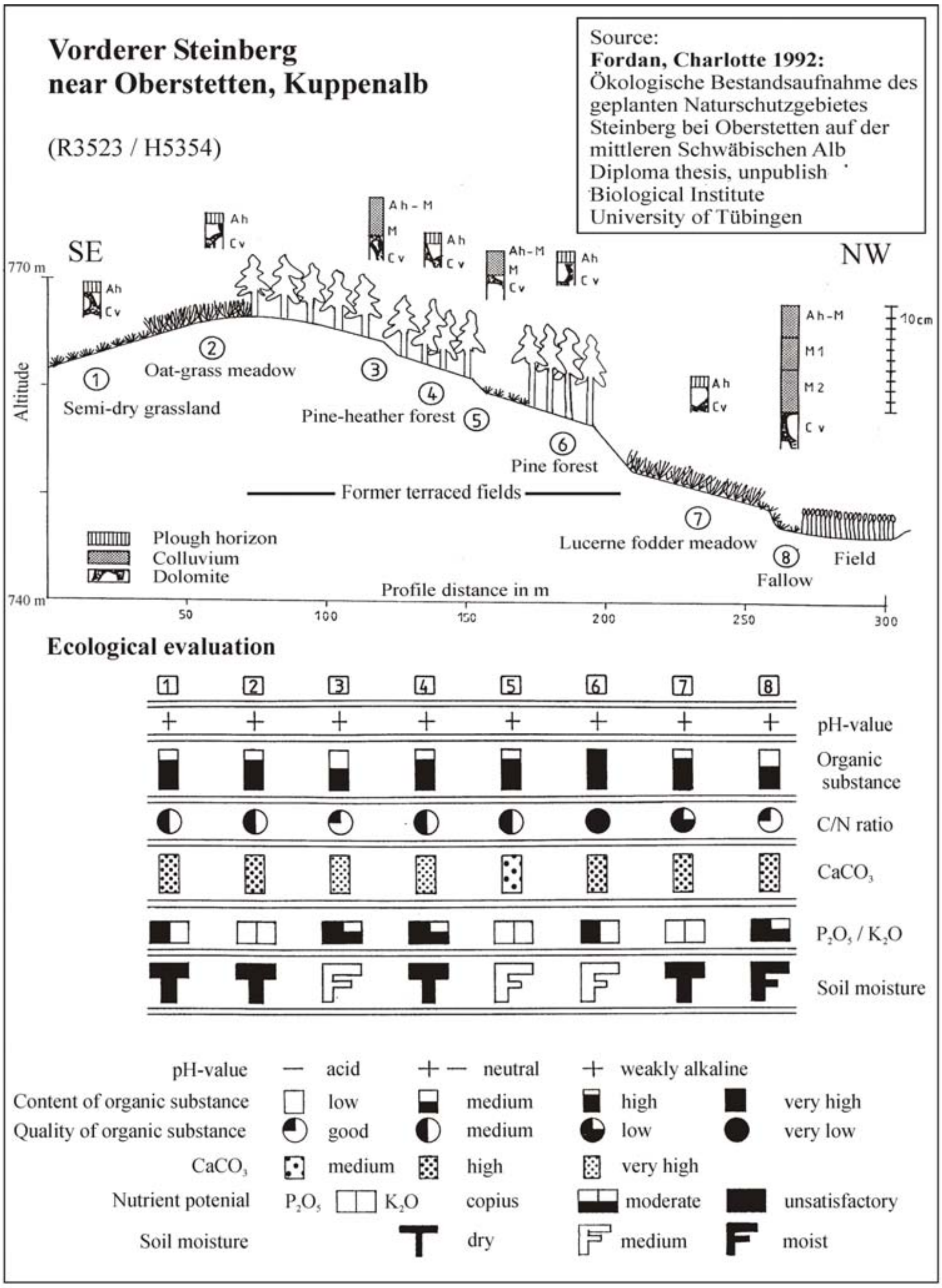

Figure 7 Geo-ecological profiles and ecological evaluation over a dome

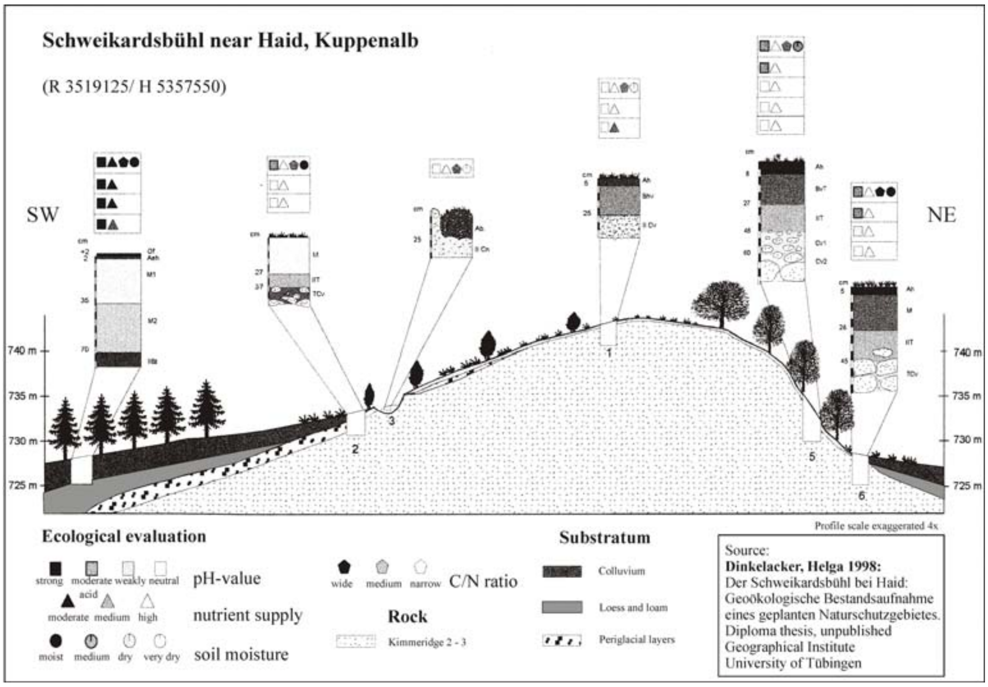

Figure 8 Geo-ecological profiles and ecological evaluation over a dome

Nutrients from the bordering agricultural fields, transported by interflow water which seeps into the dry valley slopes, also change the location conditions and nitrophilic plants such as stinging nettle (*Urtica dioica*) and elder (*Sambucus nigra*) endanger the stands (***Pfeffer, K.-H.*** 1990).

THE KARST LANDSCAPE OF THE SWABIAN ALB

The karst landscape of the Swabian Alb, with its many forms and soils, is the result of geological processes. The characteristics of the current landscape with the spatial patterns of soils and colluvium, as well as specific vegetation and land use patterns are a consequence of anthropogenic changes, begun in prehistoric times. Thus on the one hand, the Swabian Alb is a karst landscape and on the other hand a cultural landscape.

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