12th International Palynological Congress IPC-XII 2008
8th International Organisation of Palaeobotany Conference IOPC-VIII 2008
August 30 - September 5, 2008, Bonn, Germany

Excursion No. B2

Geology and Paleobotany of the Tertiary in the Wetterau Depression (Hesse) including aspects of Roman and Medieval history.

September 2, 2008

Leader: Martin Hottenrott (Wiesbaden)

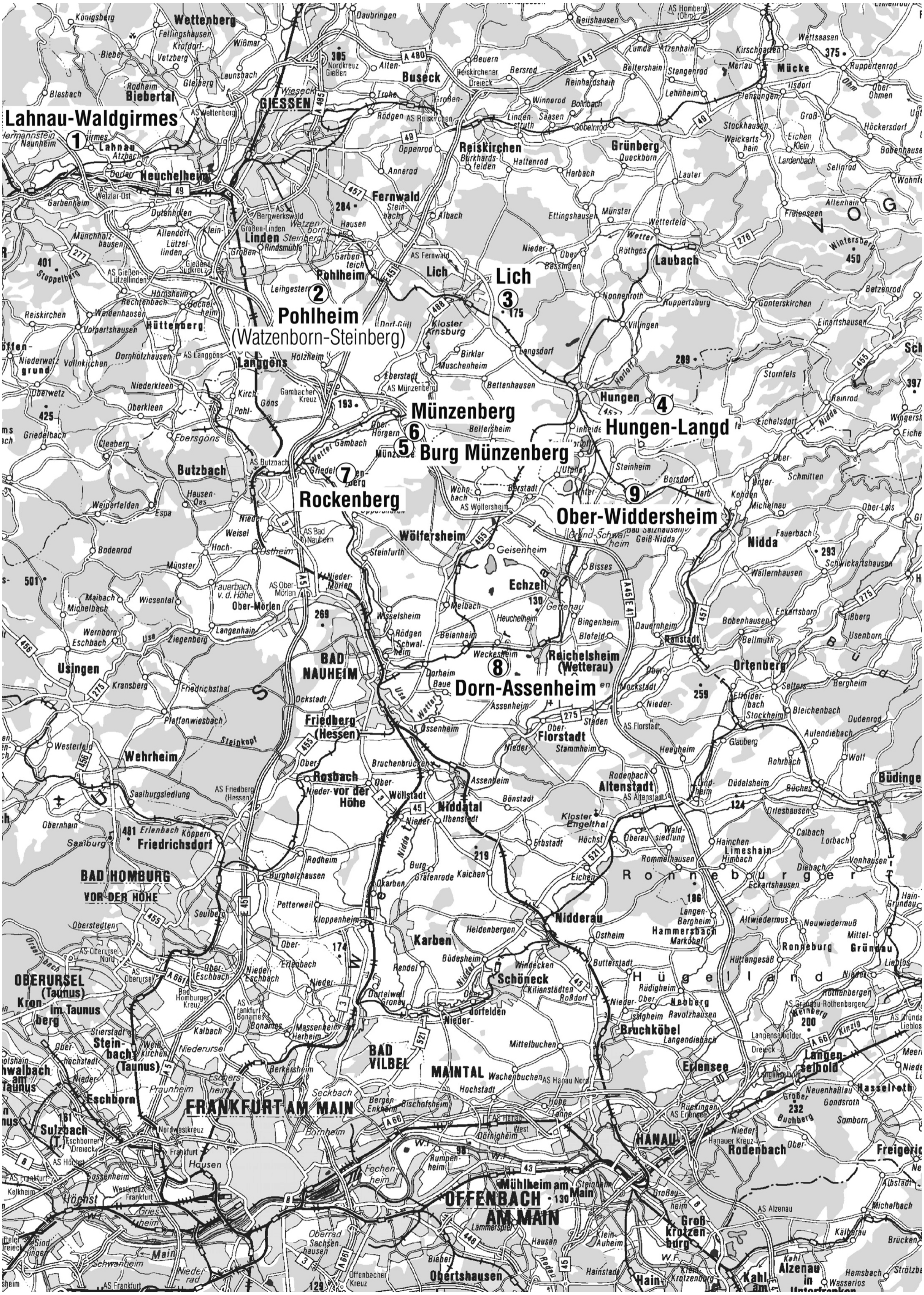

Fig. 1: Map showing the excursion area and the location of the stops.

Geology and Paleobotany of the Tertiary in the Wetterau Depression (Hesse) including aspects of Roman and Medieval history

[1] Martin Hottenrott (Wiesbaden)

The Wetterau is a small Tertiary basin which lies between the Upper Rhine Graben and neighbouring sub-basins in the south, and other Tertiary depressions in the north of Hesse (Fig. 1, 2, 3, 4).

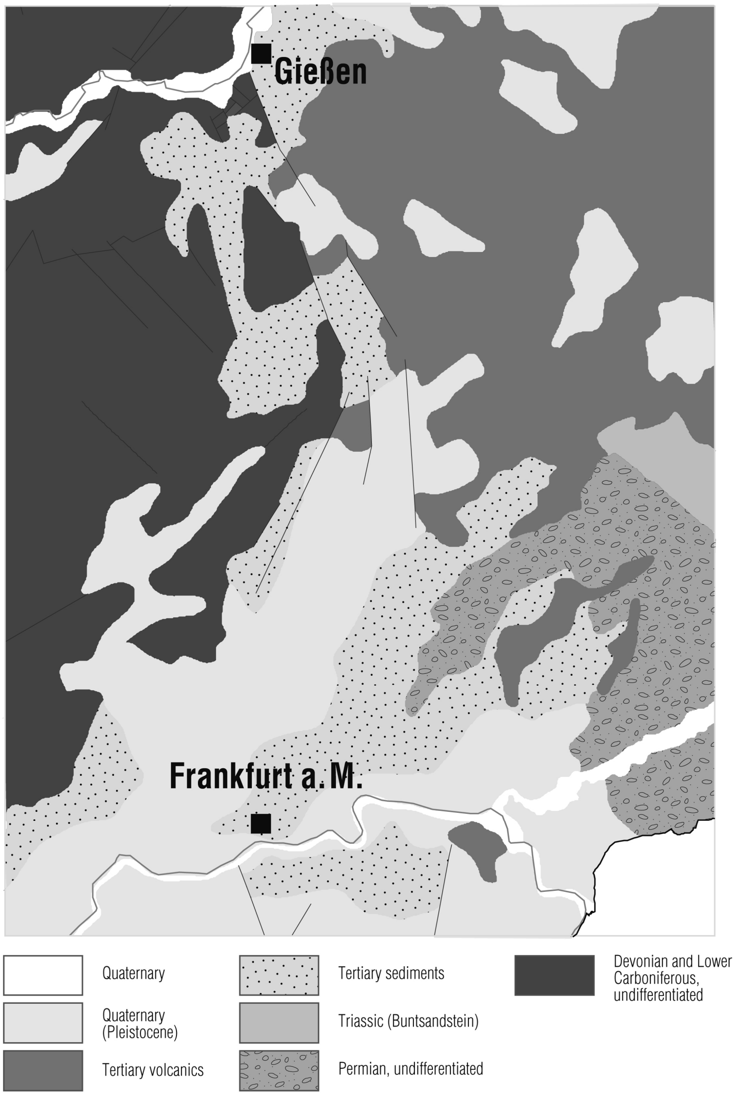

Fig. 2: Geological sketch map of the excursion area.

The Wetterau is bounded to the west by the Palaeozoic Taunus high. The depression grades into the Hanau Basin to the south with no sharp boundary. It is bordered on the east by the basalt sequences of the Vogelsberg, which also mark out the boundary in the north. The eastern section of the Wetterau Depression contains the Horloff Graben which formed during the Pliocene in the Miocene Vogelsberg volcanic rocks (cf. Fig. 2). The neighbouring Vogelsberg is part of a chain of Tertiary and Quaternary intra-plate volcanoes stretching from the Eifel to Silesia. With a still contiguous surface area of around 2,300 km^2, the Vogelsberg is the largest volcanic region in Central Europe (e.g. Schottler 1937, Ehrenberg et al. 1981, Ehrenberg & Hickethier 1985, Hoppe & Schulz 2001). Lava from the Vogelsberg also flowed into the neighbouring Wetterau Depression. The Tertiary (and the Permian) sequences (cf. Fig. 4) include some highly fossiliferous

[1] Dr. Martin Hottenrott, Hessian Agency for the Environment and Geology, Rheingaustrasse 186, D-65203 Wiesbaden, Germany, e-mail: m.hottenrott@hlug.de

paleobotanical deposits, and already attracted the attention of paleobotanists back in the 19th century. The Wetterau has been settled since the Paleolithic era, and has continuously experienced migrations. This very fertile region (loess soil) was so important to the Romans that the fortified northern boundary of the Roman Empire (Limes) bulged out northwards to encompass the Wetterau.

