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AND SURROUNDING AREAS

Special conference on

"Paleoweathering and Paleosurfaces in the Ardenne-Eifel region"

at
Preizerdaul (Luxembourg)
on 14 to 17 may 2003

Field trip guides

F. Quesnel, coordinator

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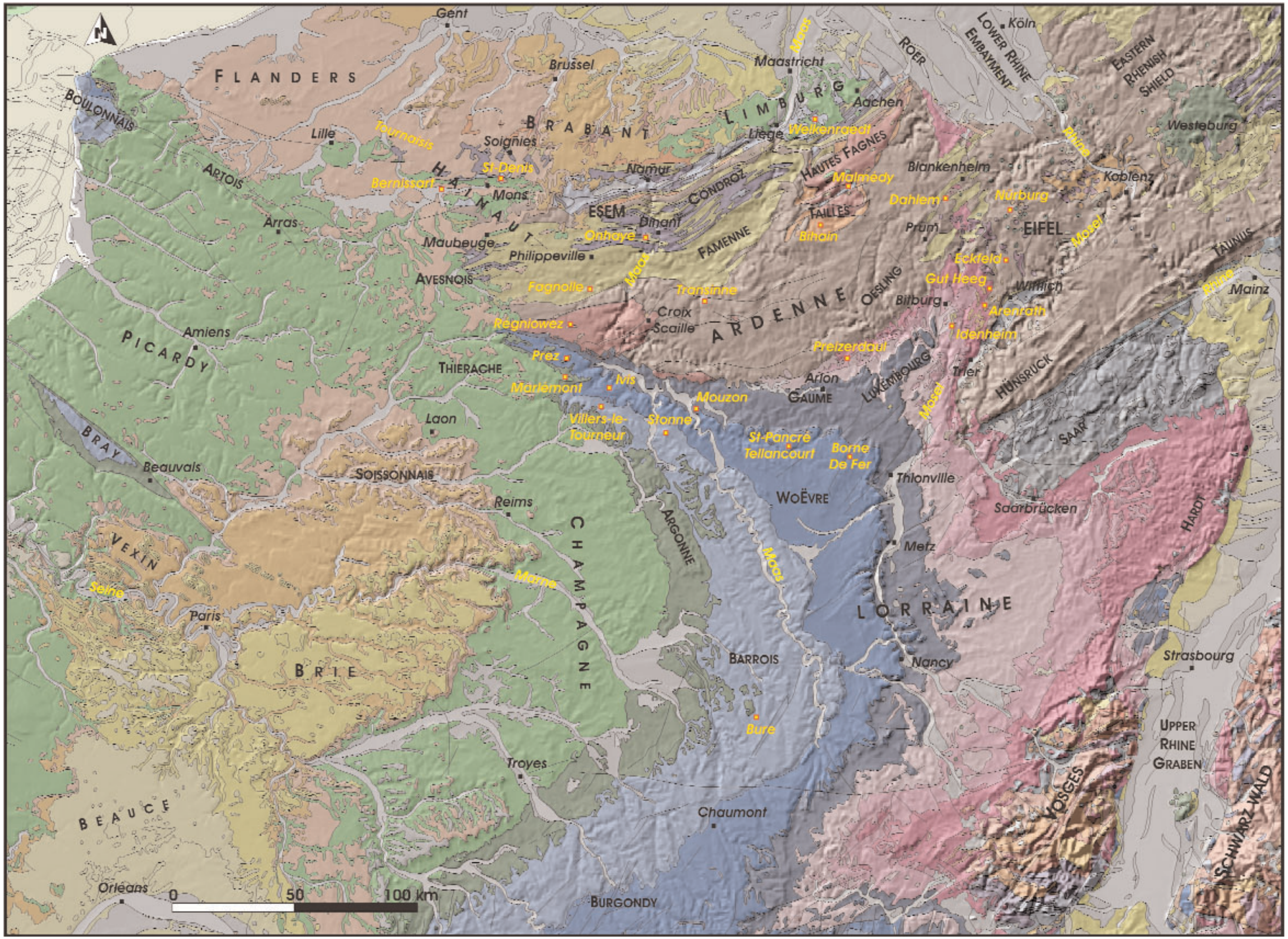

Location of the field trips stops and other paleoweathering features on the Geological map of the Ardenne-Eifel region and its borders. Digital geologic 1/1,000,000 map of France upon the European DEM (500 m step). © BRGM

Field Trip I: May 16, 2003, morning
Meso-cenozoic paleoweathering of the Haute-Lesse area (Ardenne – Belgium)

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The Haute-Lesse area is located in the Western part of the Belgian Ardenne.

We suggest to visit 2 quarries (**Fig. 1**). The first one outcrops the **un**weathered rocks near the Lesse river. The second one outcrops the weathered rocks (saprolite) on the plateau.

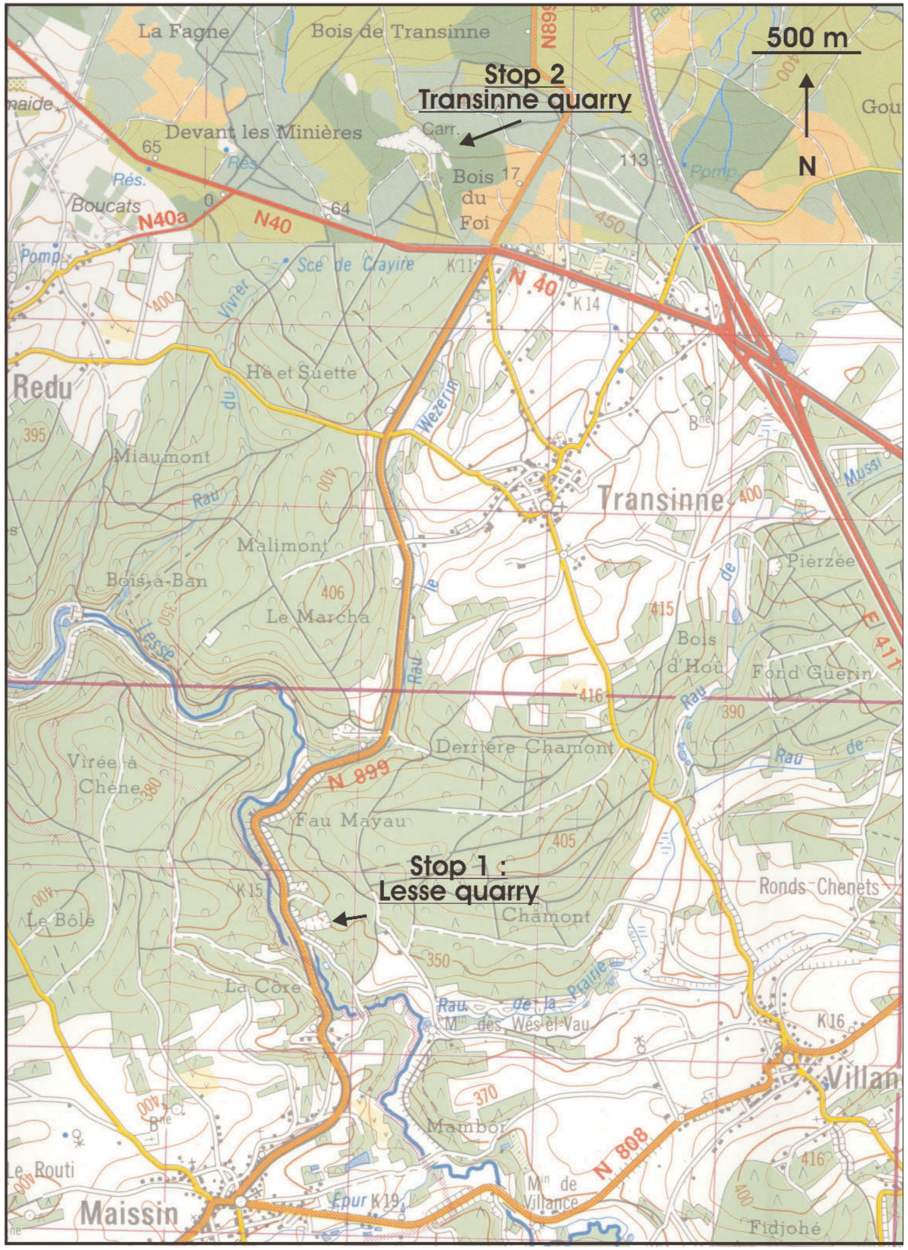


Fig. 1.- Location of the 2 stops in the Haute-Lesse area (from Belgian topographic maps - IGN 59 and 64).

STOP 1. Lesse quarry: the unweathered rocks

The old quarry (abandoned since the 1960's) is located near the Lesse river (around the Maissin village) at the elevation of 330 m. It outcrops unweathered mainly schists of the late Lochkovian (Early Devonian) Oignies Formation (**Fig. 2**).

Fig. 2.- The Lesse quarry (stop 1). The unweathered rocks consist in folded and faulted blue-green schists, siltstones and sandstones. The bars and lenses are a few centimetres to several meters thick.

The unweathered rocks of the Haute-Lesse area are poorly known. The geological map of this region dates from 1895… However we can get a structural and stratigraphic summary of the unweathered rocks in Asselberghs (1946), Beugnies (1962) and Steemans (1989).

After deposition the sediments are:

- covered by kilometric Praguian to Carboniferous shales and carbonates,

- folded and faulted during the Variscan orogen (Middle to Late Carboniferous) - illitic material formed by the orogenesis is dated 339 ± 12 Ma (K-Ar apparent age).

The unweathered schists contain various proportions of a-quartz, illite, chlorite, illite-smectite mixed-layers and pyrite. The clay mineralogy probably results from intense mineralogical transformations during the burial and tectonic diagenesis. No kaolinite is found in this sediment.

In the quarry, we can distinguish the schistosity and the numerous joints, which could have been appropriate ways for the subsequent migration of the "weathering" fluids…

STOP 2. Transinne quarry : the weathered rocks

The Transinne "Les Baraques" quarry is located near the "Barrière de Transinne" (elevation ≈ 445 m). In the beginning of the 1960's no less than 12 quarries mined the kaolin in the Haute-Lesse area. The Transinne quarry is the last one in activity (**Fig. 3 and 4**). The company CBR-Heidelbergcement (1) is mining the kaolin for the white cement industry.

Fig. 3.- The transinne quarry (stop 2)... a white flash in the green of the Ardenne area...

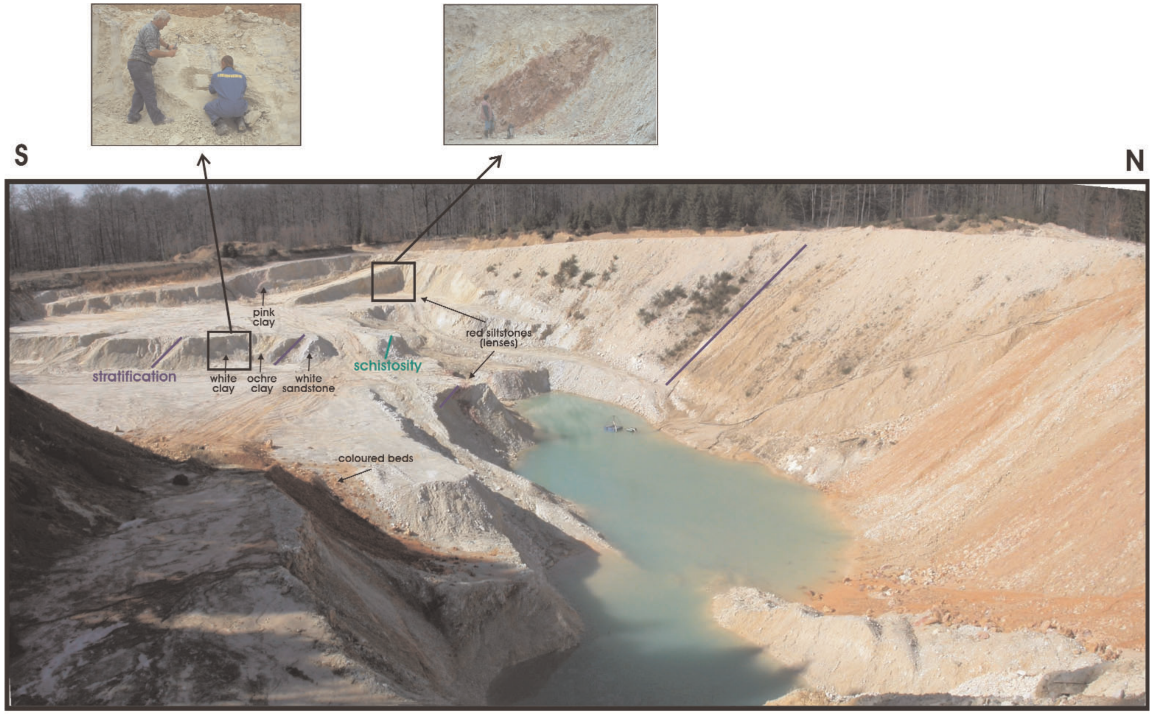


Fig. 4.- The Transinne quarry (stop 2). The quarry cuts the Northern flank of a syncline.

In the whole Haute-Lesse area the thick mined saprolites (**Fig. 5**) :

- are located above 380-390 m high, suggesting a topographic control of the weathering,

- are located near folded (25 to 60°) rocks, suggesting a tectonic control on the weathering intensity,

- affect the upper part of the Oignies Formation on the Northern part of the Redu Synclinorium, suggesting that the numerous sandstones of this part of the formation may have been active fluid drivers.