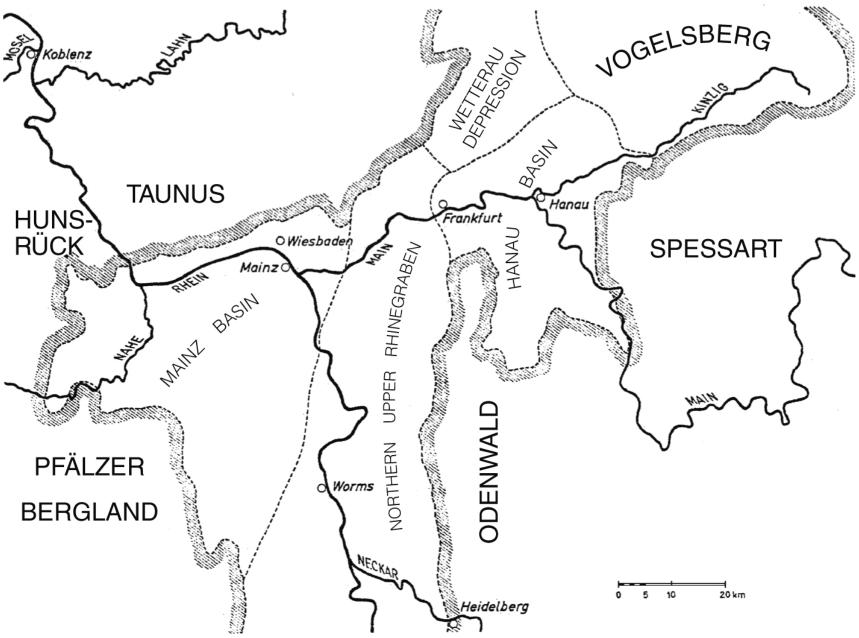

Fig 3: Tertiary basins between the Rhenish Slate Mountains and the Mid German Crystalline High (after Golwer 1968).

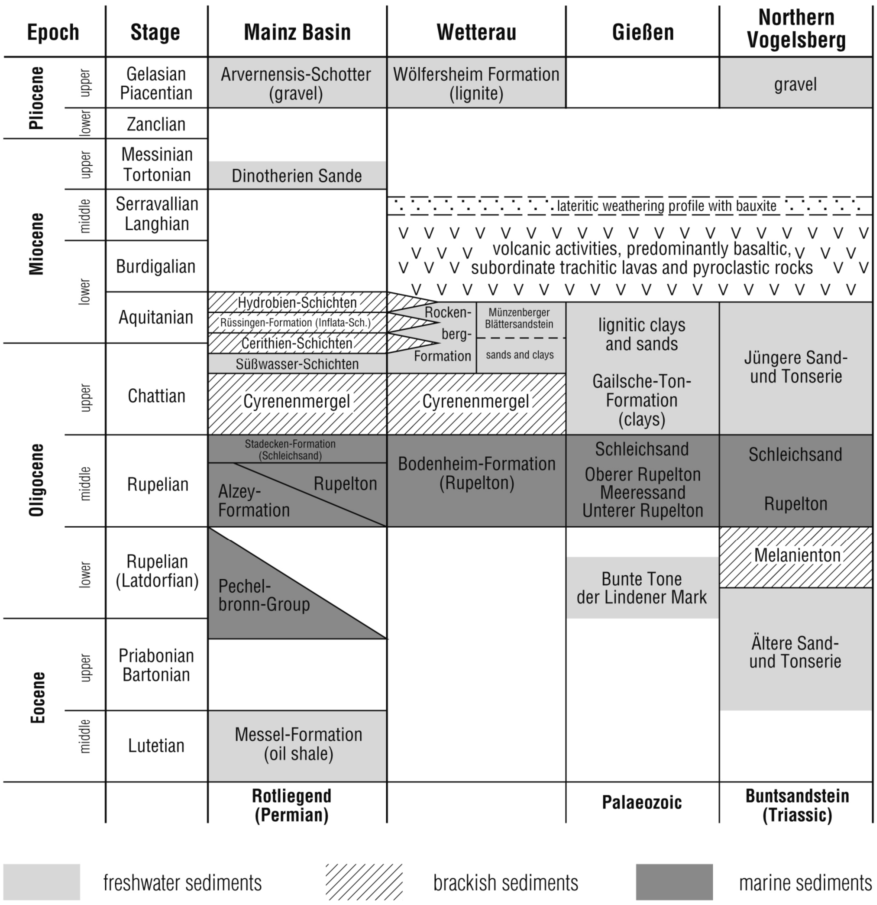

Fig. 4: Stratigraphic subdivision of the Tertiary in the area surrounding the Vogelsberg and in the Mainz Basin (after Weyl 1980, modified).

Stop 1. Ancient Roman city forum at Lahnau-Waldgirmes (town founded in the late Augustinian period).
(Map sheet 1: 25000: 5417 Wetzlar; R 3467598, H 5605971; N 50° 35.311′, E 008° 32.438′).

Remnants of an (early) Roman settlement were found at Waldgirmes on the Lahn river in the early 1990s. A Roman military camp for 1.5 legions (approx. 8000 soldiers) dating back to the reign of Emperor Augustus, was found some years earlier at Dorlar (the next village) from the analysis of aerial photographs (Wigg 1999, Becker et al. 1999). Excavations at Waldgirmes revealed the stone foundations of a central building (2200 square metres in size) which was untypical of a Roman military camp. This building is laid out like a Roman forum as found in many Roman towns. It is considered to be the oldest building north of the Alps with stone foundations. Its interior originally housed a gold-plated, bronze equestrian statue thought to depict Emperor Augustus. Local Devonian bedded limestone is the most frequently used building stone in Waldgirmes. However, the second most frequently used building stone is allochthonous: Jurassic limestone from Lothringen in France (Brachert & Keller in Becker & Rasbach 2003). The Romans therefore transported building stone to this locality, probably using waterways via the Mosel, the Rhine and the Lahn. Archaeobotanical research carried out in the Waldgirmes area identified fruits and seeds from 116 plant species. The cultivated plants included *Hordeum vulgare*, *Triticum dicoccum*, *Panicum miliaceum*, *Triticum spelta* and *Triticum aestivum,* and the oil plants *Linum usitatissimum* and *Camelina sativa*. No evidence of any Mediterranean fruit varieties was found (Kreuz in Becker & Rasbach 2003, Kreuz 2008). The winter cereals, spelt (*Triticum spelta*) and common wheat (*Triticum aestivum* s.l./*durum*/*turgidum*), identified as being present when the Romans were in Waldgirmes are absent in the region in early Germanic settlements of the same age. The Waldgirmes settlement, which was of urban character, was clearly supplied by these cereal types which were transported in over long distances. The archaeologists believe that the whole site was the core of a civilian settlement, a “nucleus city”, more than 2000 years old. It is possible that the Romans had tried to establish an administrative headquarters here with the aim of creating a new province. Numerous civilian buildings have been discovered within the rounded almost rectangular fortifications (with angular double V-shaped ditches, wall, gates and watchtowers). The settlement was abandoned in AD 9 after having been occupied for about a decade (Wigg 1999, Becker et al. 1999, Becker & Rasbach 2003, www.waldgirmes.de). This was the year of the famous Battle of Teutoburg Forest (Varus Battle), where the Romans suffered a disastrous defeat in Northern Germany: the 17th , 18th and 19th legions commanded by the governor (legatus Augusti pro praetore) Publius Quinctilius Varus, were completely wiped out)(e.g. Pörtner 1962, Harnecker 1999, Schlüter & Wiegels 1999, Clunn 2001).

Stop 2. Remains of the Roman Limes (fortified northern boundary of the Roman Empire; 3rd century AD) near Pohlheim (Watzenborn-Steinberg) on the Steinberg: Watchtower WP 4/49 with well preserved Limes and reconstruction of the tower and palisade.
(Map sheet 1: 25000: 5418 Gießen; R 3479715, H 5598156; N 50° 31.067′, E 008° 42.829′).

The Romans still occupied areas to the east of the Rhine many decades after abandoning the settlement at Waldgirmes. For around 160 years, the Roman border also ran through the Taunus and Westerwald mountains and the Wetterau Depression. This guarded and fortified border (Limes) separated the Roman provinces of Upper Germania and Rhaetia from the areas occupied by the German tribes. The Limes stretched over 550 km from the Rhine to the Danube (the remains are now Europe’s largest earth monument). Around 120 larger and smaller forts lay in the immediate vicinity of the Limes, as well as approx. 900 watchtowers (watchtowers lay directly on the Limes, were located 400 to 800 m apart, and enabled signals to be passed along the line very quickly). The main purpose of the Limes was to control the border and the movement of people and goods, it was not really an impenetrable military barrier. The Limes underwent several different phases of expansion. It was initially a sentry road with clearings in the forest containing wooden watchtowers. This first construction phase occurred during the reign of Emperor Domitian (81–96 AD). A wooden palisade was constructed in front of the sentry road during the reign of Emperor Hadrian (117–138 AD). The original wooden and earth towers and forts were replaced from the middle of the 2nd century onwards by stone buildings. The Limes was laid out as straight as possible at this time. During the reign of Emperor Alexander Severus (222–235 AD), the Limes underwent its last period of development. A V-shaped ditch was excavated behind the palisade and material was piled up to form a rampart (Klee 1989, Baatz 1993; Fig. 5). The simultaneous existence of a palisade, rampart and ditch is disputed nowadays (Schallmayer 2005, Birley & Rupp 2008). Each of the forts (with the associated watchtowers) was manned by between 100 to 1000 auxiliary soldiers. The legions (each with 5500 soldiers) were responsible for major military campaigns. Their garrisons lay some distance away from the Limes (in Mainz and Straßburg on the Rhine and in Regensburg in Raetia). The Limes was overrun by Germanic tribes (the Alemanni) for the first time in 233 AD. The Limes was finally abandoned in 260 AD after another invasion. The Romans withdrew to the Rhine, which formed the boundary of the Roman Empire for the next 145 years. The names of the following military auxiliary units were discovered in the forts in the vicinity of tower 4/49. Butzbach: Cohors II Raetorum (equitata) (to 135 AD), Cohors II Augusta Cyrenaica equitata, Ala Moesica felix torquata. Arnsburg: Cohors II Aquitanorum equitata, later Cohors I Aquitanorum veterana equitata and later, Cohors V Dalmatarum (Baatz 1993). The remains of the Limes in Germany are now a UNESCO World Heritage Site (Schallmayer 2005b, Birley & Rupp 2008, www.taunus-wetterau-limes.de).

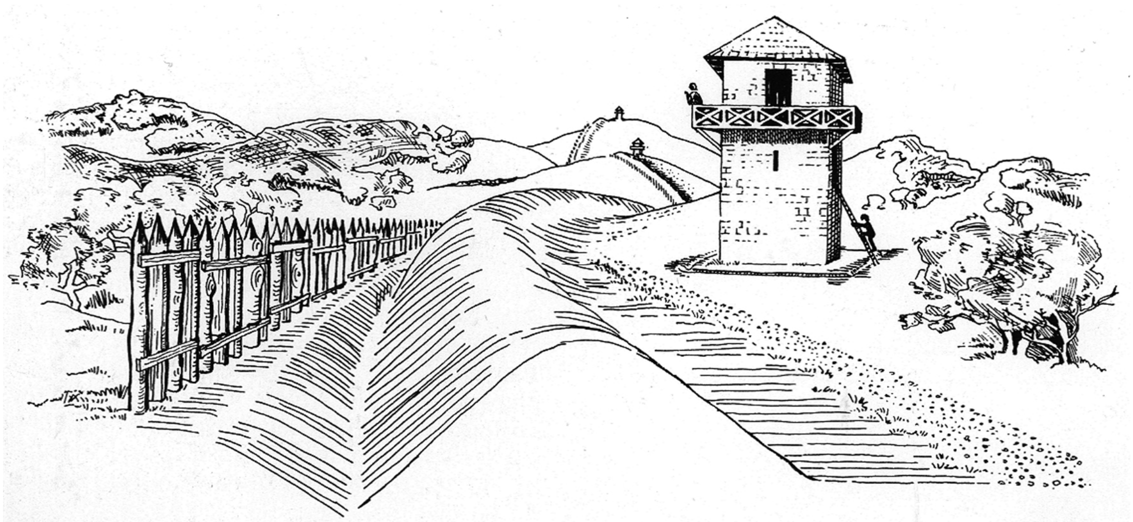

Fig. 5: Upper Germanic Limes, reconstruction of the last building phase (after Klee 1989; Baatz 1993, Vogt 2001; source: Dietwulf Baatz, Saalburgmuseum Bad Homburg).

Stop 3. Miocene lateritic weathering profile of red earth and bauxite overlying volcanic rocks near Lich (?indication of a Middle Miocene climate optimum).
"Eiserne Hose" opencast mine operated by E.G.O., E Lich.
(Map sheet 1: 25000: 5419 Laubach; R 3489340, H 5597950; N 50° 31.061′, E 008° 50.904′).

In the western part of the Miocene volcanic Vogelsberg, relicts of a formerly up to 50 m thick weathering layer are still preserved covering large areas in parts (e.g. Schottler 1921, Harassowitz 1926, Schwarz 1997; cf. Fig. 4). Thick saprolite (kaolinitic-smectitic volcanic weathering products) is overlain here by lateritic red earth (with bauxite nodules consisting of gibbsite and böhmite). The formation of this ferralitic deposit – at the time when the volcanic activity had largely come to an end – is primarily assumed to have taken place during the warm-moist climatic conditions of the late Middle Miocene (e.g. Hottenrott 1985, Schwarz 1988, 1997). This appears to have been the last climate optimum in the central European Tertiary. According to Schwarz (1997), the lateritic weathering profiles are all thought to be non-contiguous because the red earth material overlying the "in-situ weathered basalt" had already undergone solifluidal redeposition.

Although there is no longer any uncertainty today that lateritic weathering processes led to the enrichment of iron or aluminium in the alteration products saprolite, basalt ironstone, red earths and bauxite nodules (e.g. Liebrich 1892, Beyschlag 1897, Hollmann 1909, Harrassowitz 1921, 1922, 1926, Friedrich-Lautz 1963, Schellmann 1966, Wirtz 1972), the narrow, approximately north-south enrichment zones of basalt ironstones (cf. e.g. Schwarz 1997: Fig. 1) are often attributed to post-volcanic hydrothermal Fe-solutions rising upwards along faults (e.g. Chelius 1904, Münster 1905, Klüpfel 1953).

The "Eiserne Hose" opencast mine is the only outcrop in the Vogelsberg where laterite ("red earth") and saprolite (weathered basalt) are still very well exposed (cf. Fig. 6). The red earth reaches thicknesses of up to 10 m in some parts of the mine according to Schwarz (1988, 1997). The underlying saprolite, derived from tholeiitic basalt here, is over 30 m thick according to drilling results from wells which did not go deep enough to penetrate the transition to unweathered basalt. Fig. 6 shows a cross-section of the basin shape of this deposit surrounded on all sides by saprolite. In the sections shown, up to 6.5 m red earth overlie up to 7 m saprolite. With the exception of one horizon with bauxite nodules which can be followed across the whole exposure, the saprolite is largely homogenous and still displays the original fabric despite alteration of the mineral phases (e.g. plagioclase to kaolinite).

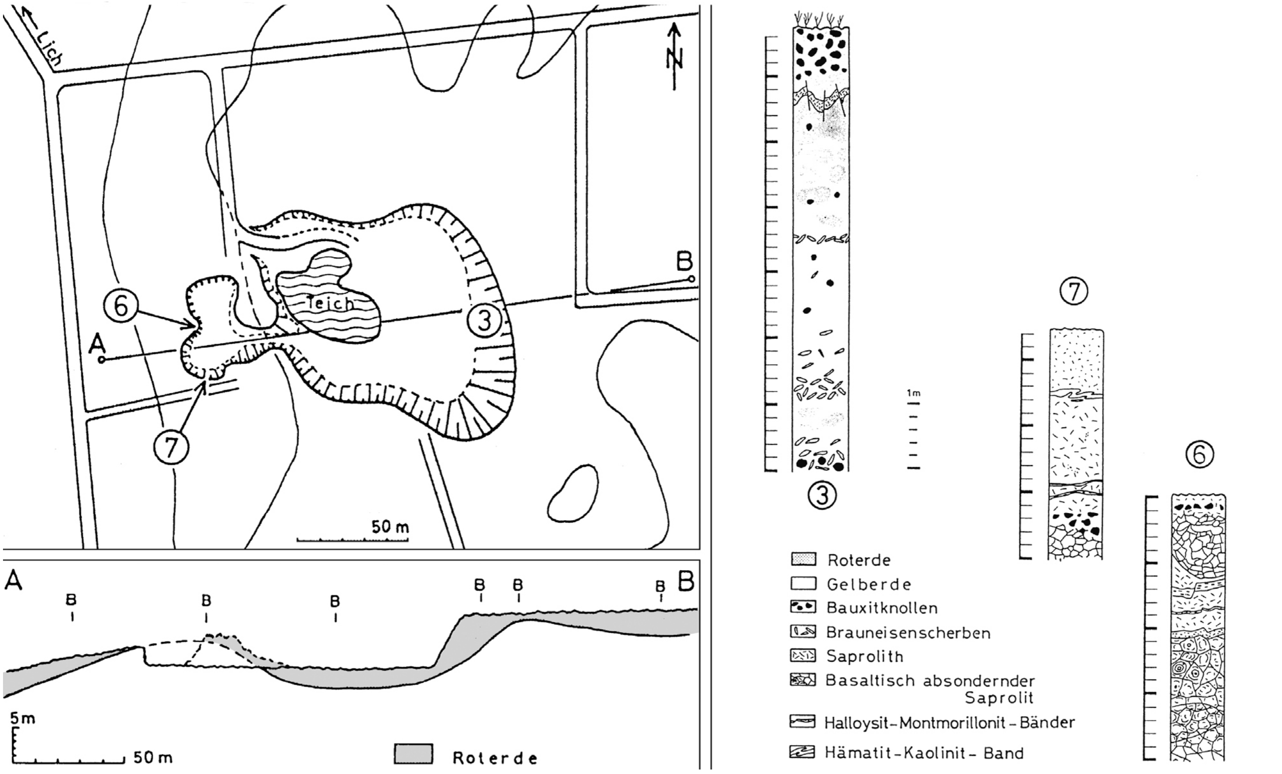

Fig. 6: “Eiserne Hose” bauxite mine to the east of Lich: location map, east-west cross-section and weathering profile (after Schwarz 1988, Schwarz et al. 1993).

An up to 7 m high face in the eastern part of the opencast mine consisting of red earth has no recognisable basaltic fabric and a large spectrum of grain sizes. The red earth is typified by alternating more strongly argillaceous layers and horizons dominated by pebbles. The material is mainly made up of a clay fraction consisting of kaolinite, gibbsite and haematite/goethite, as well as rounded quartz grains, bauxite nodules and basalt ironstone fragments. The detritus horizons largely consist of angular basalt ironstone (limonite, brown iron) in the yellow-brown coloured lower parts, and basalt nodules which dominate the upper more intensely red coloured parts. Most of these bauxite nodules exhibit a basalt fabric. Nodules also exist, however, without any relict fabrics: these must have formed as concretions within the red earth (Schellmann 1966). The inhomogeneous bedding is also clearly reflected in the distribution of the major elements and the trace elements.

The exposure is an important climate document for the period approx. 15 million years ago. The lateritic rock is a relict of soil formation which nowadays occurs in a similar form in the tropics.