(1) CBR-Heidelbergcement Harmignies, rue Blancart, 1, 7022 Harmignies, Belgium. Director: Ir P. Koch (0032 65 32 47 48)

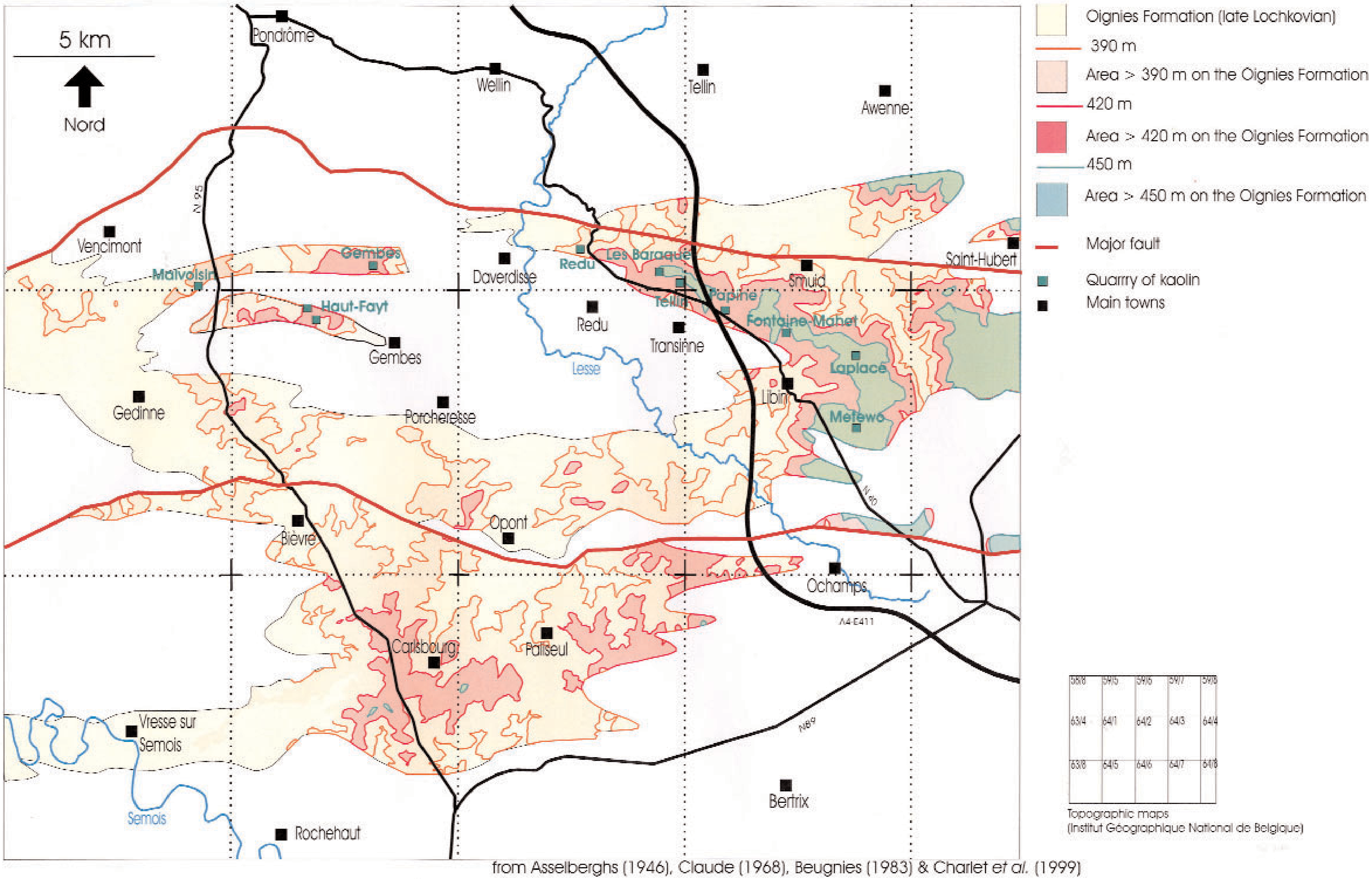
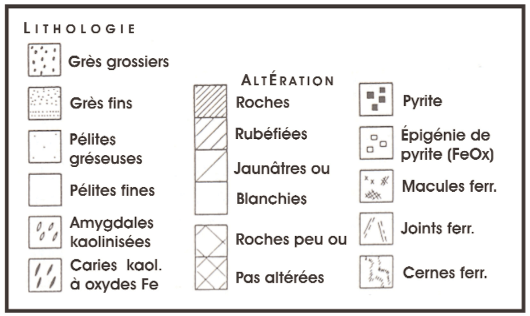


Fig. 5.- Geological setting of the kaolin quarries in the Haute-Lesse area.

The quarry cuts the Northern flank of a hectometric syncline. Main direction of the beds : N105°E / 30 to 50°S. The succession consists in numerous beds (lenses and bars) of weathered (white/ochre /yellow/pink/red) shales, siltstones and sandstones. The beds are few millimetres to several meters thick. Dupuis *et al*. (1997) give a preliminary description of the profile (**Fig. 6**). At present the quarry cuts the upper part of the profile (30 to 35 meters).



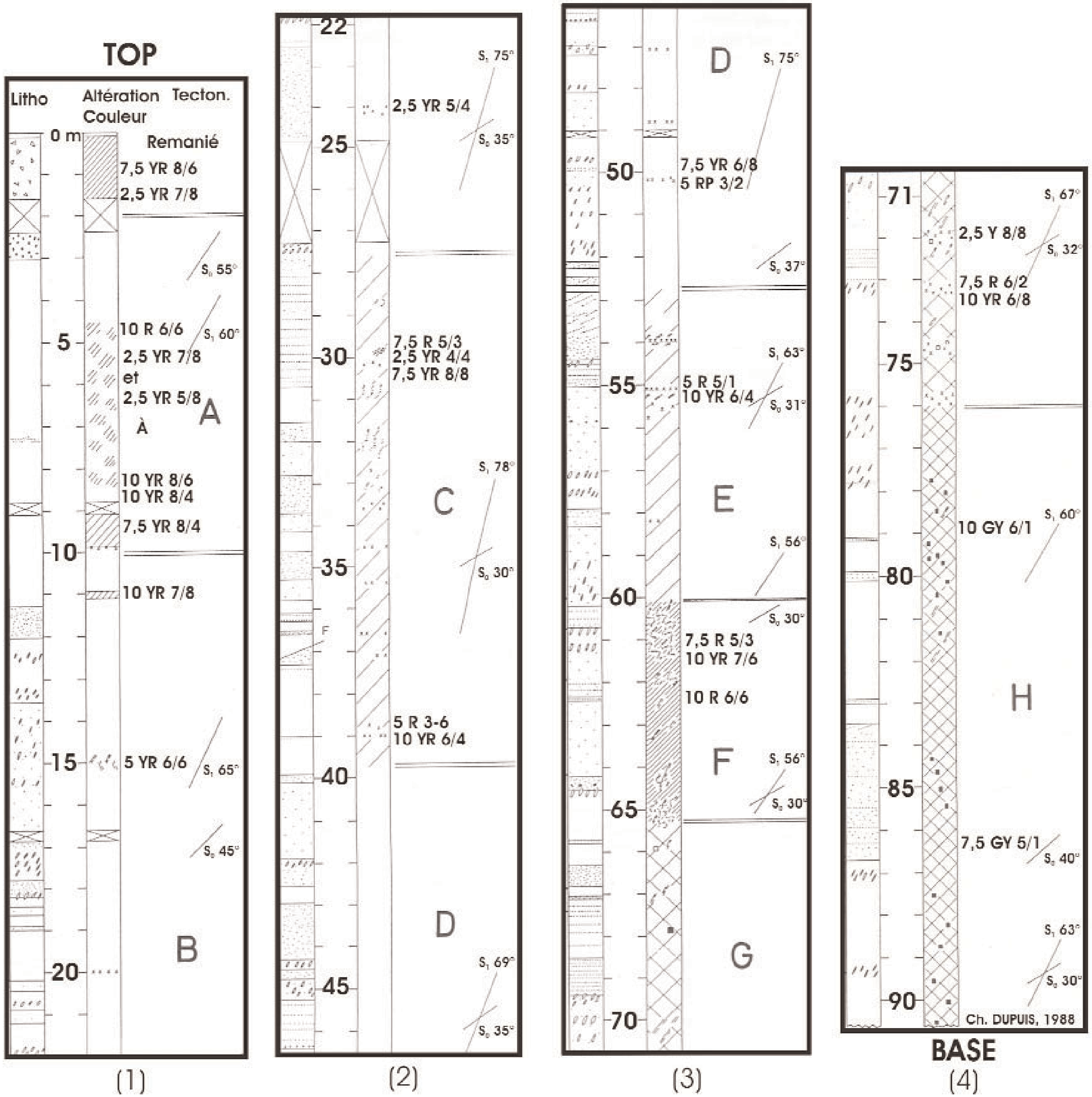


Fig. 6.- Detailed lithologies of the SGB (Service géologique de Belgique) borehole located in the Southern part of the Transinne quarry (from Dupuis et al.*, 1997). Colours from the Munsell code. S_O: stratification; S_1: schistosity. At present the Transinne quarry cuts the upper part (30-35 meters) of the profile. Unit F: front; units G and H: poorly weathered rocks.*

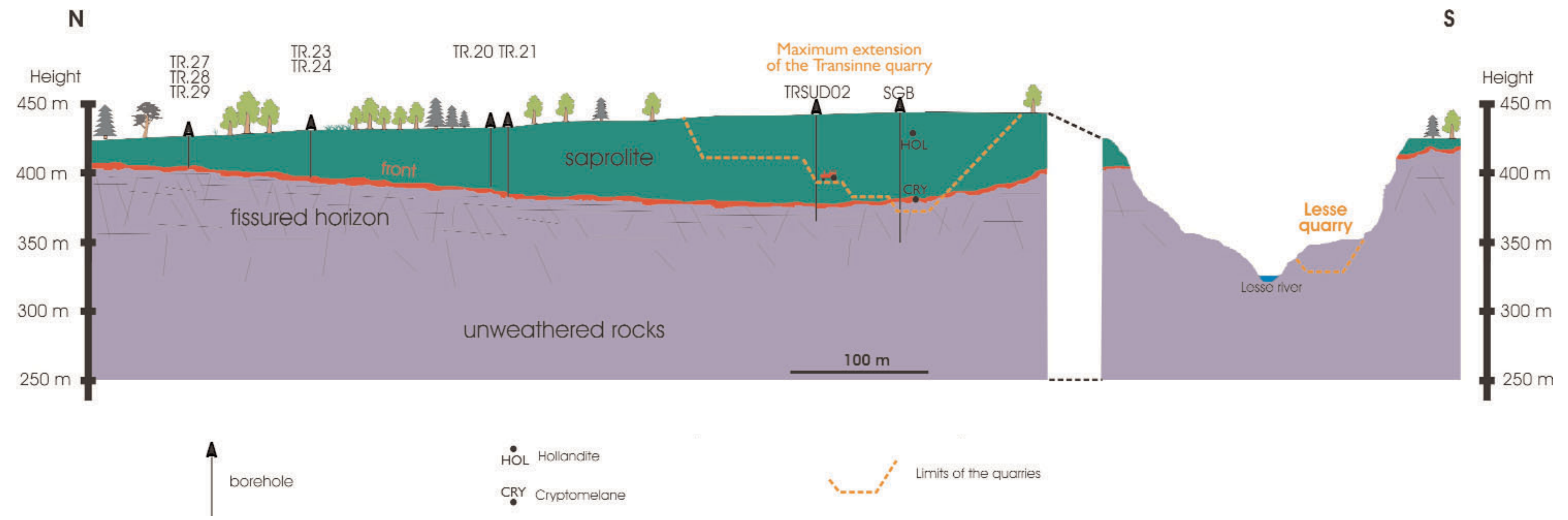


Fig. 7.- Section through the weathering profile of the Haute-Lesse area based on the 2 field trip stops. Description of the SGB borehole - see figure 6.

The Transinne regolith is a 65 m maximum thick profile (Dupuis, 1992 ; Dupuis *et al*., 1997). It generally shows a front (red siltstones) at the base (sketch of the profile in the **Fig. 7**).

The kaolin mainly contains quartz, illite, kaolinite, Fe-(hydr)oxides and locally chlorite remains. It is therefore not a true kaolin due to its poor (30 to 40 %) content of kaolinite.

The geological setting of the rocks is summarised on the **figure 8**.

The weathering phases are dated by using :

➢ K-Ar method on hollandites collected on the upper part of the profile,

➢ Paleomagnetic study on various samples collected on the upper part of the profile,

➢ Ar-Ar method on cryptomelane collected on the lowest part of the profile.

On the one hand the K-Ar apparent ages of the upper hollandites ranges from 126 ± 10 Ma to 131 ± 15 Ma (Berriasian to Barremian). Paleomagnetic results do confirm a Mesozoic weathering phase (from 120 to 170 Ma).

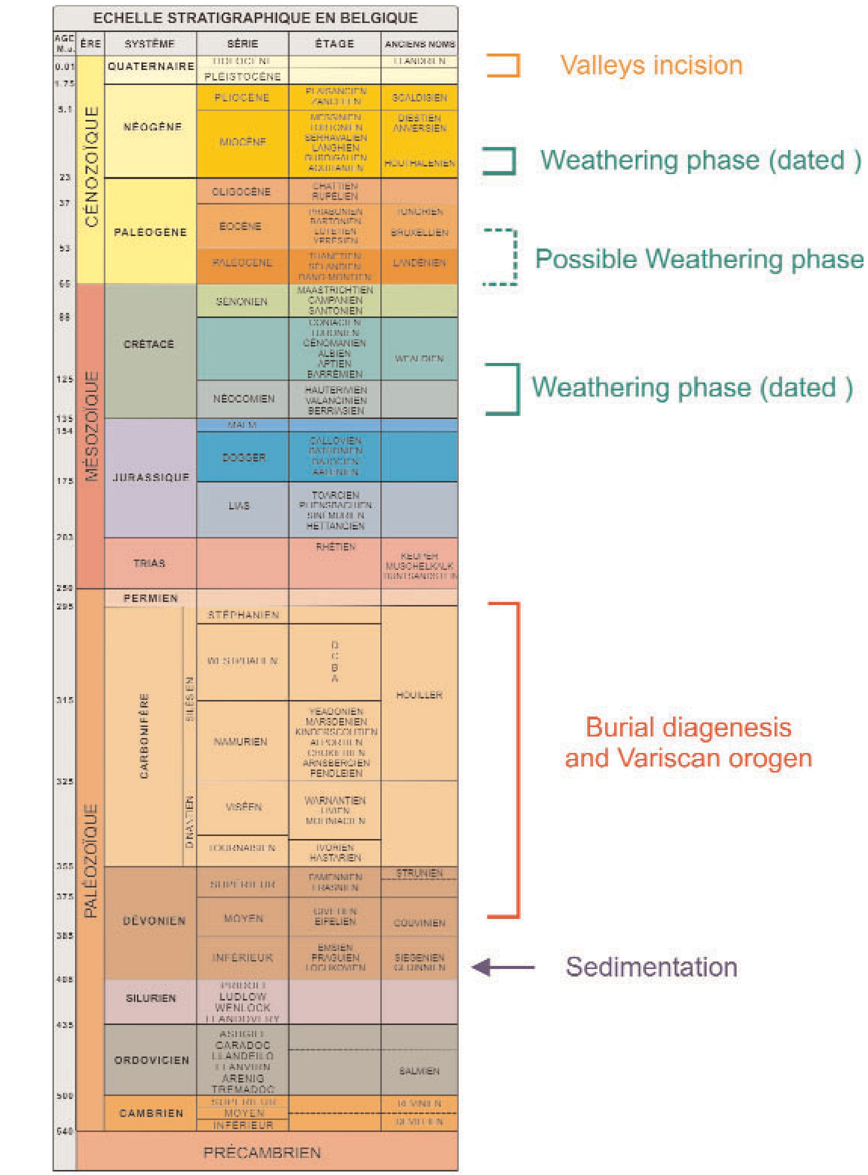


Fig. 8.- Steps of the formation of the kaolin in the Haute-Lesse area.