Stop 4. Miocene lava flows and pyroclastic layers with the remnants of a volcanic crater (lava lake) at the Hungen-Langd quarry. (Steinbruch Langd protection area; Naturschutzbund Deutschland e.V.), former quarry operated by Maikranz, approx. 500 m ESE Langd.
(Map sheet 1: 25000: 5519 Hungen, R 3497140, H 5592490; N 50° 28.107′. 008° 57.478′).

The abandoned basalt quarry reveals parts of a former Tertiary volcanic crater (Ehrenberg 1981). The crater rim exposed in the northern face in the western part of the quarry consists of a horizontal to slightly dipping sequence of four 5–8 m thick basanitic lava flows with interbedded ash tuffs (Fig. 7). They are discordently capped by an irregular horizon, dipping 40–45° south-east in the centre of the quarry. This horizon is interpreted as a strongly erosively overprinted internal crater wall, and is overlain by a slightly bedded and largely unsorted sequence of rock breccias (debris fans) dipping around 35° south-east. These rock breccias have a maximum thickness of 4 m, contain a large number of blocks of basaltic rocks, and wedge out upwards. In the direction of the assumed inside of the crater, they are overlain by a 0.5–4 m thick slag agglomerate which itself is overlain by a platy, sheet-jointed alkali olivine basalt interpreted as a relict of a lava lake. In the contact zone, the sheet-slab jointed horizon runs largely parallel to the wavy surface of the slag agglomerate, presumably compressed in part by the basalt which flowed over the top. The largely south-easterly dipping platy horizon bends “fold-like” about 10–15 m south-east of the boundary to become almost horizontally bedded. The boundary “lava lake / slag agglomerate / breccia” is sporadically exposed across the quarry from the north face, via a cliff remnant, to the southern part of the quarry. The overlying platy basalt indicates the presence of a slightly conically-shaped horizon. The shape of the crater interpreted from the platy bedding was largely verified by Schmidt & Zulauf (1991) on the basis of the different magnetisation directions of the volcanites in the crater and the crater rim.

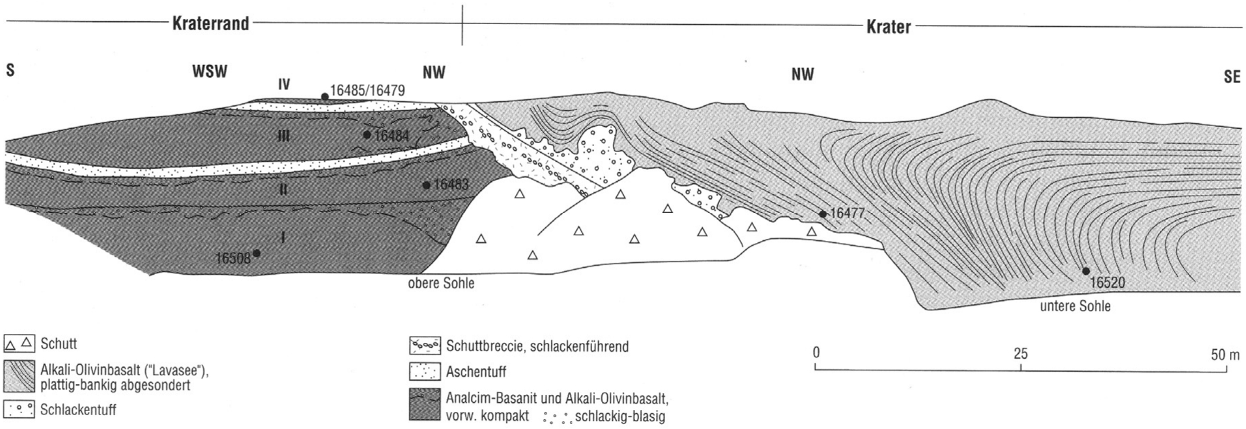

Fig. 7: Abandoned basalt quarry ESE Hungen-Langd. Discordant juxtaposition of pebble breccia, slag agglomerate and “lava lake basalt” at the crater rim formed by basanitic lava flows (after Ehrenberg 1981).

Stop 5. Medieval Münzenberg castle (12th century AD).
(Map sheet 1: 25000: 5518 Butzbach, R 3484200, H 5590620; N 50° 27.082′ , E008° 46.585′).

Built on a hill (Miocene basalt pipe), the two massive towers of Münzenberg castle (the “Wetterau ink pot”) are dominant landmarks in the Wetterau. The precise age of the castle is unknown. Konrad II von Hagen und Arnsburg acquired the basalt dome from the Fulda monastery in the middle of the 12th century AD. His son, Kuno I von Hagen-Arnsburg, who built the castle, was already named after his new fortified home (von Münzenberg) in 1162 AD. The construction of Münzenberg castle was probably part of a strategy by the Staufer King Konrad III to cement the Wetterau as a central part of his royal territory – Konrad von Hagen-Arnsburg belonged to the king’s inner circle. His son, Kuno, became the dominant territorial-political force in the Wetterau.

Kuno I was the Royal Imperial Treasurer to Emperor Friedrich I Barbarossa (from 1162 AD, cf. Fischer-Fabian 1977) and a very rich man. This probably also explains the unusually complex architectural ornamentation of the Romanesque great hall (numerous capitals, ornamented cornices extending from the fireplace jambs, window frames with a large number of different designs, and the arrangement of the bossed stones). Kuno I was also benevolent: when persecution of the Jews began in Frankfurt in connection with Emperor Barbarossa’s crusade (3rd crusade), Kuno I gave the fleeing Jews refuge in Münzenberg. When the Münzenberg line died out, the Falkensteins took over the castle in 1265 AD. Phillip von Falkenstein (died 1270 AD) extended the Romanesque castle with additions in the gothic style prevalent at the time. The new gothic Falkenstein buildings made of black basalt were much more austere (and more forbidding) than the Romanesque building. The Falkenstein great hall contains no architectural ornamentation of any kind; it appears undecorated, and therefore echoed the architectural zeitgeist of the period. Comparable great halls also tend to be austere, reducing the gothic elements to their essence (Söllner 1965, Jost 2000, Vogt 2001). The castle was destroyed during the Thirty Years War (1626 AD and later) and has been a ruin ever since.

Stop 6. Miocene Münzenberger Blättersandstein (Leaf sandstone; Rockenberg Formation), profile in an old quarry to the south of the stable.
(Map sheet 1: 25000: 5518 Butzbach, R 3484620, H 5591210 and on the Götzenstein, R 3484570, H 5591020; N 50° 27.327′, E 008° 46.941′ and N 50° 27.408′, E 008° 46.941′).

The Münzenberger Blättersandstein is also part of the lower sandy and quarzitic section of the Rockenberg Formation, even though it is only a few kilometres away from Rockenberg. It is a special local facies of the Rockenberg Formation (Fig. 4). The former quarry near the stable now only exposes part of the sequence described in older references (e.g. Plank 1910; Kümmerle 1981, Fig. 8). There is still a poor exposure there of the yellow and brown-red, blue-red and pale-red "cemented sandstone" (Fig. 8). Parts of the sandstone contain leaf impressions and stems, as well as baryte, FeMn oxide and siliceous precipitates (mostly in joints). This is overlain by the fine-grained yellow "friable sandstone". The 0.40 m thick *Corbicula* bed at the top of the quarry is inaccessible and has been so for many decades (Weyl 1980, Kümmerle 1981). The current floor of the quarry is underlain by sandstones (initially argillaceous) (approx. 11 m), with underlying quartzite (11 m). A 2.30 m thick silt horizon with lignite forms the base of the Tertiary overlying the Devonian argillaceous slates at the base of the sequence (Kümmerle 1981).

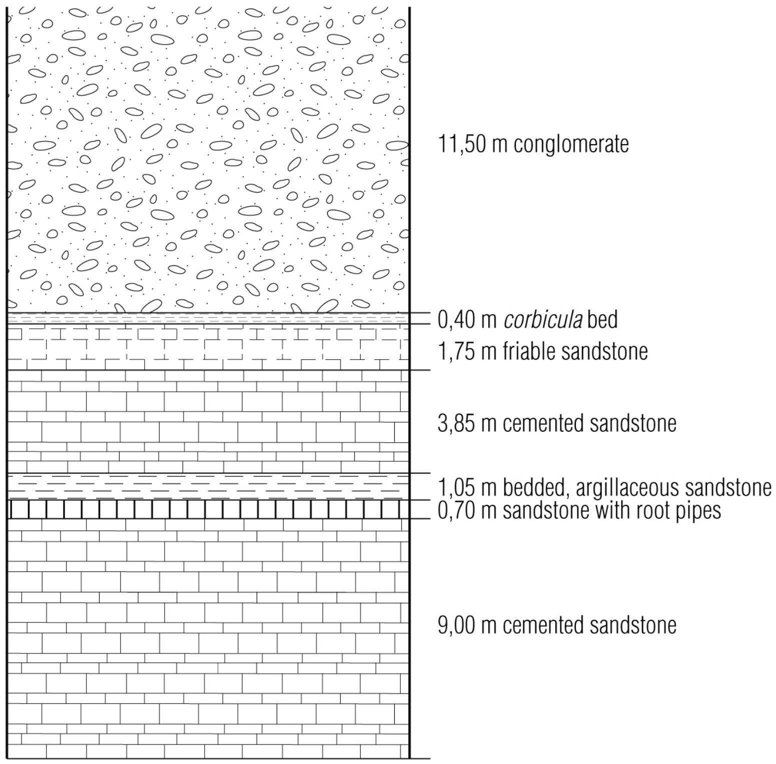

Fig. 8: Section in the old Münzenberg quarry with the Götzenstein (south of the stable), after Plank 1910).

A short walk south over the meadow above the top of the quarry to the top of the Götzenstein (nature conservation area), leads to coarse conglomerate and conglomeratic quartz beds which form the overlying sequence to the Münzenberger Blättersandstein. The cementation of the conglomerates (and probably also the Münzenberger Blättersandstein) is probably mainly attributable here to hydrothermal mineralisation (mainly quartz and baryte) affecting the easternmost marginal step fault of the Taunus (Taunus east edge fault) (Kirnbauer 1998). A type of boulder field has been created as a result of erosion of less cemented zones, the break-up of bedding packages, and Quaternary solifluction. The thickness of the conglomeratic beds and the diameter of the pebbles increases from west to east (cf. Stop 7: Rockenberg). Huckriede (1960) interpreted this as a sign that the pebbles were transported away from a point "to the east of the current locality during the volcanic formation of the Vogelsberg."

A notable feature of the gravels in the Münzenberg area are the presence of fossiliferous quartzite pebbles of Ordovician age (Huckriede 1960, Struve 1975), which contain the oldest known macro-fossils (trilobites) found in Hesse. This source rock of the Münzenberg pebble deposit was redeposited several times during the intervening epochs, and was the raw material for the Münzenberger Pebble Culture during the Stone Age (Palaeolithic) (Huckriede 1960, Krüger 1994).

The sandstone at Münzenberg became famous because of its fossil flora, which is also the origin of its name "Münzenberger Blättersandstein" (leaf sandstone). The plant remains (mainly leaves) are mainly found in the (lower) "Thonstein" described by Ludwig (1859–1861) = "bedded argillaceous sandstone" of Plank (1910; cf. Fig. 8), but they are also present in sandstones, and can be found occasionally in the quarry near the stable. The rich flora was first described in detail by Ludwig (1859–1861), together with the fauna at the Rockenberg locality. They were also investigated later by other famous paleobotanists (v. Ettingshausen, Engelhardt, Kirchheimer, Mai, etc.; cf. Mai 1995). The flora is one of the type references for the Münzenberg-Bitterfeld flora complex (Krutzsch 1988, Mai 1995). It consists of rich arcto-Tertiary assemblages, mixed in with Laurophyllic elements. The most frequent form here is *Taxodium dubium*, and characteristic forms include *Cercidiphyllum crenatum*, *Cyclocarya cyclocarpa*, *Gleditsia lyelliana*, *Laurophyllum nemejcii*, *Myrica undulatissima*, *Ludwigia kräuselii*, *Athrotaxus couttsiae*, *Cunninghamia miocenica*, *Glyptostrobus europaea*, *Sequoia abietina*, *Tetraclinis brongniartii*. Occasional "early Tertiary" elements are also found including *Carpinus cordataeformis*, *Eotrigonobalanus furcinervis*, *Daphnogene septimontana* and *Comptonia schrankii*. New species include *Azolla nikitinii*, *Caldesia provitentia*, *Laporta europaea* and *Stratiotes sibirica*. The most frequent fossils found in recent decades include leaves from *Magnolia*, *Cinnamomum*, *Acer*, *Quercus*, *Ulmus*, *Zelkova* respectively *Planera*, *Sabal* and fragments of *Sequoia*. Pine cones and the fruit of *Juglans* have also been found on rare occasions (Weyl 1980, Kümmerle 1981, Mai 1995). The Münzenberg-Bitterfeld flora complex is macro-paleobotanically characteristic of the lowest Miocene (Krutzsch 1988, Mai 1995).

Stop 7. Miocene Rockenberg sands with quartzites (Rockenberg Formation), nature conservation area "Hölle von Rockenberg". (Map sheet 1: 25000: 5518 Butzbach, R 3481140, H 5589180; N 50° 26.260′, E 008° 44.023′).

The abandoned sand pit to the north of the former "Marienschloß" monastery, exposes yellowish, brown, partly white sand, with limonitic sandstones and quartzites in the upper part. Layers with gravel and conglomerate are also concentrated in the upper part of the section. Gravel particles also occur in the quartzite blocks exposed at the surface above the face of the pit. Cross-bedding can be observed in parts (particularly on the top). Gravely-conglomeratic intercalations limited to the top part of the section can also be seen in the quartzites on the plateau above the top of the quarry.

The Rockenberg Formation in the Wetterau Depression consists of an extremely wide range of coarse to fine clastic sediments, and underlies here the volcanic sequence of the Vogelsberg volcanism (Fig. 4). The parallel correlation of each package of layers is complicated by the marked changes between coarse and fine-grained sediments both horizontally as well as vertically. The sequence is subdivided regionally into a sandy lower section and a gravely-conglomeratic upper section (Kümmerle 1981). The sandy deposits have been cemented in part to form sandstones and quartzites, as well as into conglomeratic quartzites. Cementation of the sands increases upwards. The general opinion is that the quartzites were formed in a zone affected by a fluctuating water table under the influence of a warm, damp climate; but hydrothermal silicification may also have played a role (Plank 1910, Freyberg 1926, Kirnbauer 1998). The quartzites are penetrated locally by root pipes, and rare leaf impressions have also been found; plant remains are more frequent in the limonitic sandstones.

The younger part of the Rockenberg Formation in particular (not exposed here) is characterised by silty-argillaceous sediments, and frequently contains thin lignite seams. Marls and limestones are also found locally in this argillaceous sequence. The local micro-fauna with *Hydrobia paludinaria* allows correlation of the top of the Rockenberg Formation with the Hydrobien-Schichten (*Hydrobia* Beds) in the Mainz and Hanau basins (KÜMMERLE 1981; cf. Fig. 4). The lower sandy parts of the Rockenberg Formation contain stone cores of *Falsocorbicula faujasii* found in the Münzenberger Blättersandstein (Stop 6), which form characteristic shell beds in the Rüssingen Formation (*Corbicula*-Schichten, *Corbicula* Beds or *Inflata*-Schichten, *Inflata* Beds, cf. Fig. 4) in the adjacent zones to the south and south-east. The sediments in the Rockenberg Formation are therefore interpreted as time equivalent deposits (mainly non-calcareous marginal facies) of the "Calcareous-Tertiary" of the Mainz and Hanau basins. Here, they represent the chronostratigraphic upper Oligocene and Lower Miocene (cf. Fig. 4). An "aquitane" micro-flora is found accordingly in the lignite, partially with abundant dinoflagellate cysts (*Deflandrea*), which are also concentrated in some sections of the Calcareous-Tertiary in the Mainz and Hanau basins (Stegemann 1964). The dinoflagellate cysts indicate that the Rockenberg Formation was deposited under brackish to marine conditions, in part at least – as also indicated by trace fossils: pipe-like structures are frequently found in the sand as well as in the cemented sections, including worm casts of *Ophiomorpha*-type (Kümmerle 1981). The well-known Rockenberg macro-flora is found in a local ferruginous sandy claystone ("Gelbeisenstein"), in the lower part of a conglomerate horizon found in the upper part of the working face of the former sand pit (Ludwig 1859–1861, cf. Kümmerle 1981). The Rockenberg flora is comparable to that found at Münzenberg (Ludwig 1859–1861, Mai 1995).

The quartz sands of the Rockenberg Formation contain baryte in the form of concretions and rosetta-like aggregated crystals along one of the fault zones (step fault along the eastern edge of the Taunus). The Neogene to sub-Recent hydrothermal mineralisation of the sands covers a zone several hundred metres wide and approx. 2.5 km long. It is considered to be a result of the upwelling of thermal water along major fault structures at the edge of the Taunus: the juvenile water cooled as it rose causing dissolved constituents to precipitate out as hydrothermal deposits which impregnated the country rock (thermal spring paragenesis, Kirnbauer 1998). The mineralisation is more strongly concentrated in a few clusters and a zone with a width of a few tens of metres.

Stop 8. Pliocene lignite of the Horloff Graben (Wölfersheim Formation), ancient lignite opencast mine VII near Dorn-Assenheim. (Map sheet 1: 25000: 5619 Staden, R 3488830, H 5578785; N 50° 20.768′, E 008° 50.593′).

The Pliocene fill of the Horloff Graben is divided up into the lower clay, the main lignite horizon and the argillaceous-silty upper beds (cf. Fig. 9). The graben formed in the Miocene volcanic rocks of the south-western Vogelsberg (e.g. Leschik 1956, Janoschek 1970, Boenigk et al. 1977, Herter 1985, Dahlmann 2001a, b). The Wölfersheim Formation in the graben is underlain by Miocene lateritic weathering products (red earth with basaltic ironstone and bauxite nodules), of the Vogelsberg basalts (cf. Fig. 9; cf. Stop 3).

Sedimentation in the graben continued into the Pleistocene. The local development of moors in the Horloff flood plain and in the Wettertal valley indicate that subsidence has continued up to the present day (Kümmerle 1976, Motzka-Nöring et al. 2006).

The lignite is paleontologically characterised by the "Wetterau-Wölfersheim" macro-flora complex (Krutzsch 1988, Mai 1995), and the "Wölfersheim (Echzell)" mammal fauna in the lower clay (Tobien 1953, Dahlmann 2001a, b).