On the other hand the Ar-Ar apparent age of the lower cryptomelane is 21.1 ± 0.4 Ma (Early Miocene).

These results clearly suggest a polyphased weathering…A Palaeogene weathering could also have occurred, and could then be recorded in the middle part of the profile, but we currently do not have data to confirm or infirm this hypothesis (work in progress).

De Putter & Yans (2003) suggest a long-lasting weathering process, involving dominant carbonic fluids producing (and local sulphuric acid from the dissolution of pyrite), at length, a monotonous thick profile.

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Field Trip I: May 16, 2003, picnic and afternoon

The "Pierres de Stonne" and the "Borne de fer", as main features of Meso-Cenozoic paleoweathering of the Upper Lorraine and Ardennian Thiérache areas

(Ardennes and Moselle departments, France)

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The Upper Lorraine and the Ardennian Thiérache areas are located in the eastern part of France, South of the Ardenne Massif and the Luxembourg (see the **Geological map** introducing the field trip guides). The geological substratum of these areas is made of Jurassic limestones and marls. The plateaus are covered by weathering profiles whose thickness ranges from around 10 to 30 m. The weathering profiles, usually mapped as "Limon des plateaux" (LP) on the 1/50,000 geological maps, are often rich in heaps or pockets of iron ore (Voisin, 1994) - named "fer fort" in French and "bonherz" in German. They were mined before the industrial revolution and the mining of the Aalenian oolithic iron rich deposits.

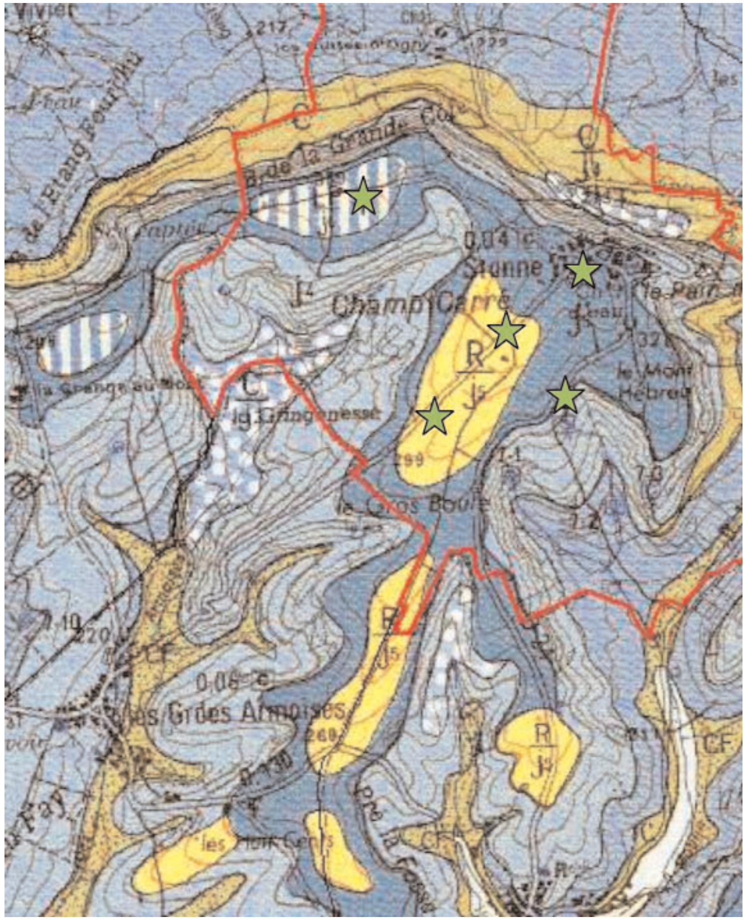
The "Pierres de Stonne" are also sprinkled over the plateaus above the weathering mantle - and residual Cretaceous deposits - and are often reworked in the Early Pleistocene fluvial deposits. Voisin (1988) mapped and studied these siliceous residual blocks whose remains are very seldom found *in situ*, in large amount and/or slabs of important size.

We suggest to have a picnic at Stonne, on the top of the hill where the "Pierre de Stonne" was defined in the 19th Century and where few blocks still crop out (**Fig. 1**). Unfortunately, it will not be possible to see any fresh section, so we shall have a look at the different facies of the "Pierre de Stonne" resting along the streets and the public square of the village.

This stop will allow discussions about all the Tertiary residual deposits of the Ardennian Thiérache - Rocroi plateau - Upper Lorraine, of which the "Pierres de Stonne" and the "Landenian" sand, sandstone and conglomerate are the most common features and were recently dated in the Régniowez section (**Fig. 2A**).

Then, we will visit 2 sections. The first one is a quarry of Bajocian formations at Ottange (**Fig. 3**), where limestones and silty marly beds are widely exposed, the latter lithology being probably the parent rock of the thick saprolite cropping out in Upper Lorraine, Luxembourg, Gaume and Ardennian Thiérache. This quarry also exposes the base of the saprolite above the Bajocian substratum and the oxidation front within the limestones. The second section is the "Borne de fer", a ferricrete cropping out in the "Audun-le-Tiche" forest – on the top of a hill whose elevation is one of the highest points of the Jurassic plateau in Lorraine – and capping a thick saprolite – around 30 m – above the Bajocian substratum (**Fig. 3**).

Acknowledgements to Geneviève Farjanel, Laurent Bailly, Véronique Pedroletti, Christian Dupuis and Roby Colbach



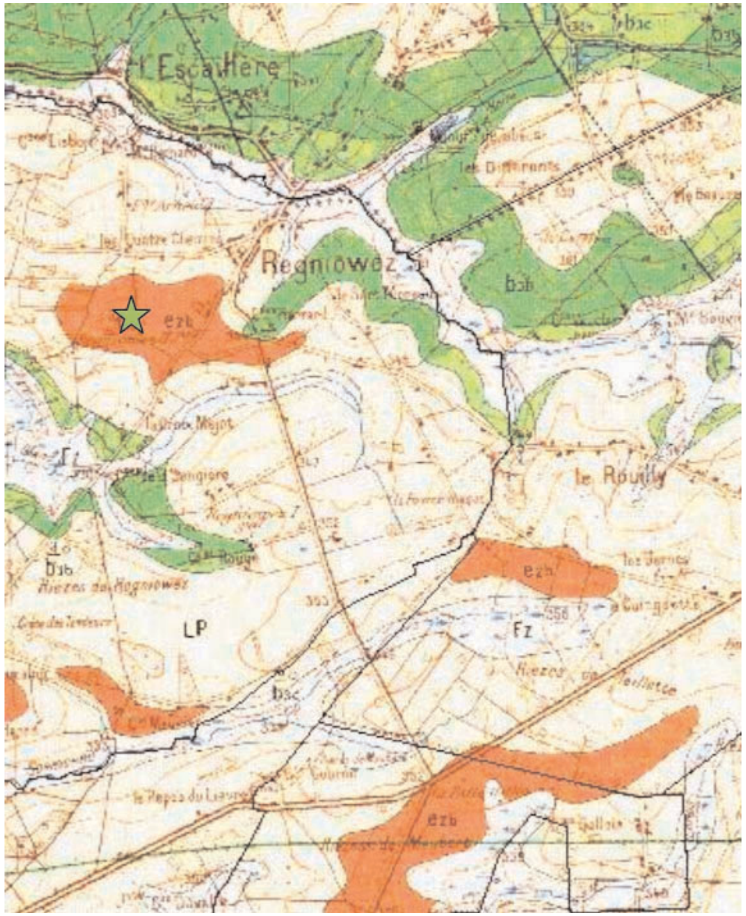


Fig. 1.- Location of the Stonne hill on the Geological map of France at 1/50,000 scale, sheet Raucourt-et-Flaba, n° 87 © BRGM – the red line corresponds to the Stonne village's border – and some isolated "Pierre de Stonne" slabs (green stars) found in fields – coordinates in the French IGN "Lambert II étendu" projection system – X: 787435.830 Y: 2508910.390; X: 787417.980 Y: 2509047.240; X: 787209.730 Y: 2508791.390; X: 787078.830 Y: 2508642.640.

Fig. 2.- A - Location of the Régniowez abandoned sand quarry (green star) – and its coordinates in the French IGN "Lambert II étendu" projection system (X: 749721.840 Y: 2550616.005) – and some Landenian outcrops – in orange – on the Geological map of France at 1/50,000 scale, sheet Rocroi, n° 52 © BRGM

Fig. 2B - Location of the Prez abandoned sand quarries (pink stars) – and their coordinates in the French IGN "Lambert II étendu" projection system (X: 745143.730 Y : 2535264.960 ; X: 745132.160 Y: 2535970.990) – on the Geological map of France at 1/50,000 scale, sheet Renwez, n° 68 © BRGM

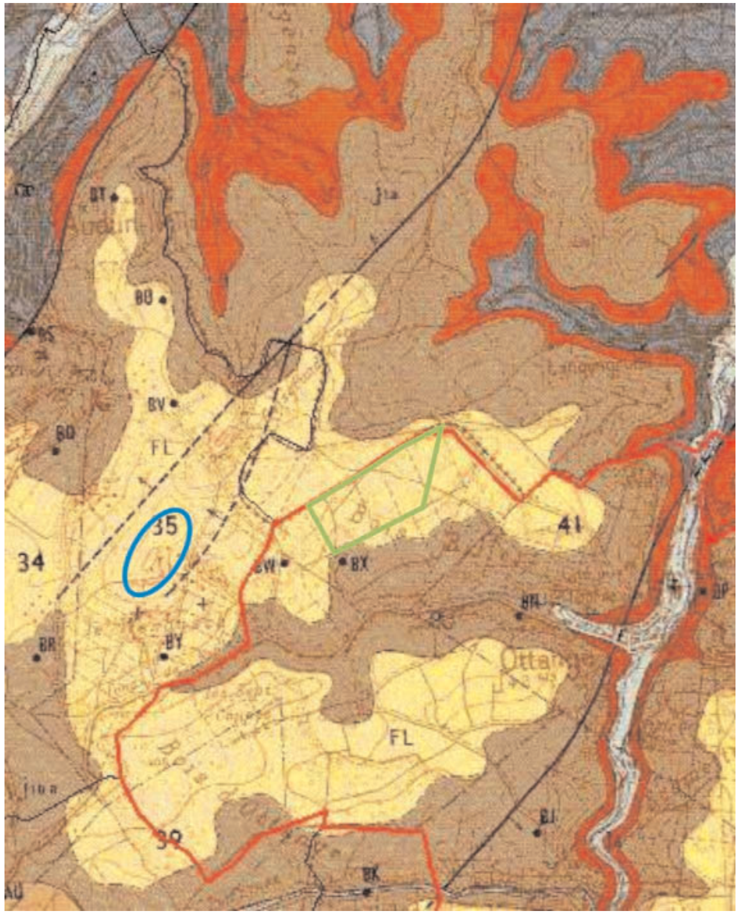


Fig. 3.- Location of the Ottange limestone quarry (X: 865218.800 Y: 2501240.930; green line) and the "Borne de fer" section (X: 863592.970 Y: 2500810.750; blue line) – coordinates in the French IGN "Lambert II étendu" projection system – on the Geological map of France at 1/50,000 scale, sheet Longwy-Audun-le-Roman, n° 113 © BRGM

STOP 1: The “Pierre de Stonne”

The “Pierre de Stonne” is a fine grained sandstone or quartzite, of light grey to beige colour, very often with an ochre to brown patina due to iron oxides. Its most striking feature is its extremely cohesiveness and hardness, so that it defies hammers and jigsaws (Voisin, 1988).

First noted around Stonne (**Fig. 1**) and named “Caillou de quartz” (Quartz boulder) by Sauvage and Buvignier in 1842, these siliceous concretions are named “Caillou de Stonne” (Stonne boulder) by Gosselet in 1880, then “Pierre de Stonne” (Stonne stone) by this author in 1890, and “Grès quartzite de Stonne” (sandstone-quartzite of Stonne) by Cayeux in 1906 (Voisin, 1988). These rocks are considered by Barrois as the equivalents to the Landenian (1) sandstone of the Paris Basin since 1879 and soon compared to the “Grès de Marlémont” (Marlémont sandstone). Other authors attribute the “Pierre de Stonne” to the Oligocene or Miocene (Hummel, 1920; Baeckeroot, 1929; Tricart, 1949; Pierre, 1999) and compare this formation to the Fontainebleau sandstone of the Paris Basin and the Braunkohlenquartzit of the Lower Rhine Embayment (Baeckeroot, 1929).

These residual - but sometimes numerous - rocks were mapped as isolated slabs and more extended outcrops during the successive geological mapping surveys from Thiérache and Upper Lorraine in France to Gaume in Belgium, Guddland in Luxembourg and Eifel and Mosel trough in Germany (Delepine, 1924; Baeckeroot, 1929; Gardet & Capot-Rey, 1929; Lucius, 1948; Désiré-Marchand, 1984; Löhnertz, 1978). Unfortunately, many interesting occurrences have disappeared following constant exploitation of the formation to reinforce the bed of roads and lanes, the angles of barns and farms and first of all to build Neolithic dolmens.

The “Pierre de Stonne” is defined by Cayeux (1906) as a quartzite-sandstone, of which the quartz are unequigranular, angular or rounded, not sorted. The quartz grains exhibit irregular secondary overgrowths and the cement is made of very fine quartz, with a little opal here and there. Cayeux also remarks some typical features: the very frequent hillocky surface of the Landenian sandstones and some deep, uneven and dichotomous holes in the “Pierre de Stonne” which suggest roots features.

Cayeux criticizes the hypothesis of Buvignier and Gosselet who proposed an “atmospheric metamorphism” to explain the alteration of the cortex of boulders by spraying the quartz grains and then cementing the fragments. Many years later some authors write that these relics overlie some peneplains or pre-existing reliefs and are remains of previously more extended duricrusts (Baeckeroot, 1929; Tricart, 1949). Finally Bonte (1960, 1978) evokes a surficial diagenesis of any - weathered - rock or sediment existing at the site where the silicification occurred, therefore establishing a “weathering” theory to explain the origin of the “Pierre de Stonne”.