The wealth of mammal fossils found in the lower clay at the Wölfersheim and Echzell localities is stratigraphically very important (Tobien 1953, 1970, 1977, Dahlmann 2001a, b). Also very important stratigraphically are the thoroughly and repeatedly studied macro-flora and micro-flora of the Wetterau main lignite (e.g. Ludwig 1857, Kirchheimer 1934, Leschik 1956, Janoschek 1970, Brelie 1977, Herter 1985, Krutzsch 1988). The mammal fauna suggest a late Lower Pliocene age for the lower clay (end of the Lower Pliocene; Late Ruscinium, MN 15), which would correspond to an absolute age of 3.4 – 3.8 million years. The Wölfersheim fauna is one of three Ruscinium faunas found in western Central Europa, but by far the most important (Dahlmann 2001a, b). The fauna includes mastodons, *Tapirus* and *Rhinoceros*. 77 different mammals have been identified, including 56 small mammals (totalling around 5000 separate fossils; Tobien

1953, Dahlmann 2001a, b). The locality is one of the most important mammal localities in the European Tertiary. Dating the Wetterau main lignite based on macro-botanical and micro-botanical analysis failed to produce an unequivocal result. The interpretations regarding the Pliocene stratigraphic subdivision underwent frequent changes over the course of time (Ludwig 1857, Kircheimer 1934, Leschik 1956, Janoschek 1970, Boenigk et al. 1977, Herter 1985). It is now considered certain that the Wetterau main lignite is of Upper Pliocene age (Krutzsch 1988). The siderite clay in the upper sequence may correspond to the Dutch Tiglian according to palynological analysis (including some “exotic elements” such as *Sciadopitys*, *Nyssa*, *Carya*), in other words, still part of the uppermost Upper Pliocene (Krutzsch 1988).

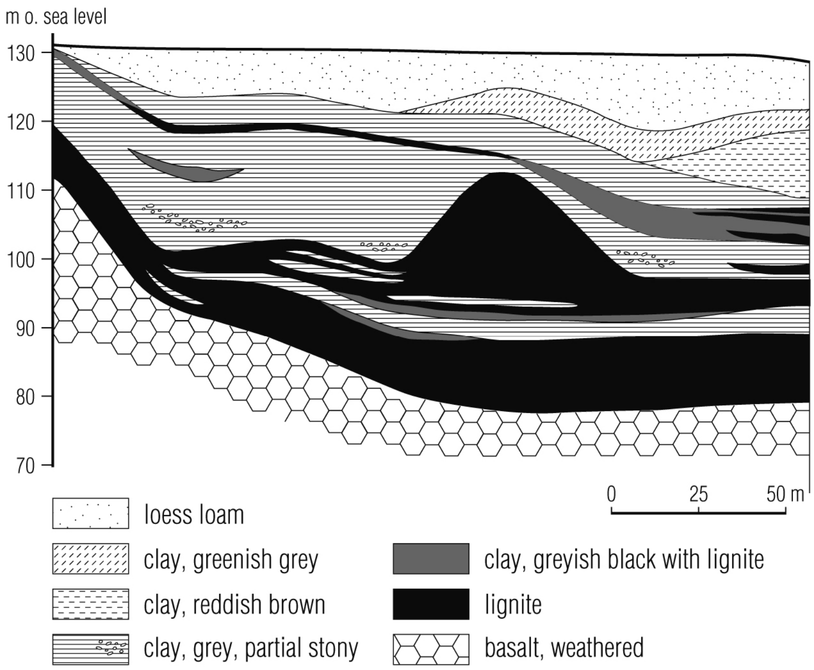

Fig. 9: Stratigraphy and depositional relationships of the Pliocene Wetterau lignite (after Schenk 1956 and Prinz-Grimm & Grimm 2002).

The macro-flora first described by Ludwig (1857) gave its name to the “Wetterau-Wölfersheim” macro-flora complex (Krutzsch 1988). It is a rich flora of mixed mesophytic forests containing quite a few Miocene species (Kirchheimer 1934, Mai 1995). Characteristic floral elements include *Nyssa*, *Pinus, Picea*, *Alnus*, *Quercus*, *Ilex*, *Carya*, *Pterocarya*, *Sciadopitys*, *Tsuga*, *Betula*, *Ulmus*, *Salix,* Taxodiaceae, *Vitis*, *Prunus*, *Castanea* and *Carpinus*. Palynological analysis reveals three climatic subdivisions in the main seam: at the base, a transitional phase from a lower minimum, a maximum in the center, and at the top, the upper flank of a maximum heading into another minimum. The maximum still contains *Tricolporopollenites edmundi*, *Gothanipollis*, *Intratriporopollenites insculptus*/*polonicus*-group, *Liquidambar*, *Keteleeria* and *Symplocos* (Krutzsch 1988).

Stop 9. Miocene basaltic and pyroclastic rocks in the Ober-Widdersheim quarry (operated by the company, Nickel) with leaf bearing pyroclastic layers.
(Map sheet 1: 25000: 5519 Hungen, R 3495780, H 5588150; N 50° 27.748′, 008° 56.202′).

The eastern face of the quarry has an approx. 400 m wide and 65 m high exposure comprising two, and locally also three, basaltic lava flows and interbedded ash tuffs and lapilli tuffs (Fig. 10). It shows the following stratigraphy from bottom to top: (cf. Ehrenberg 1979, 1986, Schenk 1964):
From the lowest (5th) level of the mine up to the 2nd level, around 40 metres of an up to 65 m thick alkali olivine basalt lava flow are exposed (aoB1). The aoB1 is largely vertically columnar jointed. Platy jointing is only seen in the immediate vicinity of “Daug bodies”, i.e. variably structured up to 30 m thick vesicular-foamy, partially brecciated zones.

The compact aoB1 grades irregularly upwards into a 6–10 m thick roof breccia. Some apophyses of compact aoB1 extend upwards into this roof breccia.

The aoB1 roof breccia is overlain in the southern part of the eastern face by an alkali olivine basalt lava flow (aoB2) which wedges out to the north and has an irregular wavy base. A single exposure in 1980 showed a 0.5–1 m wide, steeply dipping vein-like part of the aoB2 extending several metres downwards into the aoB1 roof breccia. This was not, however, a connection between aoB1 and aoB2 (different chemistry and modality; Ehrenberg 1986), but a fissure which had been filled from above with lava.

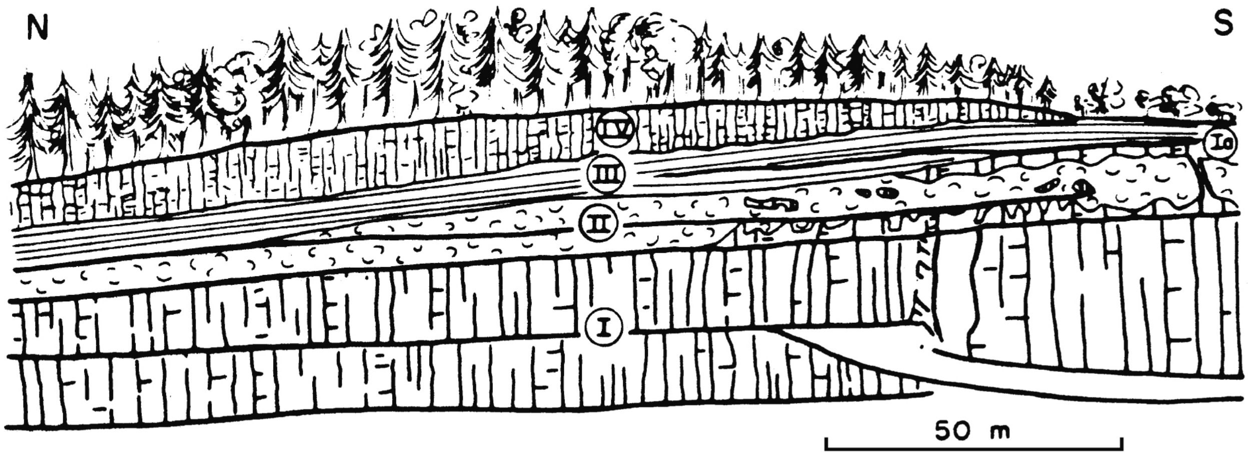

Fig. 10: Sketch of the Ober-Widdersheim working face: I = coarse columnar, compact alkali olivine basalt (aoB1), II = roof breccia of aoB1, Ia = alkali olivine basalt (aoB2), III = interbedded series of ash tuffs and lapilli tuffs, IV = basanite (from Dersch-Hansmann et al. 1999, Ebhardt et al. 2001)

The aoB2 lava – or the aoB1 roof breccia in the central northern part of the eastern face – is overlain by an up to approx. 10 m thick very well stratified interbedded sequence of ash tuffs and lapilli tuffs lying on an almost flat surface dipping slightly NNE in the outcrop. With constant dip and form, the base of the tuffs discordantly overlies the aoB1 roof breccia and the aoB2 lava flow. It also runs concordant to the stratification of the tuffs.

The tuff series consists of an interbedded sequence of largely montmorillonitised ash and lapilli horizons, which in addition to almost complete montmorillonitisation, formerly contained ± vesicular basaltic pyroclasts, some with very high concentrations of quartz grains. The lower part is dominated by fine-grained ash tuffs and lapilli tuffs (fall and surge deposits), including some beds which wedge out northwards. The lower ash tuff beds include horizons with concentrations of accretionary lapilli (<1 cm Ø). A very special feature, particularly in the lowest tuff beds, are impressions of plants (leaves, rare branches and trunks), which in some cases are not laid down conformable to the bedding. Matrix-rich, poorly sorted, coarser layers are more frequently intercalated towards the top of the tuff series (mass flow deposits), and have fabrics with clear grading (inverse as well as normal).

The volcaniclastic sequence is overlain by a basanite lava which baked the underlying tuffs to a depth of up to 1 m, giving rise to intense red coloration and small columnar jointing in parts.

An intensely montmorillonitised zone runs approximately north-south through the centre of the quarry, and is assumed to follow the line of a fault because drilling revealed that the base of the aoB1 lava lies more than 30 m deeper to the east of this line than to the west.

Interpretations: Whilst Schottler (1921, 1937) interpreted the sequence to indicate surface volcanism, and the thick aoB1 lava as a "shallow spill-over dome above the mouth of the conduit", Schenk (1964) came to the conclusion that the aoB1 was intruded into the stratified tuffs ("subfusion"). Some of these tuffs are interpreted to have been incorporated within the intruding molten rock ("Daug bodies"), or led to the development of "subfusion breccias" at the base, and primarily at the roof.

The interpretation of aoB1 subfusion is contradicted by the flat boundary between the stratified tuffs and the roof breccia of aoB1 and aoB2 lavas, as well as the complete absence of any contact effects in the lowermost tuff beds (unlike the uppermost tuffs which have been significantly thermally altered by the overlying basanite lava). The unit interpreted by Schenk (1964) as a subfusion breccia is actually the roof breccia of the thick aoB1 lava flow, whilst the basal surface of the stratified tuff series is a peneplanation surface formed by denudation over a wide area (Ehrenberg 1979). A hiatus in time must therefore be assumed to exist between the formation of the aoB1 lava (and locally also still the aoB2 lava) and the deposition of the tuff series, leading to the formation of soils and the growth of vegetation. This is indicated by the plant remains which are particularly rich in the lowest tuff beds, as well as by the violet coloration of the roof breccia of the aoB1 lava flow lying directly beneath the stratigraphic boundary. Numerous plant impressions (leaves, rare branches and trunks) have been found in the pyroclastites.

References

Baatz, D. (1993): Der römische Limes. Archäologische Ausflüge zwischen Rhein und Donau, 3. überarbeitete Auflage: 1–364, Berlin (Gebrüder Mann).

Becker, A., Köhler, H.-J. & Rasbach, G. (1999): Der römische Stützpunkt von Waldgirmes. – Archäologische Denkmäler in Hessen, **148**: 1–20, Wiesbaden.

Becker, A. & Rasbach, G. mit Beiträgen von Bieger, S., Brachert, T., Keller, T., Kreuz, A. & Schreiber, U. (2003): Die spätaugusteische Stadtgründung in Lahnau-Waldgirmes. Archäologische, architektonische und naturwissenschaftliche Untersuchungen. – Germania, **81**: 147–199, Mainz.

Beyschlag, F. (1897): Die Eisenerze des Vogelsberges. — Z. prakt. Geol., **1897**: 337–338, Berlin.

Birley, H. & Rupp, V. mit Beiträgen von Heimes, H. & Kreuz, A. (2008): UNESCO-Welterbe Limes. Römisches Erbe in Hessen. – 1–44, Wiesbaden (Landesamt für Denkmalpflege Hessen).

Boenigk, W., Brelie, G. von der, Brunnacker, K., Kempf, E.K., Koči, A., Schirmer, W., Stadler, G., Streit, R. & Tobien, H. (1977): Jungtertiär und Quartär im Horloffgraben/Vogelsberg. – Geologische Abhandlungen Hessen, **75**: 1–80, Wiesbaden.

Brelie, G. von der (1977): Die Mikroflora. – In: Boenigk, W., Brelie, G. von der, Brunnacker, K., Kempf, E.K., Koči, A., Schirmer, W., Stadler, G., Streit, R. & Tobien, H. (1977): Jungtertiär und Quartär im Horloffgraben/Vogelsberg. – Geologische Abhandlungen Hessen, **75**: 55–65, Wiesbaden.

Chelius, C. (1904): Eisen und Mangan im Großherzogtum Hessen und deren wirtschaftliche Bedeutung. — Z. prakt. Geol., **12** (10): 356–362, Berlin.

Clunn, T. (2001): Auf der Suche nach den verlorenen Legionen. – 1–336, 5. Auflage, Bramsche (Rasch).

Dahlmann, T. (2001a): Die Kleinsäuger der unter-pliozänen Fundstelle Wölfersheim in der Wetterau (Mammalia: Lipotyphla, Chiroptera, Rodentia). – Cour. Forsch.-Inst. Senckenberg, **227**: 1–129, Frankfurt a.M.

Dahlmann, T. (2001b): Die fossile Wirbeltierfauna von Wölfersheim. – Paläontologische Denkmäler in Hessen, **10**: 1–15, Wiesbaden.

Dersch-Hansmann, M., Ehrenberg, K.-H., Heggemann, H., Hottenrott, M., Kaufmann, E., Keller, T., Königshof, P., Kött, A., Nesbor, H.-D., Theuerjahr, A.-K. & Vorderbrügge, T. (1999): Geotope in Hessen. – In: Hoppe, A. & Steininger, F.F. (Hrsg.): Exkursionen in Hessen und Rheinland-Pfalz sowie zu naturwissenschaftlichen Beobachtungspunkten Johann Wolfgang von Goethes in Böhmen. – Schriftenreihe Dt. Geol. Ges., **8:** 69–126, Hannover.

Ebhardt, G., Ehrenberg, K.-H., Hottenrott, M., Kött, A., Leßmann, B. & Nesbor, H.-D. (2001): Geologie und Hydrogeologie des südwestliches Vogelsberges und seiner Umrahmung (Exkursion C am 19. April 2001). – Jber. Mitt. oberrhein. geol. Ver., N.F. **83**: 65–87, Stuttgart.

Ehrenberg, K.-H. (1979): The Vogelsberg Volcanism. – In: R. Brousse, W. Wimmenauer et Coll.: Le volcanisme alcalin lié aux distensions cénozoïques de l'Ouest Européen (Massif Central, Fossé Rhénan), Livret-guide d'excursion. – Sciences de la Terre, **23** (3): 32–33, 55–57, Nancy.

Ehrenberg K.- H. (1981): Ein tertiärer Vulkankrater bei Hungen-Langd (Vogelsberg). – Geol. Jb. Hessen, **109**:103–113, Wiesbaden.

Ehrenberg, K.-H. (1986): Vulkanische Bildungen im Vogelsberg. – Fortschr. Miner.,**64**, Beih. 2: 1–34, Stuttgart.

Ehrenberg, K.-H. & Hickethier, H. (1985): Die Basaltbasis im Vogelsberg. Schollenbau und Hinweise zur Entwicklung der vulkanischen Abfolge. – Geol. Jb. Hessen, **113**: 97–135, Wiesbaden.

Ehrenberg, K.-H., Fromm, K., Grubbe, K., Harre, W., Hentschel, G., Hölting, B., Holtz, S., Kreuzer, H., Meisl, S., Nöring, F., Plaumann, S., Pucher, R., Strecker, G., Susic, M. & Zschau, H.-J. (1981): Forschungsbohrungen im Hohen Vogelsberg (Hessen). Bohrung 1 (Flösser-Schneise). Bohrung 2/2A (Hasselborn). – Geol. Abh. Hessen, **81**: 1–166, Wiesbaden.

Fischer-Fabian, S. (1977): Die deutschen Cäsaren. Triumph und Tragödie der Kaiser des Mittelalters. – 1–320, München (Droemer Knaur).

Freyberg, B. von (1926): Die Tertiärquarzite Mitteldeutschlands und ihre Bedeutung für die feuerfeste Industrie. – 1–212, Stuttgart (Enke).

Friedrich-Lautz, I. (1963): Zusammensetzung und Entstehung der Brauneisenerzlagerstätten in den Tagebauen der Gewerkschaft Louise bei Merlau/Oberhessen. – Notizbl. hess. L.- Amt Bodenforsch., **91**: 277–317, Wiesbaden.

Golwer, A. (1968): Paläogeographie des Hanauer Beckens im Oligozän und Miozän. – Notizbl. hess. L.-Amt Bodenforsch., **96**: 157–184, Wiesbaden.

Harnecker, J. (1999): Arminius, Varus und das Schlachtfeld von Kalkriese. – Museum und Park Kalkriese, Schriften **1**: 7–111, Bramsche (Rasch).

Harrassowitz, H. (1921): Die Bauxitlagerstätten des Vogelsberges. – Metall und Erz, Z. Metallhüttenwesen u. Bergb., **18**, N. F., **9**: 567–577, Halle.

Harrassowitz, H. (1922): Die Entstehung der oberhessischen Bauxite und ihre geologische Bedeutung. – Z. dt. geol. Ges., **73** (6/7): 179–192, Berlin.

Harrassowitz, H. (1926): Laterit. Material und Versuch erdgeschichtlicher Deutung. – Fortschr. Geol. Palaeont., **4** (14): 253–566, Berlin.

Hollmann, E. (1909): Über Basalteisenstein des nordwestlichen Vogelsberges. – Diss. Univ. Gießen, 1–51, Düsseldorf .

Hoppe, A. & Schulz, R. (Hrsg.): Die Forschungsbohrung Vogelsberg 1996. Einblicke in einen miozänen Vulkankomplex. – Geologische Abhandlungen Hessen, **107**: 1–213, Wiesbaden.

Hottenrott, M. (1985): Palynologie und Stratigraphie im Vogelsberg mit besonderer Berücksichtigung der Tiefbohrung Salzhausen. – Geol. Jb. Hessen, **113**: 75–82, Wiesbaden.

Huckriede, R. (1960): Die Ordovic-Gerölle des hessischen Tertiärs und ihre Verwendung in einer pleistozänen Geröllkultur. – N. Jb. Geol. Paläont., Abh., **111** (2): 234–256, Stuttgart.

Janoschek, A. (1970): Jung-Pliozän und Alt-Pleistozän im Horloff-Graben (Wetterau). – Diss Univ. Gießen, 1–58, Gießen.