From south-western Ardenne to Thiérache and Argonne, Voisin (1981, 1988) studied and mapped the siliceous rock occurrences which crop out slightly on the SW part of the Ardenne Massif and more widely on the Cretaceous and Jurassic substrates (**Fig. 4**). He explored neither the Upper Lorraine nor the Belgium, Luxembourg and Germany, where these rocks also crop out on the same formations and also Triassic rocks. For these areas, it is useful to examine the maps and notes of Baeckeroot (1929), Gulinck & Tavernier (1948), Lucius (1948), Désiré-Marchand (1984), Kadolski *et al*. (1983) and Löhnertz (1978).

Voisin (1981, 1988) singles out by petrographic analyses the “Pierre de Stonne” *sensu stricto*, from the sandstone and conglomerate (with flints pebbles of the Cretaceous; quartzite and quartz pebbles of the Ardennian basement), the two latter formerly attributed to the “Landenian” by facies analogies (**Fig. 5 and 6**). He finds the hillocky surface and roots holes as constant features and also remarks that the different facies are very often mingled on field. He finds very useful fossil remains in Landenian sandstone near Signy-l’Abbaye (Voisin, 1981; **Fig. 7**): some rhizomes and hanging roots and some internal casts of *Phacoïdes, Avicula, Tellina pseudorostralis, Cardium basini, Avicula aizyensis*, the two latter allowing to give a marine origin and a Middle to Upper Thanetian age to the original sediment (Determinations by Michel Perreau of Paris VI University).

Voisin interprets all these siliceous relics (“Pierre de Stonne”, Landenian sandstone and conglomerate) as former sediments of different origins: alluvial silt and sand to coarse gravel, very often unsorted and without any fluvial structure preserved, marine Landenian sands, and of course some shoreline remnants which

(1) NB: The “Landenian” stage is a former and today abandoned stratigraphic term, which was subdivided in the Marine Landenian at the base and the Continental Landenian above (Gosselet, 1883; Leriche, 1929). It corresponds to the current Thanetian stage regarding the marine deposits, and to the “Sparnacian” continental formations regarding the upper deposits. The latter exhibit many weathering features and do not correspond yet to a completely defined stage by the international stratigraphic committee (see Dupuis, 2002).

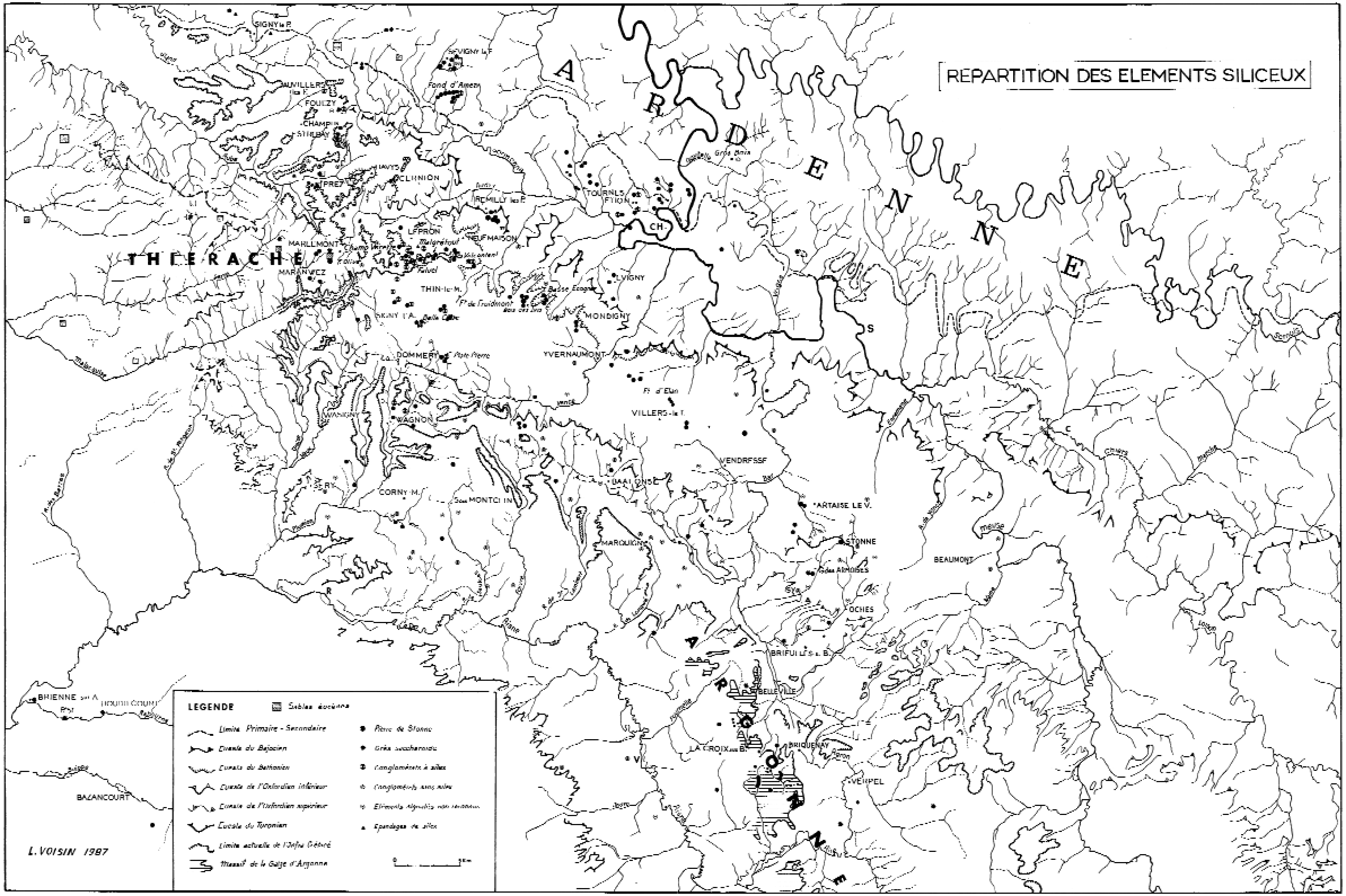
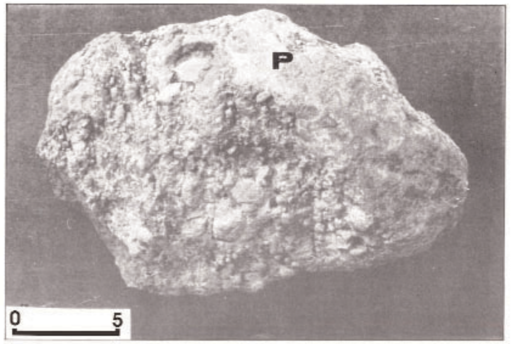
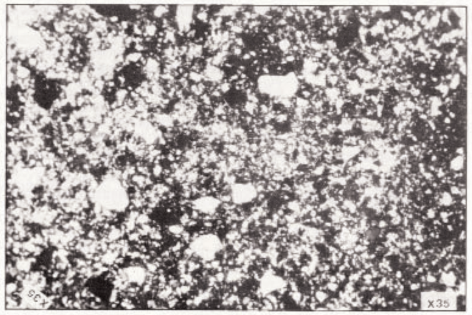


Fig. 4.- Distribution of the siliceous relics ("Pierre de Stonne", Landenian sandstone and conglomerate) in south-western Ardenne, Thiérache and Argonne (after Voisin, 1988).

"Pierre de Stonne" slab at Giraumont



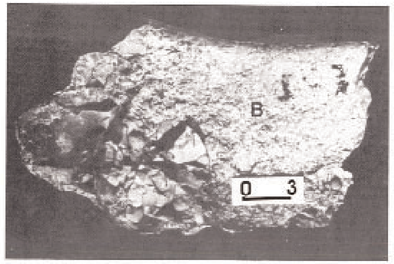
"Pierre de stonne" exhibiting a Lumpy habit; scale in cm, P: area with normal white patina



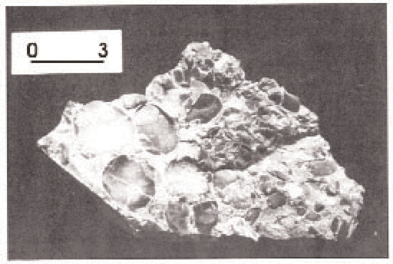
Thin section in a "Pierre de Stonne" of Sévigny-la-Forêt showing unsorted quartz grains

Fig. 5.- Macroscopic and microscopic aspects of the "Pierre de Stonne" sensu stricto *(after Voisin, 1988).*

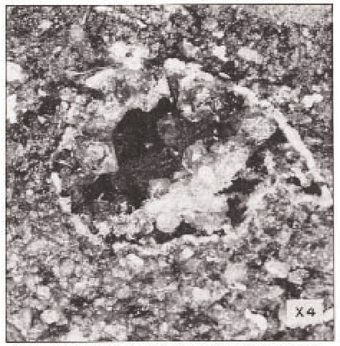
Landenian (or saccharoid sandstone) with a big and unique "root" hole



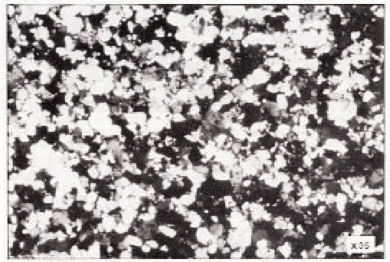
Landenian flint Puddingstone-breccia (near Estrebay) scale in cm



Landenian flint Puddingstone (near Foulzy) scale in cm



Quartz overgrowth in dissolved cast vacuum (Photo R. Behr)



Thin section in a "saccharoid" (Landenian) sandstone (Prez)

Fig. 6.- Macroscopic and microscopic aspects of the Landenian sandstone, conglomerates and breccias (after Voisin, 1988).

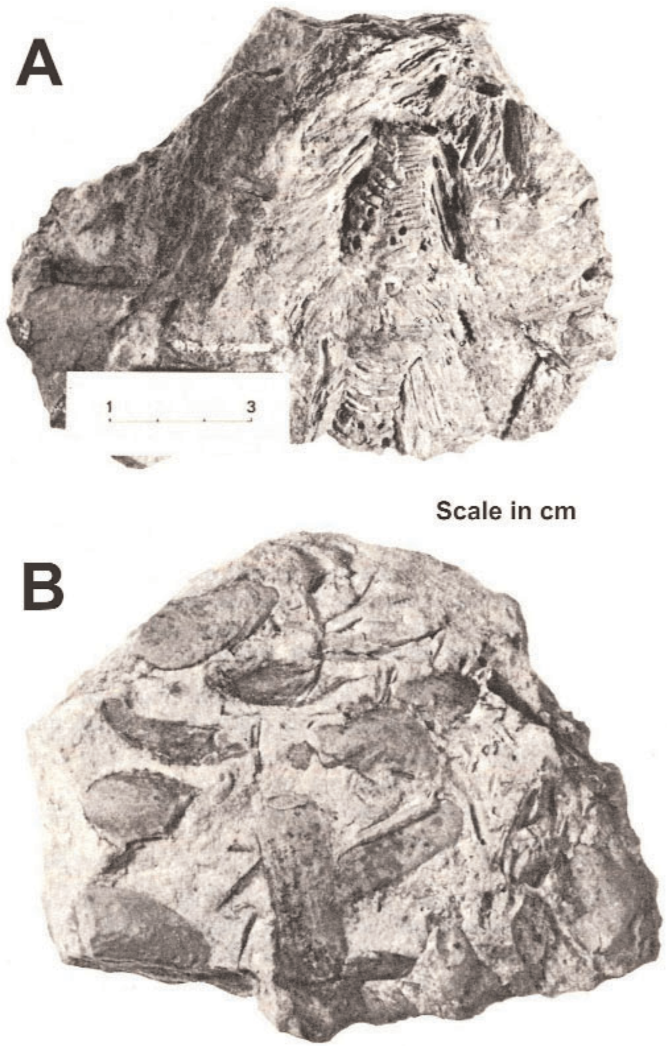


Fig. 7.- Some fossils in Landenian sandstones (after Voisin, 1981; La-Belle-Corre woods, near Signy-le-Petit).

A : Landenian sandstone with rhizomes and hanging roots, Determinations by Jean-Claude Koeniguer from Paris VI University)
B : Landenian sandstone with internal casts of Avicula Aizyensis Desh (Middle to Upper Thanetian of the Paris Basin, Determinations by Michel Perreau from Paris VI University).

he discovered and pointed, often against the Ardennian basement relief. He explains the silicification - after deposition of the whole set - by meteoric water in an area where flows slow down, due to alternating wet and dry seasons, in a continental paleoenvironment with different vegetation strata (trees, shrubs, bushes, high and low grass) thus having different root sizes. Finally, he reconstructs a paleolandscape as a “piedmont” area, rather flat, below the Ardenne relief and compares this to the landscapes described in other parts of the world for such siliceous crusts.

Comparing the Ardenne border with Australian cratons, Léon Voisin wonders in 1988 - at the end of his important and synthetic paper on the “Pierre de Stonne” - whether the development of the kaolinitic weathering profiles of the Ardenne Massif could be synchronous with the formation of the siliceous duricrusts on the piedmont below. At this moment, he has not any definitive answer, due to the absence of geochronological constraints, but solving this question is of utmost importance to understand the paleosurface development and the related geodynamics of this large area.

In 2000-2003, Quesnel and others map the saprolites, siliceous and ferruginous relics of Lorraine and Thiérache, in order to reconstruct the paleosurfaces of the north-eastern Paris Basin and its Ardennian border, then to model the paleohydrogeologic flows of the whole area (Sedimor Project). The points located by Léon Voisin - and former authors - are very often found, Voisin’s facies descriptions and petrographic analyses are confirmed. Then the “Pierre de Stonne” is also found in Champagne, South of the Thiérache, in Upper Lorraine, on the eastern part of the 1/50,000 Thionville sheet (Geological mapping of the France Project), in Luxembourg and in Germany, on Cretaceous, Jurassic and Triassic substrates (**Fig. 8**).

A particular facies soon appears to be a constant feature: the lumpy facies (“faciès grumeleux”) defined by Voisin (1988), for which he had never clearly developed any detailed explanation. In the whole area, many “Pierres de Stonne” show the current ochre patina, and exhibit a nodular to microcolumnar habit, some vertical joints filled with siliceous granules and silica cutans (**Fig. 9**). This allows suggesting a pedogenic origin for the silicification and establishing a link with the Eocene pedogenic silcretes described by Thiry (1981, 1993, 1999) in the southern Paris Basin. Microscopic examinations (**Fig. 10**) do confirm the pedogenic macro-structures, since capping are made of siliceous granules embedded in thinly laminated deposits of opaline silica and titania rich oxides. Illuviations, etched quartz and the leucoxene grains observed in the "Pierre de Stonne" are typical features of the Eocene pedogenic silcretes described by Thiry (1981, 1999), thus constraining the processes involved in the duricrust formation on the considered paleosurface in the north-eastern Paris Basin. This fact also allows proposing a Middle Eocene age for the "Pierre de Stonne". The Sparnacian dating obtained for the weathering and silicification of the "Pays de Caux Sandstone" by Dupuis & Steurbaut (1987) and Dupuis *et al.* (1998) in Varengeville, Upper Normandy, reinforces this Eocene age since this formation - also named quartzitic silcrete - is the strict equivalent to the Landenian sandstone, and crops out from Normandy to Belgium northwards and to Thiérache, the Rocroi Plateau (**Fig. 11**), Upper Lorraine and Luxembourg north-eastwards, where it is mingled with "Pierre de Stonne" on field. Note also that these Eocene silcretes, whether pedogenic ones or Landenian sandstone facies ones, are widespread in England (Summerfield and Goudie, 1980; Isaac, 1981, 1983; Summerfield, 1983), Normandy (Quesnel, 1997), the whole southern Paris Basin (Thiry and Simon-Coinçon, 1996), Brittany (Esteoule-Choux, 1983; Wyns, 1991; Thomas, 1999; Brault, 2002), Anjou-Poitou-Vendée (Wyns, 1996), upon Siderolithic formations in the Massif Central and its borders (Thiry *et al.*, 1983; Thiry & Turland, 1985; Simon-Coinçon *et al.*, 1997) and around the Morvan.

Appendice to the stop 1: The Régniowez and Prez sections (located on Fig. 2A and B)

On the Rocroi Plateau, azoic sand and sandstone are attributed since the Nineteenth century to the "Landenian" by facies analogies with the dated deposits of the northern Paris Basin and the Belgian Basin. Nevertheless none of these was ever really dated.

Some sands of this supposed Landenian formation were studied by Voisin (1996, 1999) in the Régniowez section (**Fig. 12**), on the top of which slabs and lenses are ferruginised, the iron oxides cementing little vegetal twigs in the sand. On the bottom of the section, the sand is well sorted, has a 88 µm median particle diameter and the major part of the grains is well blunt, suggesting a possible marine origin. Here Christian Dupuis observed ghosts of Mollusca casts, unfortunately unsuitable for determinations. In the upper ferruginised sands, no paleobotanic determination was possible, since neither leaf, fruit, nor stem is fossilised. The palynologic analysis was thus the only method able to date the

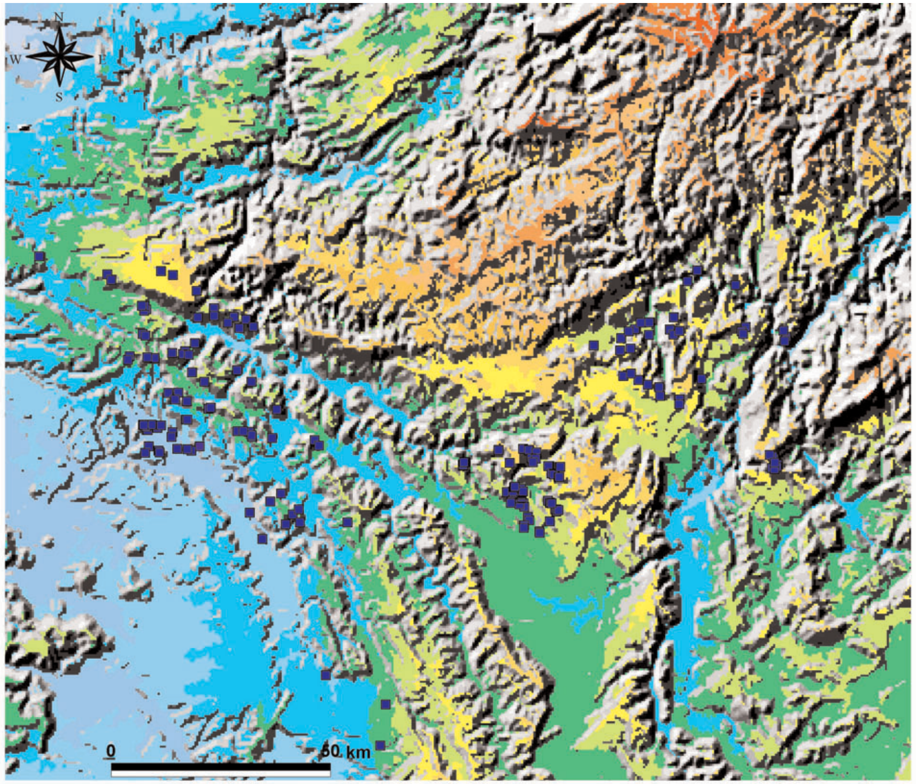


Fig. 8.- Distribution of the "Pierre de Stonne" and "Landenian" sandstone and conglomerate in Thiérache, Rocroi Plateau, Upper Lorraine and Luxembourg upon the map of the benches elevation.

initial sandy deposits. Two samples were taken from the same ferruginous level, prepared in the BRGM Laboratory and studied by Geneviève Farjanel.

Palynologic determination of the Régniowez ferruginous sand (Geneviève Farjanel and Jean-Jacques Chateauneuf)

The organic matter is made of an amorphous organic matter accompanied by very numerous vegetal tissues of yellow colour and some charcoal fragments.

The microflora is very abundant, well preserved, rather diversified and is represented by the following taxons :

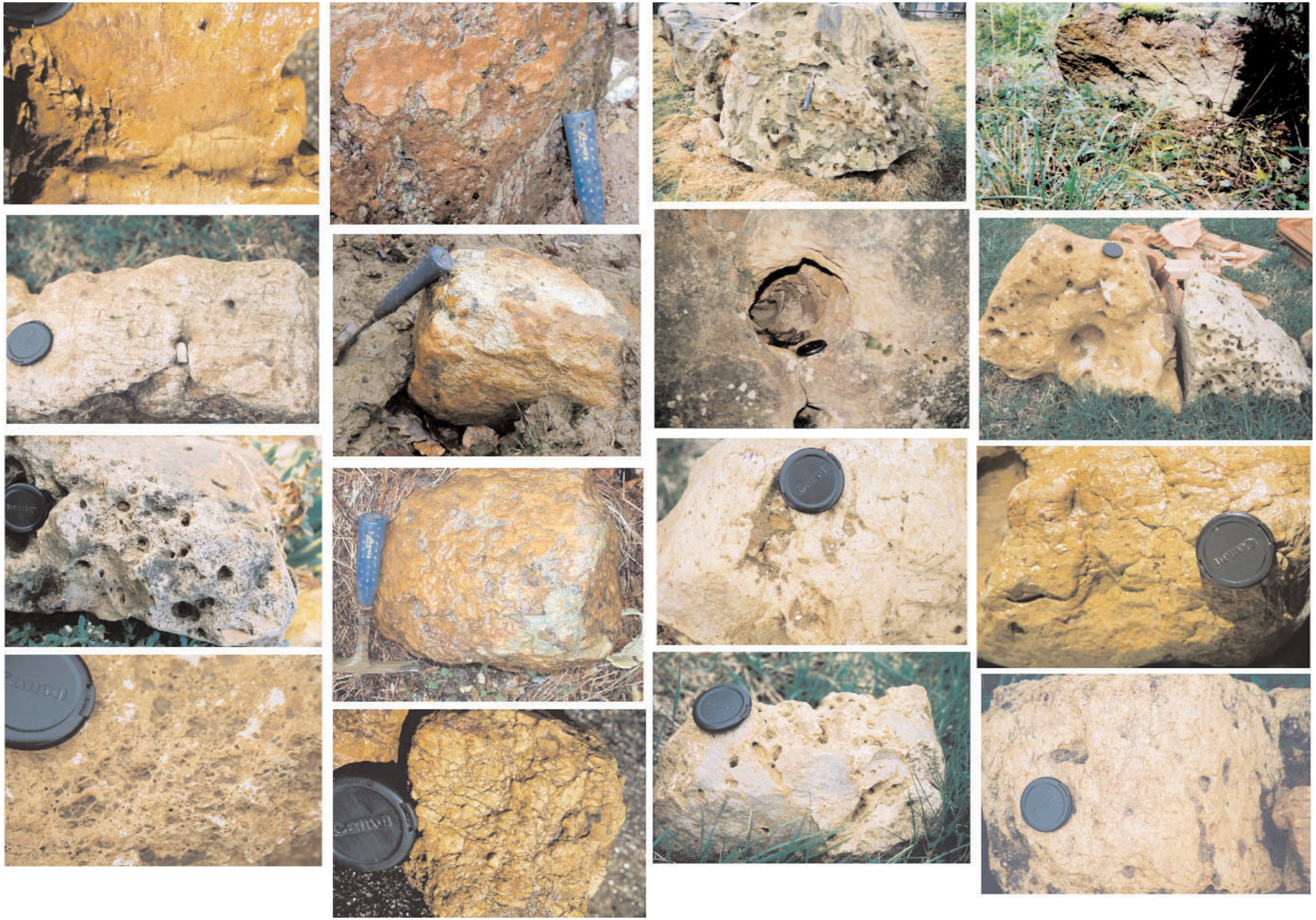


Fig. 9.- Different macroscopic aspects of the "Pierres de Stonne" and Landenian Sandstone in Upper Lorraine, Thiérache and Luxembourg.

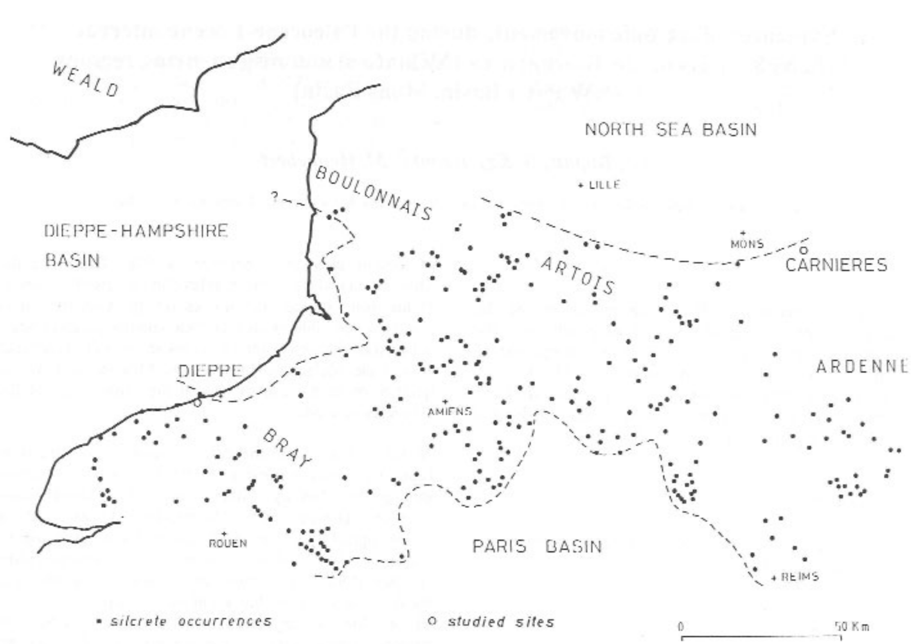


Fig. 11.- Distribution of the Eocene "quartzitic silcretes" between North Sea, Paris Basin, Dieppe-Hampshire Basin and Ardenne Massif, resulting from the weathering of the Upper Palaeocene sands (after Dupuis, 1979; Dupuis et al.*, 1997).*

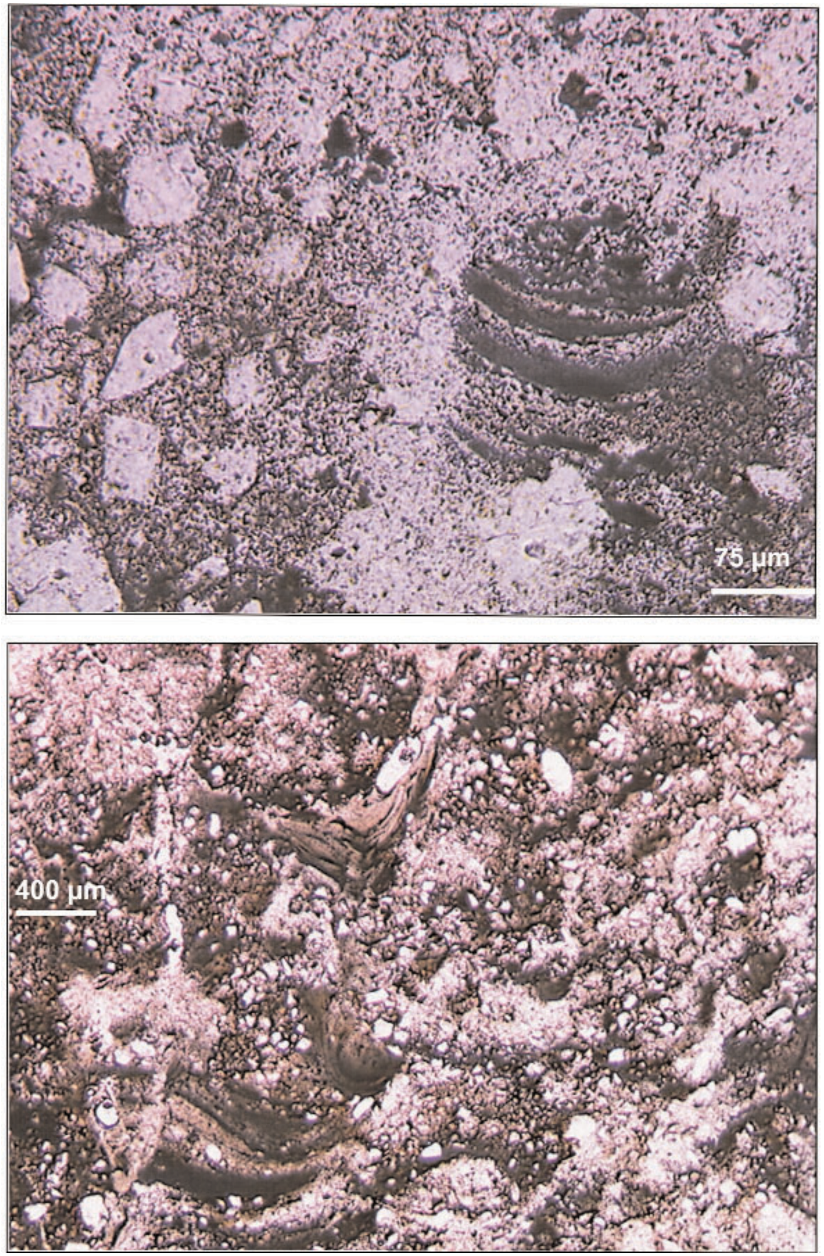


Fig. 10.- Thin section of a "Pierre de Stonne" from Longuyon, showing the typical features of pedogenic silcretes: illuviations made of siliceous granules embedded in thinly laminated deposits of opaline silica and titania rich oxides - probably leucoxene grains - and some etched quartz grains.