Jost, B. (2000): Burgruine Münzenberg. In: Mathieu, K.R. (Hrsg): Edition der Verwaltung der Staatlichen Schlösser und Gärten Hessen: Informationsbroschüren, Broschüre **9**; 3–52, Regensburg.

Kirchheimer, F. (1934): Das Hauptbraunkohlenlager der Wetterau. – Ber. wetterau. Ges. ges. Naturkde., **33**: 1–74, Hanau.

Kirnbauer, T. (1998): Jungtertiäre und rezente Mineralisationen. – In: Kirnbauer, T. unter Mitarbeit von Schneider, J. (Hrsg.): Geologie und hydrothermale Mineralisationen im rechtsrheinischen Schiefergebirge. Tagungsband zur VFMG-Sommertagung 1998. – Jb. Nass. Ver. Natkd., So. Bd. **1**: 226–236, Wiesbaden.

Klee, M. (1989): Der Limes zwischen Rhein und Main. – 1–122, Stuttgart (Theiss).

Kreuz, A. (2008): Archäobotanische Großrestuntersuchungen zu den Jahrhunderten um Christi Geburt im Lahntal. – In: Schnurbein, S. von et al.: Archäologische Ausgrabungen der Römisch-Germanischen Kommission im Mittleren Lahntal. – Römisch-Germanische Forschungen, Frankfurt am Main, 2008/09 (in press).

Krüger, H. (1994): Die altpaläolithische Geröllgeräte-Industrie der Münzenberger Gruppe in Oberhessen. – Materialien Vor- und Frühgeschichte Hessen, **10**: 1–171, Wiesbaden.

Kümmerle, E. (1981): mit Beiträgen von Abel, H., Beurer, M., Blum, R., Scharpff, H.-J., Schrader, L., Schricke, W., Strecker, G. & Wiegand, K.: Erl. geol. Kt. Hessen 1: 25000, Bl. 5518 Butzbach, 214 S., Wiesbaden (Hessisches Landesamt für Bodenforschung).

Leschik, G. (1956): Die Entstehung der Braunkohle der Wetterau und ihre Mikro- und Makroflora. – Palaeontographica, **B 100**: 26–64, Stuttgart.

Liebrich, A. (1892): Bauxit. – Ber. oberhess. Ges. Natur u. Heilk., **28**: 57–98, Gießen.

Ludwig, R. (1859–1861): Fossile Pflanzen aus der ältesten Abtheilung der Rheinisch-Wetterauer Tertiär-Formation. – Palaeontographica, **8** (2–5. Lfg.): 39–154, Cassel.

Mai, D.H. (1995): Tertiäre Vegetationsgeschichte Europas. Methoden und Ergebnisse. – 1–691, Jena – Stuttgart – New York (G. Fischer).

Motzka-Nöring, R., Hottenrott, M., Ehrenberg, K.-H., & Kowalzcyk, G. (2006): Geologische Karte von Hessen 1: 25000, Blatt 5619 Staden, Wiesbaden (Hessisches Landesamt für Umwelt und Geologie).

Münster, H. (1905): Die Brauneisenerzlagerstätten des Seen- und Ohmtales am Nordrand des Vogelsgebirges. Ein Beitrag zur Kenntnis der Basalteisensteine. – Z. prakt. Geol., **13** (6/7): 242–258, Berlin.

Plank, A. (1910): Petrographische Studien über tertiäre Sandsteine und Quarzite. – Ber. oberhess. Ges. Natur- u. Heilkde, naturwiss. Abt., N.F., **4**: 5–43, Gießen.

Pörtner, R. (1962): Mit dem Fahrstuhl in die Römerzeit. Städte und Stätten deutscher Frühgeschichte: 1–447, Gütersloh (Signum).

Prinz-Grimm, P. & Grimm, I. (2002): Wetterau und Mainebene. – Sammlung Geologischer Führer, **93**: I–IX + 1–167, Berlin, Stuttgart (Borntraeger).

Schallmayer, E. (2005a): Neue Forschungen am Limes in Hessen. – Denkmalpflege und Kulturgeschichte, **3**-2005: 17–22, Wiesbaden.

Schallmayer, E. (2005b): Der Obergermanisch-Raetische Limes. Von der römischen Reichsgrenze zum UNESCO-Weltkulturerbe. – Denkmalpflege & Kulturgeschichte, **3**-2005: 4–7, Wiesbaden.

Schellmann, W. (1966): Die Bildung von Roterde und Bauxitknollen im Vogelsberg. – N. Jb. Miner., Mh., **11**: 321–341, Stuttgart.

Schenk, E. (1956): Erosion und Sedimentation im Hauptbraunkohlenlager der Wetterau. – Notizbl. hess. L.-Amt Bodenforsch., **84**: 328–355, Wiesbaden.

Schenk, E. (1964): Die geologischen Erscheinungen der Subfusion des Basaltes. – Abh. hess. L.-Amt Bodenforsch., **46**: 31 S.; Wiesbaden.

Schlüter, W. & Wiegels, R. (1999) (eds.): Rom, Germanien und die Ausgrabungen von Kalkriese. Internationaler Kongress der Universität Osnabrück und des Landschaftsverbandes Osnabrücker Land e.V. vom 2. Bis 5. September 1996 – Kulturregion Osnabrück, **10** (Sonderausgabe) [zugleich: Osnabrücker Forschungen zu Altertum und Antike-Rezeption, **1**]: 5–740, Osnabrück (Universitätsverlag Rasch).

Schmidt, H. & Zulauf, G. (1991): Geomagnetische Anomalien im Bereich eines tertiären Vulkankraters bei Hungen-Langd (Vogelsberg). – Geol. Jb. Hessen, **119**: 229–233, Wiesbaden.

Schottler, W. (1921): Erläuterungen zur Geologischen Karte von Hessen 1: 25000, Blatt 5519 Hungen, 107 S., Darmstadt (Hessische Geologische Landesanstalt).

Schottler, W. (1937): Der Vogelsberg. – Notizbl. hess. geol. L.-Anst., (V) **18**: 3–86, Darmstadt.

Schwarz, T, (1988): Laterit im Vogelsberg (Hessen): Bauxitkonkretionen und umgelagerte Roterde. – Bochumer geol. u. geotechn. Arb., **29**: 179–183, Bochum.

Schwarz, T. (1997): Lateritic bauxite in central Germany and implications for Miocene palaeoclimate. – Palaeogeography, Palaeoclimatology, Palaeoecology, **129**: 37–50; Amsterdam.

Söllner, M. (1965): Im Trockenmeer der Wetterau. Erdkundlich-geschichtlicher Wanderführer: 1–120, Münzenberg (Gratzfeld).

Stegemann, W. (1964): Zur Datierung der Rockenberger und Ostheimer Schichten in der Wetterau and Allgemeines zur Sporenstratigraphie im Chatt/Miozän Hessens. – Notizbl. hess. L.-Amt Bodenforsch., **92**: 139–153, Wiesbaden.

Struve, W. (1975): Die ältesten Fossilien Hessens. – Natur und Museum, **105** (9): 268–282, Frankfurt a.M.

Tobien, H. (1953): Die oberpliozäne Säugetierfauna von Wölfersheim (Wetterau). – Z. dt. geol. Ges., **104**: 191, Hannover.

Tobien, H. (1970): Biostratigraphy of the mammalian faunas at the Plio-Pleistocene boundary in Middle and Western Europe. – Palaeogeogr., Palaeoclimat. & Palaeoecol., **8**: 77–93, Amsterdam.

Tobien, H. (1977): Fauna. – In: Boenigk, W., Brelie, G. von der, Brunnacker, K., Kempf, E.K., Koči, A., Schirmer, W., Stadler, G., Streit, R. & Tobien, H. (1977): Jungtertiär und Quartär im Horloffgraben/Vogelsberg. – Geol. Abh. Hessen, **75**: 65–68, Wiesbaden.

Tobien, H. (1963): *Dorcatherium* KP. und *Heteroprox* ST (Artiodactyla, Mamm.) aus der miozänen Kieselgurlagerstätte von Beuern im Vogelsberg (Kr. Gießen). – Notizbl. hess. L.-Amt. Bodenforsch., **91**: 7–15, Wiesbaden.

Vogt, M. (2001): Ruinen und die Aura der Geschichte. Begegnungen mit Ruinen in Hessen. In: Sparkassen-Kulturstiftung Hessen-Thüringen, Landesamt für Denkmalpflege Hessen (Hrsg.): 5–115, Frankfurt am Main, Wiesbaden.

Wenz. W. (1921): Das Mainzer Becken und seine Randgebiete. – 1–351, Heidelberg (W. Ehrig).

Weyl, R. (1980)(Hrsg.): Geologischer Führer durch die Umgebung von Gießen. 2. Aufl. neu bearb. v. F. Stibane. – 1–193 S., Gießen (Mittelhess. Druck- u. Verlagsgesellschaft).

Wigg, A. (1999): Neu entdeckte halternzeitliche Militärlager in Mittelhessen. – In: Schlüter, W. & Wiegels, R. (eds.): Rom, Germanien und die Ausgrabungen von Kalkriese. – Internationaler Kongress der Universität Osnabrück und des Landschaftsverbandes Osnabrücker Land e.V. vom 2. Bis 5. September 1996 – Kulturregion Osnabrück, **10** (Sonderausgabe) [zugleich: Osnabrücker Forschungen zu Altertum und Antike-Rezeption, **1**]: 419–436, Osnabrück (Universitätsverlag Rasch).

Wirtz, R. (1972): Beitrag zur Kenntnis der Paläosole im Vogelsberg. – Abh. hess. L.-Amt Bodenforsch., **61**: 159 S., Wiesbaden.