Spores

Cicatricosisporites dorogensis
Toroisporis torus
Monoleiotriletes minimus
Leiotriletes adriennis et *L. microadriennis*
Leiotriletes maxoides minoris
Leiotriletes microsinusoides
Leiotriletes microlepioides
Concavisporites sp.
Toroisporis postregularis
Polypodiaceoisporites verruspeciosus
Polypodiaceoisporites potoniei
Goczanisporis verrubacculatus
Punctatisporites crassiexinus
Laevigatosporites haardti
Verrucatosporites favus

Pollens

Monocolpopollenites tranquillus
Monocolpopollenites zievelensis
Arecipites variegatus
Monocolpopollenites sp.
Inaperturopollenites dubuis
Taxodiaceae
Graminidites sp.
Sparganiaceaepollenites sparganioides
Plicapollis pseudoexelsus
cf. *Diporites* sp.
Triatriopollenites engelhardtioides
Triatriopollenites platycarioides
Triatriopollenites paleobetuloides
Corsinipollenites oculis noctis
Subtriporopollenites cf. *campbonensis*
Subtriporopollenites subporatus
Triatriopollenites bituitus
Triatriopollenites sp. *(Myricaceae)*
Caryapollenites sp.
Subtriporopollenites anulatus
Subtriporopollenites constans
Polyporopollenites undulosus
Compositoipollenites minimus
Pentapollenites pentangulus
Polyporopollenites stellatus
Tricolpopollenites asper (Fagaceae)
Emmapollis pseudoemmaensis
Retitricolpites rauscheri
Retitricolpites henisensis
Tricolpopollenites librarensis
Psilatricolporites cf. *megahexactus*
Bacutricolpites variabilis
Scabratricolpites crassiexinus
Tricolpopollenites retiformis
Retitricolpites cf. ilex
Tricolporopollenites sp.
Striatricolporites sp.
Tetracolporopollenites sapotoides
Retistephanocolporites sp.

Age and paleoenvironment

The microflora is ruled by one pollen species: *Plicapollis pseudoexcelsus*; the spores are very abundant and diversified, characterising a hygrophilic environment.

The typical normapols of the Palaeocene are absent. An Upper Sparnacian age seems probable (or from the Sparnacian/Cuisian limit).

An Upper Sparnacian age is given here, thus offering a very important step to confirm a Palaeogene age for the paleosurface on the Rocroi plateau and the adjacent benches.

Another step is the Marlémont Hill on the top of which Landenian sandstone and a few "Pierre de Stonne" crop out, and the Prez abandoned sand quarry where Wealden, Albian and Landenian sand and sandstone are trapped in a karstic pocket (**Fig. 13**; see the location of these sections on the **Geological map** introducing the field trip guides).

In the north-eastern Paris Basin and the Ardenne south-western border, all these residual silcretes ("Pierre de Stonne", Landenian sandstone and conglomerates) and Sparnacian (ex continental Landenian) deposits are thus used as markers to reconstruct the geometry of the Palaeogene surface (**Fig. 14**; Quesnel *et al.*, 2002). These very well developed silicifications should not be confused with the "Meulières" (Millstones) (Ménillet, 1993), nor the sandstones of the Hautes Fagnes area, nor the poorly developed Plio-Quaternary silicifications affecting the Miocene lignitic sands of the Lower Rhine Embayment (Demoulin, 1990). Finally, it should be an interesting point of discussion to compare these silcretes with the cherts of Idenheim which we will see on the German field trip on May 17.

STOP 2: The Ottange quarry [(2)]

The Ottange quarry (located - near the Luxembourg border - on the **Fig. 3**) cuts the Bajocian limestone which exhibits among others some coralline facies and few blue-grey marl beds which are supposed to be the parent rock of the thick saprolites cropping out on the nearby plateaus. This quarry also exposes on its upper part - at around 415 m - the base of the saprolite above the Bajocian substrate and the oxydation front within the limestones (**Fig. 15**).

Some X-Ray diffraction analyses were performed on the marls (supposed parent rock) in the BRGM Laboratories and provided the following results [(3)]:

Sample Blue-grey (parent rock) bottom:

- quartz in traces to low content (~ 20%)
- calcite present (~ 50%)
- microcline in traces
- hematite in infratraces
- pyrite possible in infratraces
- clay fraction in traces to low and containing (on a 100 total):
  . smectite ~ 72%
  . chlorite ~ 6%
  . illite/mica ~ 18%
  . kaolinite ~ 4%

(2) Intermoselle SARL, Carrière d'Ottange, BP 4, F-57840, Ottange, France. Director: Bernard Kubiak (0033 382 50 50 67)
(3) the phase termed "smectite" to simplify the results presentation corresponds more probably to a mixed layer clay illite/smectite with a ~ 40% content of smectite.

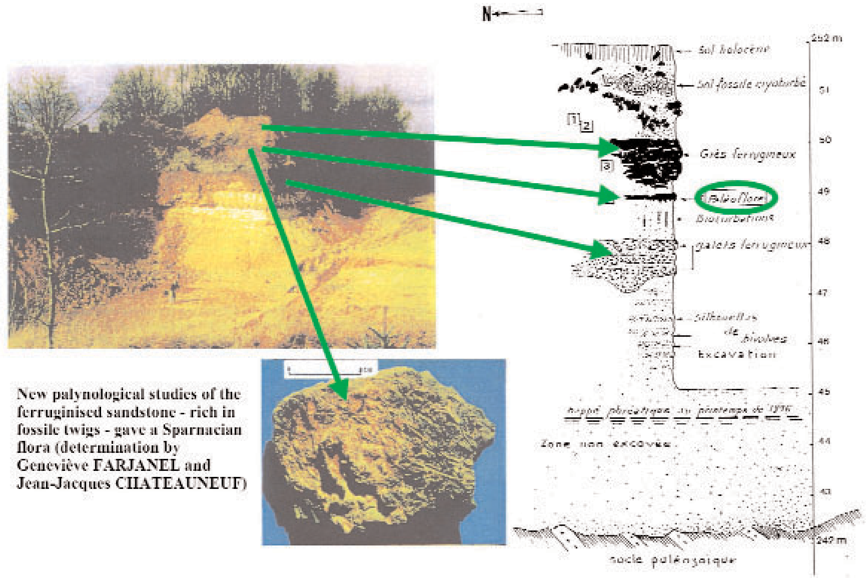


Fig. 12.- The Régniowez section, Rocroi plateau, with iron cemented sandstone on the top (after Voisin, 1996, 1999).

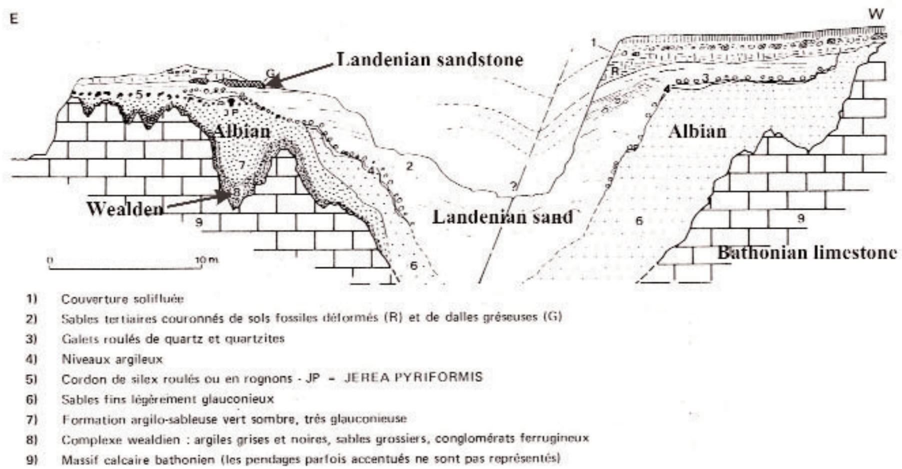


Fig. 13.- The Prez section, Ardennian Thiérache (after Voisin, 1978, 1981).

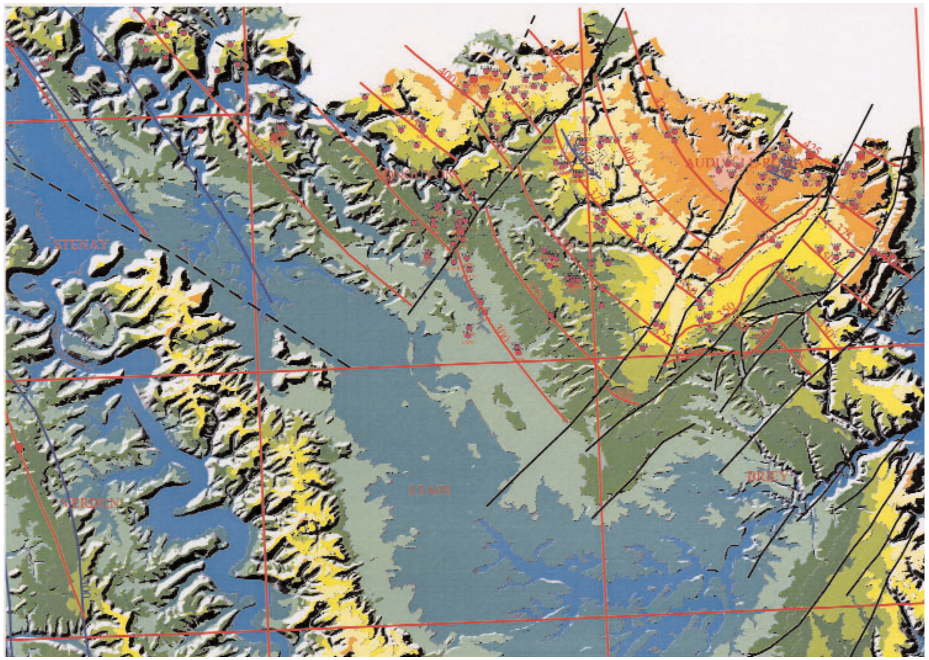


Fig. 14.- Structural map of the Infracretaceous and Palaeogene paleosurfaces in Upper Lorraine and Thierache (after Quesnel et al.*, 2002).*

Sample beige-grey (parent rock) top:

- quartz low to present (~ 30%)
- calcite low to à present (~ 30%)
- microcline in traces
- clay fraction low to present and containing (on a 100 total):
  . smectite ~ 80%
  . illite/mica ~ 18%
  . kaolinite ~ 2%

We will see on the resulting saprolites how this original mineral assemblage evolves.

Fig. 15.- Some aspects of the Ottange quarry (general and detailed photos of the quarry, the oxidation front, the parent rock of the surrounding saprolites).

STOP 3 : The “Borne de fer”

The “Borne de fer” is located south-east of Longwy, very close to the Ottange quarry, on the top of a hill at around 450 m. It was mined for its iron ore from Middle Ages to the industrial revolution in the Nineteenth century, until the Aalenian oolithic iron rich deposits - termed Minette - was discovered and mined. On the hill only saprolite and ferricrete crop out - without any rock of the Bajocian substratum (its unique outcrop is made by the quarry) - so that the thickness of the weathering profile can be deduced as being around 20 to 30 m. Note that the saprolite seems to be very thick in all this area, because the parent rocks were probably more silty and/or clayey before the weathering than westwards or eastwards. The Jurassic deposits have probably such a nature because of the structural setting (Luxembourg Trough) which was active during sedimentation (Le Roux, 1980; Muller, 1987).

No “Pierre de Stonne” was found on the hill, although existing on the benches below. The saprolite is ochre to red and can be seen beneath the trees pulled out after big storms (**Fig. 16**); it is capped by some slabs of ferruginous sandstone looking like a ferricrete, and showing a thickness of 1 to 3 m. These are made of iron oxides and quartz grains (**Fig. 16**). Some X-Ray diffraction analyses were performed on the saprolite and ferricrete from the top of the hill and provided the following results [(3)]:

Sample “Borne de fer” ferricrete

- quartz present to abundant (~ 65%)
- goethite low

Sample “Borne de fer” – ochre saprolite

- quartz in traces to low (~ 12%)
- goethite present
-clay fraction low to present and containing (on a 100 total):
. smectite ~ 10%
. kaolinite ~ 90%
. chlorite possible en traces

then possible amorphous phase, as Iron oxihydroxides (*e.g.* ferrihydrite)

Fig. 16.- Some aspects of the “Borne de fer” (general and detailed photos of the saprolite and the ferricrete).

Sample "Borne de fer" – red saprolite

- quartz present to abundant (~ 60%)
- goethite low
- clay fraction in traces to low and containing (on a 100 total):
  . kaolinite ~ 100%
  . vermiculite and/or weathered chlorite possible in traces

then possible amorphous phase, as Iron oxihydroxides (*e.g.* ferrihydrite)

These results confirm the "due to weathering" nature of the material *i.e.* show that the mineralogical content of the parent rock has been completely transformed during the processes which led to the saprolite and ferricrete. Apart quartz which seems to be inherited from the parent rock, calcite and smectite disappears and new minerals are produced: kaolinite and goethite are found, but no hematite. The latter, if ever produced, could have been changed in goethite. Note that few boreholes - with a motored auger - are planned here in July in order to check the saprolite's thickness and nature. X-Ray diffraction analyses will also be performed on the samples taken in order to study the development and intensity of the weathering processes across the profiles.

A paleomagnetic study was carried out on the "Borne de fer" ferricrete in March 2001 (Théveniaut, this volume), because this ferricrete caps a weathering profile on Jurassic silto-argilaceous formation and may correspond to a scarce remain of an old weathering event of greater importance. Paleomagnetic, rockmagnetic and petrographic analyses reveal presence of a dominant hydroxide contribution with a magnetic remanence carried by goethite.

The "Borne de Fer" ferricrete was sampled on six outcropping profiles, some having different bedding attitude. Two of them are facing each other as inclined towards a karst "pipe". One is slightly tilted, the others being horizontal. We collected 75 minicores using a portable petrol-powered drill. Cores were taken throughout the profile at 5 to 20 cm interval and in order to possibly evaluate some magnetostratigraphic between profile correlation.

All samples showed a strong contribution of goethite on the magnetization with a low and disturbed contribution of hematite. Paleomagnetic direction appeared better defined for the goethite component than for the hematite one. This result confirms the X-Ray diffraction data and thus suggests that the "Borne de fer" is not a true ferricrete *(i.e.* a ferralitic duricrust), but more likely the result of an iron rich sandstone weathering (pyrite oxidised in goethite which cements the sand).

The comparison of the derived virtual geomagnetic pole (VGP) for both component with the new apparent polar wander path (APWP) for stable Europe (Besse and Courtillot, 2002) allows relative dating of the components. The chemical remanent magnetization (ChRM) acquired during the weathering process dates the ferruginization phase. The goethite component pole (**Fig. 17**: pole B1) shows a 120 Ma age, its error circle being between 80 and 130 Ma. Few reversals were measured in the studied profiles, so that the period between 83.5 and 120.5 Ma - Long Normal Cretaceous Superchron - can be rejected. The possible age is thus ante 120.5 Ma or post 83.5 Ma. Given the regional setting, with Campanian and Maastrichtian sediments on the Hautes Fagnes, and important weathering features of the Wealden episode (Yans *et al*., this volume: Field trip I, morning), the 120-130 Ma age seems to be the most probable.

Conclusion

The "Borne de fer" thus corresponds to an old relief (inselberg) of the past - and possibly exhumed - infra Cretaceous paleosurface above a much more widely extended "glacis" whose major features are the Eocene silcretes, therefore being the Palaeogene paleosurface (**Fig. 18**). This approach can also be developed for the huge weathering profiles which cover the Ardenne plateaus (Dupuis, 1992; Voisin, 1995) and whose recent dating - obtained by isotopic tools - gives also Early Cretaceous ages (Yans *et al*. this volume). The next steps of our work will consist in obtaining more datings, in better mapping the weathering profiles and residual deposits in order to reconstruct the current geometries of the paleosurfaces (**Fig. 14**), and their initial ones. Then we intend to model the long term evolution of the landscapes (Gallagher *et al*., 1998; Rohrman *et al*., 2002; Van der Beek & Braun, 1998; Van der Beek *et al*., 1999) between each step in response to the vertical deformation of the lithosphere, the eustatic level evolution and possibly also the climatic imput (CO_2 content of atmosphere).

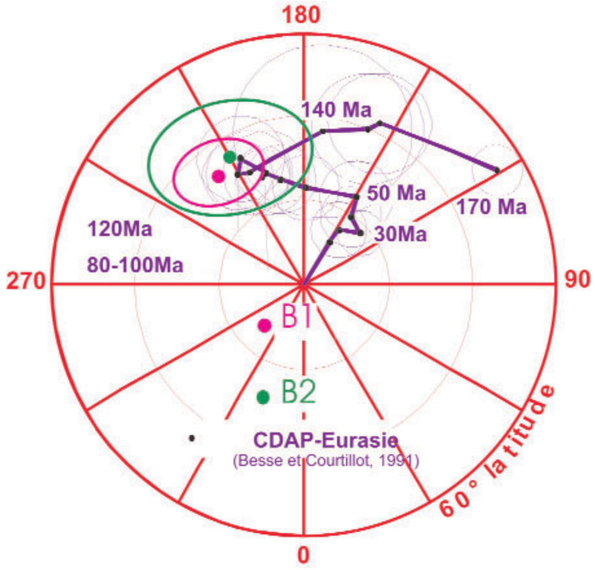


Fig. 17.- Geomagnetic Virtual Poles of the"Borne de fer" with the APWP of Eurasie of Besse & Courtillot (1991).

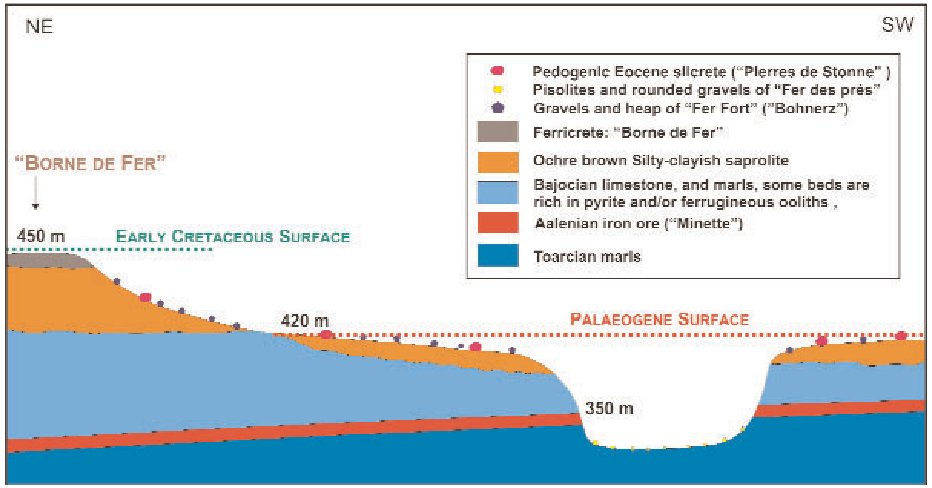


Fig. 18.- Geologic schematic cross section of the "Borne de fer" and its surrounding paleosurfaces (after Quesnel et al.*, 2002).*

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Field trip II: May 17, 2003
Cenozoic morphology of the Eifel
(SW Rhenish Shield, Germany)

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(Contributions by A. Muller [(3)], P. Felix-Henningsen [(4)])

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1 - General topic (W. Löhnertz)

The field trip wants to give an overview about the Lower Tertiary of the south-western part of the Rhenish shield, especially along the north-eastern outcrop of the Mesozoic of the Trier-Luxembourg Embayment **(Fig. 1)**. Points of interest and presented sediments are chosen by the criteria of datability and of clear correspondence between sediment and morphology around.

It is important to note that Tertiary sediments have been well known for a long time from various places in the Rhenish shield. But if there are immense and very homogeneous layers of Devonian in the base, it is not possible to exclude a tectonic layering with certainty. Corresponding Tertiary sediments at the base of Pleistocene layers are normally explained by post sedimentary tectonics. The position of the sediments chosen for the field trip - just in front of the Buntsandstein cuesta, partly on Devonian partly on Buntsandstein, respectively on the cuesta of the Upper Muschelkalk offers no possibility to explain by tectonics (1) the high difference in elevation between the planation surface on top of the Buntsandstein and the Eocene valley nor (2) the Eocene at the base of Pleistocene layers.

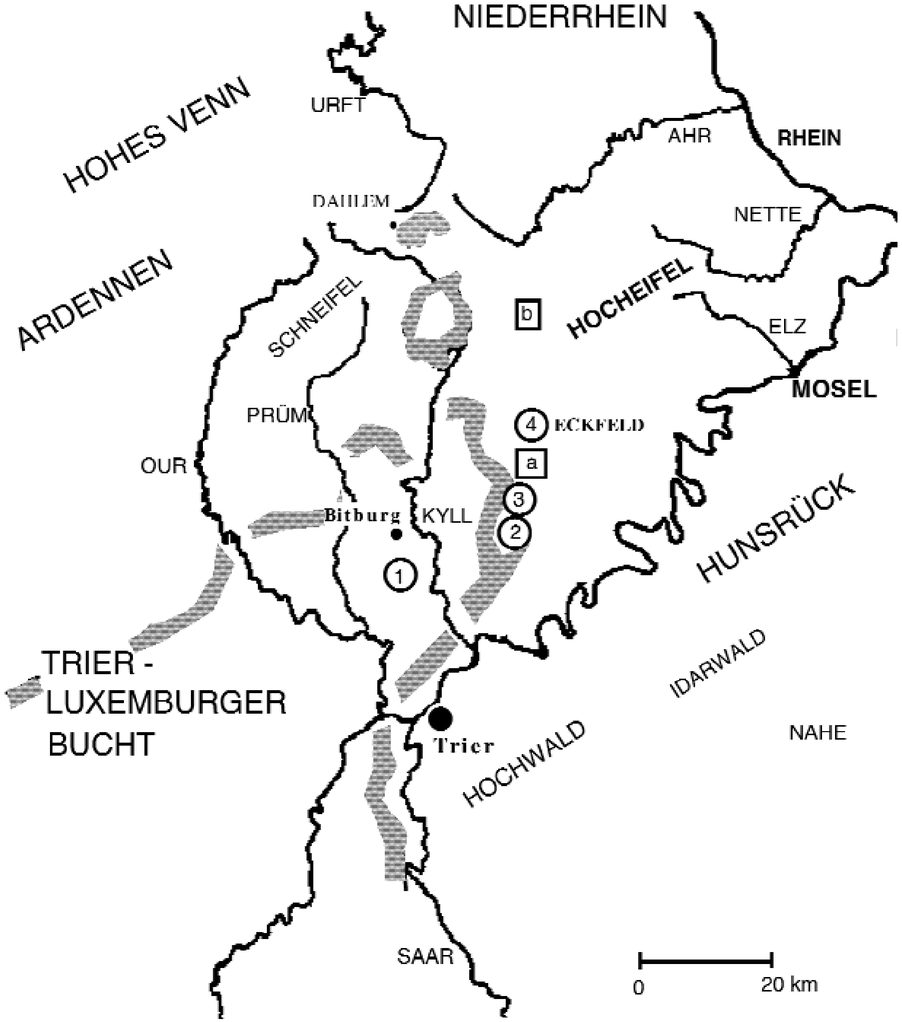


Fig. 1.- Regional setting, outcrop of Buntsandstein and stops.

Fig. 2.- "Dawn-horse" Propalaeotherium voigti. *Pregnant female with soft tissue preservation and "stomach contents". Length ca. 70 cm. Inv.-Nr. MNHM PW 1992/53-LS.*

There are three major topics to be in the focus of interest:

(i) The reconstruction of the morphological setting during the Lutetian[(1)] by presenting one of the most spectacular continental "fossillagerstaetten" of the European Tertiary: The Eckfeld Maar (Neuffer *et al*., 1994) offers a wide window into the Lutetian. (**Stop 4).** The maar lake sediments provide unique data for paleoenvironmental and paleoclimatological research. The spectrum of fossils includes almost everything from organic molecules to articulated mammals with soft tissue preservation and contents of the digestive tract (**Fig. 2**). Corresponding sediments of the Lutetian are to be seen at Binsfeld and Arenrath (**Stop 2**) with an intensive pre Lutetian tropical weathering profile at the base.

(ii) The demonstration of the theory of "Talverschüttung" (valley filling, **Fig. 3**), first developed by Louis (1953) and confirmed by Löhnertz (1978b): The pre-Lutetian planation surface was deeply cut by river erosion - probably due to tectonic uplift - in the Late Lutetian or Lowest Priabonian. Channel sediments consist of milky quartz gravels to nearly 100%, in the mass out of the Buntsandstein, and subordinately some quartzite, sandstones and slate. Indicator gravels especially out of the Permian volcanic rocks in the Upper-Nahe area permit the reconstruction of a Saar river prototype running along the southern slope of the Eifel and of some tributaries (Löhnertz, 1994). Obviously there was a river erosion at the end of the Middle Eocene cutting up to 200 m below the nearby planation surfaces. This erosion formed a well marked Buntsandstein cuesta of considerable height (**Stop 2 and 3**). This relief was filled up again due to an ingression at the time of the uppermost Lower Oligocene or the Lowest Rupelian. Deeply incised valleys were flooded more than hundred km inland and the "Trogregion", the today 400 m level, was formed on top of the valley filling by lateral erosion over a long time. At last there existed an estuarian or lagoon environment near sea level (**Stop 1**), brackish conditions on various points of the Eifel (**Fig. 4**) prove connections to the Mainz basin, the Lower Rhine Embayment and the Paris Basin.

(iii) To prove that a considerable denudation between the Rupelian and the Old Pleistocene in this south-western part of the Rhenish shield is missing: In the Upper Oligocene the removal of the huge mass of Eocene/Oligocene sediments

(1) Also named Geiseltalian, see the appended stratigraphic scale, p. 49.

started. Clay and sands from the Upper Oligocene in front of the northern border of the Rhenish shield (Meyer, 1994) and the Miocene cover above the coal in the Lower Rhine Embayment are evidence. A high dominance of quartz gravel shows that it is pure removal or pure clearances because there is obviously no considerable erosion in the unweathered rocks beneath the Tertiary cover. This was also proved by Negendank (1978) in his study of the heavy minerals in the fluvial sediments of the Mosel system.

Some profiles along the outcrop of the Buntsandstein with the distances to the dated sediments may demonstrate that the post Oligocene denudation is strongly determined by the amount of Pleistocene uplift:

a) Near the strongly uplifted volcanic area of the Hocheifel the retreat of the Buntsandstein cuesta of at least 4 km since the Oligocene to today outcrop can be proved by the existence of Buntsandstein in the lava of the Arensberg (**Fig. 1, 4b**) near Zilsdorf, dated 32 Ma (Meyer, 1994). There are also pieces of Buntsandstein in the nearby volcano Beuel (1 Ma) indicating that this was mainly an act of the Pleistocene (Fuchs, 1969).

b) At Eckfeld (**Stop 4**) the absence of Buntsandstein in the diatreme breccia of the maar (Fischer, 1999) gives a clear proof that at the moment of eruption in the Lutetian (44 Ma) the pre-Permian landscape was already exhumed and that the retreat of the Buntsandstein between maar and today outcrop can be at most 4 km. At the same moment this demonstrates that there was already a relief of at least 175 m regarding the difference in elevation between base and top of the Buntsandstein (**Fig. 5**).

c) This is also to be seen few km outwards near Manderscheid (**Fig. 1, 3a**), where the maximal retreat of the Buntsandstein is now limited to less then 3 km (Fig. 5), although there is a very well pronounced cuesta.

d) At Gut Heeg (**Stop 3**) the sediments of the Late Lutetian river lie immediately on the Buntsandstein cuesta, partly on Devonian partly on Buntsandstein. Obviously there has been no retreat of the Buntsandstein cuesta since the Eocene at all.

e) At the most southern point of the field trip at Arenrath (**Stop 2**) the Eocene gravel lies on the Middle Buntsandstein in front of the smooth cuesta of the Upper Buntsandstein, showing that the base of the Buntsandstein was deformed at least pre by Lutetian and not by post Eocene tectonics.

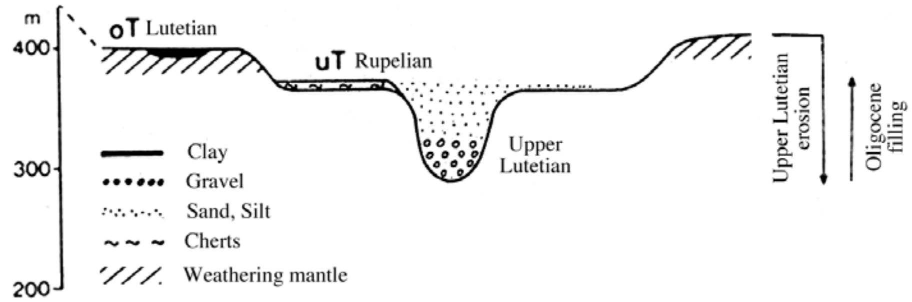


Fig. 3.- The theory of "valley filling" according to Löhnertz (1978).

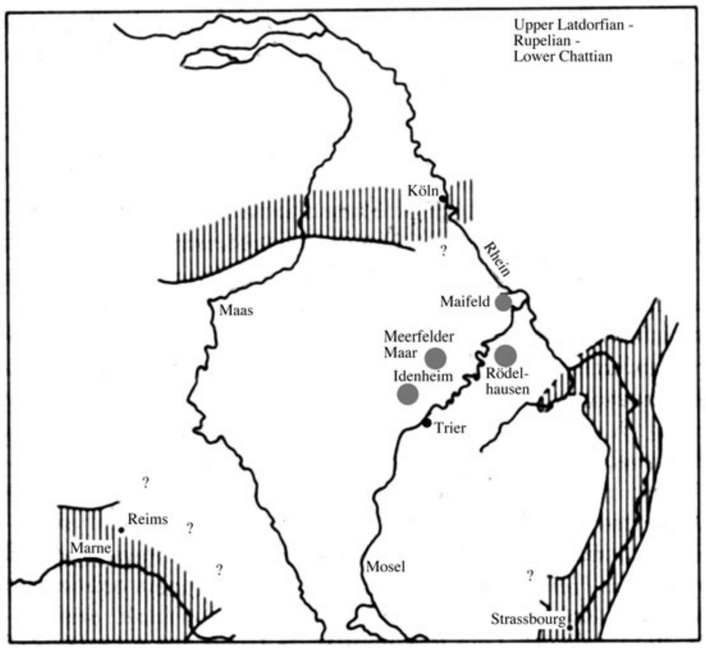


Fig. 4.- Relations of the Eifel to the marine - brackish foreland in the Oligocene.

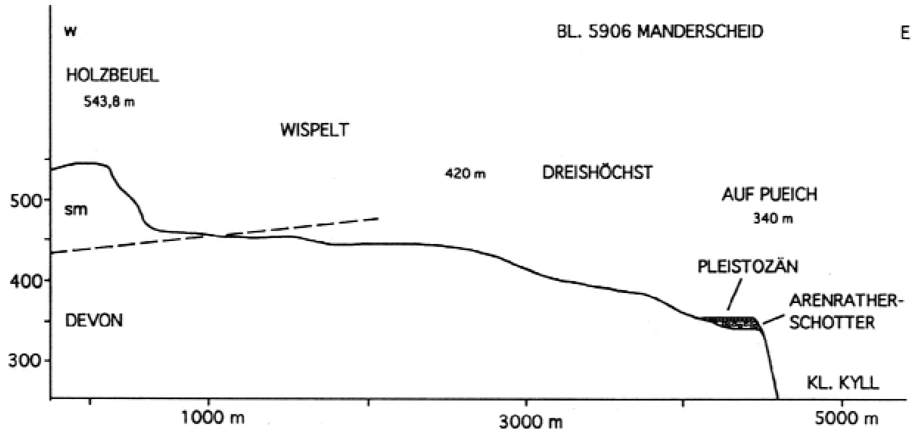


Fig. 5.- Profile of Buntsandstein cuesta and Eocene valley near Manderscheid/Eifel.

2 - Approach (A. Muller)

Route: Preizerdaul – Saeul – Mersch – Larochette –Echternach – B51 Trier – Bitburg

The approach to the eastern field trip area passes through three very different but specific sedimentation areas. In Triassic times the western Ardenne Massif was subdued to denudation. The most western sediments of the ”Germanic Basin“ were deposited in the Lower and Middle Triassic in the Belgium-Luxembourg frontier area as alluvial fans and in braided rivers systems. This facies on the margin of the sedimentation area was described by Lucius (1959) for the area West of the Alzette and, in its extremely coarse clastic and unsorted development for the area West of the Roudbaach. It makes sense to integrate these sediments according to lithostratigraphical methods as Roudbaach Group (Bintz & Muller, in press).

In the area East of the Alzette, for example in the valleys of the Süre, the Mosel and the Saar, these Triassic sediments seem similar to the “Germanic facies“ *sensu stricto*. Nevertheless in the Luxembourg Guddland and in the southern Eifel they have a reduced thickness, some lithological singularities and the filling up of the sedimentation area was forced by a local specific subsidence. Theses sediments are to be seen partially in the valleys of Prüm, Nims and Kyll. They are integrated by Bintz & Muller (*op. cit.*) as a Sarre-Mosel-Süre Supergroup.

In the future Paris Basin the area of sedimentation was extended during the Lower Liassic far to the West. In an interdependence with the marine flow pattern the sediments of the clayish-marlaceous Jamoigne formation are interfingered with those of the sandy Luxembourg formation. On the approach road to the southern Eifel the sandstones of this Luxembourg formation are moulding the landscape between Saeul and Echternach.

3 - Route and stops

On the way (W. Löhnertz)

From Helenenberg on the B51 in the direction of Bitburg over the Oligocene planation surface of the so-called “Trogregion” at about 400 m above sea level.

This surface is on top of the Upper Muschelkalk cuesta and is covered by a loam, the so called “Höhenlehm”. In the area around Helenenberg there are many karstic sinks - 0,5 m in width and about 4-6 m in distance - filled with this loam. Mückenhausen has made investigations in an old limekiln and Muschelkalk quarry south of Helenenberg and frequently found relics of the Mesosoic-Tertiary Weathering Mantle, for example Terra fusca and Terra rossa. He describes similar material from the Northern Eifel in Mückenhausen *et al.* (1975). Kremb-Wagner (1996) assumes a tectonic origin of these sinks in Tertiary times, for she found a direct correlation between the width of the sinks and a presumed tectonic dilation, but more proofs are to be found.

STOP 1: Idenheim (W. Löhnertz)

Field 200 m E junction B51 Trier - Bitburg to Idenheim (“Beilenholz”)
TK25 6105 Welschbillig (R2539500, H5527900) (**Fig. 4, Fig. 6**)

Situation

At an elevation of 380-390 m above sea level on the “Trogregion”, which is here identical with the watershed between the rivers Kyll and Nims (**Fig. 6**).

The ground is formed by the Upper Muschelkalk, the cuesta of the Upper Muschelkalk, created in the Plio-Pleistocene (360 m level) by the lateral erosion of the Kyll and her tributaries, lies about 500 m in the East. Some flat hills with forest in the surroundings are formed by the Lower Keuper. The view to the Southwest reaches to the quartzitic monadnocks of the Hunsrück (700-800 m above sea level) in the background. More in front the Plio-Pleistocene landscape (360 m level) and the Upper Oligocene Trogregion (400 m level).

Embedded into a brown loamy cover - a trial pit on the *locus typicus* gave a thickness of 180 cm - there is a poor spread of four different residual rocks: red coloured milky quartz and quartzitic gravels, mostly well rounded (“rote Höhenkiese” according to Kurtz, 1938), blocks and pieces of bog iron ore, Tertiary Quartzites (Braunkohlenquarzite or “Lignitic Quartzites”, “grès quarzites” or “Pierre de Stonne”) and rare fossiliferous cherts (“meulière”). The combination of these four sediments as residual rocks demonstrates a rearrangement - probably in the Pliocene - the original position during sedimentation should be slightly higher.

As it is difficult to find fossiliferous cherts in adequate time, material is prepared for the field trip of the coll. Löhnertz.

Material

The cherts are in most cases angular or subangular, extremely hard, homogeneous and without any cleavages. Often to see a white weathering rind of 1-3 mm thickness (**Fig. 7**) and then a red coloured zone due to post sedimentary infiltration of ferrous oxide. Only some greater blocks show a grey-blue colour, which may be the primary one.

(i) Terrigeneous components are limited to clay and fine silt indicating a transport of the material by very low velocities, (ii) biogeneous components are unsorted, unrounded and not adjusted, indicating almost stillwater conditions and (iii) a relatively high degree of illuviated organic mater indicates a short distance to the shores, (iv) sheet cracks are indicating stadiums of subaerial exposition and of evaporation, (v) the silicification of very fine organic material in the Gyrogonites of Gyrogona *medicaginula* (Lamarck), especially the very fine dividing walls of the spiral cells (**Fig. 8**), whereas the former limestone of the cells has gone, finally proves a nearly synsedimentary silicification.

A small mollusc fauna with *Nystia* (*Nystia*) *jeurensis* (**Fig. 9**) indicates slightly brackish conditions and a lagoon environment. It cannot be excluded that the assumed salinity of 0,3-0,5 % is due to an enrichment of salt by evaporation. Other

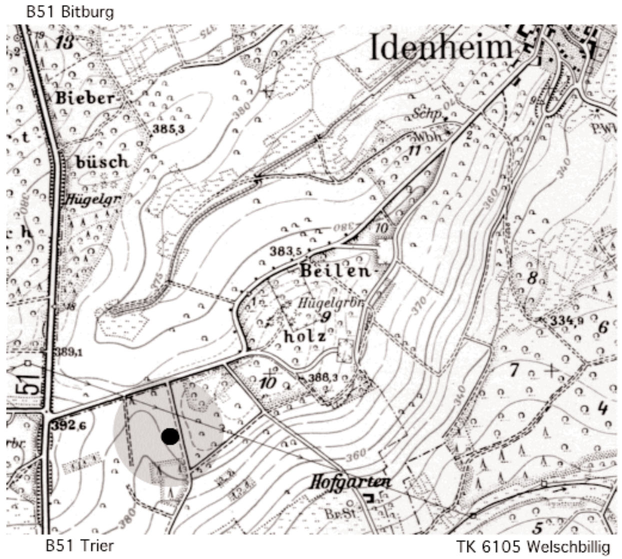


Fig. 6.- Regional setting of Rupelian findings in Idenheim.

molluscs like *Planorbis prevostinus* and also the Charophytes indicate freshwater conditions.

Dating

The cherts of Idenheim and the surroundings were first dated by Baeckeroot (1929) as Aquitanian especially by “*Litorinella ventrosa* MTG” as Litorinella limestone. New collections of his material by Löhnertz were dated by Kadolsky *et al.* (1979, 1983) as Lower Rupelian or Stampien using the Charophytes, especially *Gyrogona medicaginula* (Lamarck) as guide fossil. In 1979 a good correlation seemed possible with the Lower Rupelian of the “Meulière de Brie”. New findings of *Gyrogona medicaginula* in the Mainz Basin (Mittlere Pechelbronn Schichten, Latdorfian: Schwarz, 1984) and in Sieblos/Rhön (Latdorfian: Schwarz, 1998) further indicate the Lower Oligocene and also the Maifeld-Schichten of the Neuwied basin - used as best correlation to the Idenheim fauna and in 1979 seen as Rupelian - are now dated as Lower Oligocene (Heizmann & Mörs, 1993; Martini & Schiller, 1998), too. Dating may therefore be in the uppermost parts of

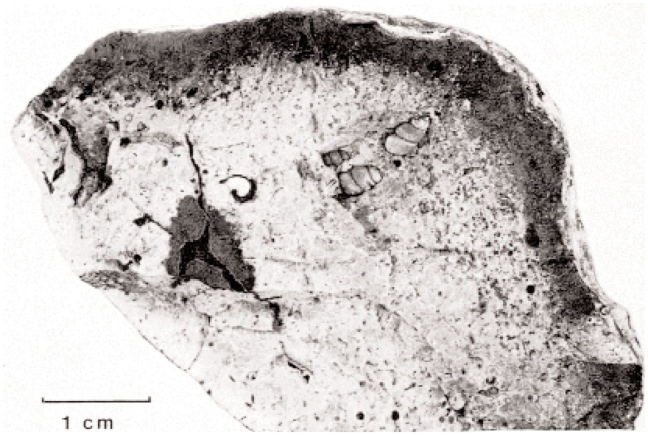


Fig. 7.- Chert with guide fossil Nystia jeurensis *and sheet crack.*

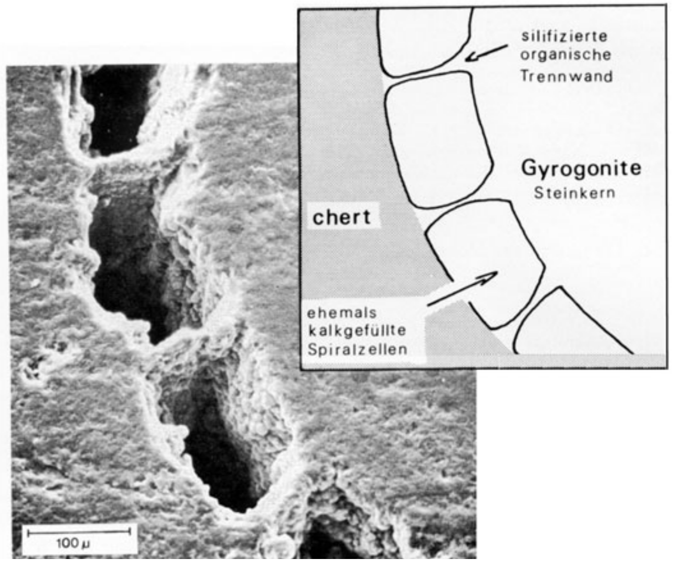


Fig. 8.- Silicified dividing walls of the spiral cells of a Gyrogonite.

the Latdorfian or Lowest Rupelian and it may be possible that the Idenheim fauna is a little older than the other brackish sediments on the Rhenish shield (**Fig. 4**).

Morphological implications

The position of the Oligocene fossiliferous cherts on the surfaces of the Upper Muschelkalk cuesta and in fluvial deposits of the Salm, coming at least from the surfaces at the top of the Buntsandstein, demonstrates that the Eocene valley in front of the Buntsandstein cuesta (**Stop 3**) has been filled up again. The "Trogregion", the today 400 m level, was formed at the end of an ingression and on top of the valley filling by lateral erosion over a long time. Findings of (i) a Middle Oligocene fauna in the rather young Meerfelder Maar (Sonne & Weiler, 1984), of (ii) Middle Oligocene foraminifers (V. Sonne *in* Zöller, 1983) and (iii) of beach-ridges in the Hunsrück-Mosel-area (Zöller, 1984), and (iv) investigations of sediments along the Rhine valley (Semmel, 1999) have confirmed the datings of the so-called "Trogregion" at 400 m above sea level (**Fig. 4**).

Also confirmed was the theory of Löhnertz (1978b) that the valley filling took place near sea level and was caused by an eustatic rise of the sea level. As most Oligocene shorelines are well-known in the Paris and Mainz Basins as well as in the Lower Rhine Embayment, conditions of sedimentation should be: (i) some distance from the sea, (ii) following an ingression and (iii) in an estuarian or lagoon environment (Kadolsky *et al*., 1983). In Oligocene times distances from the Eifel-Mosel area to the Mainz or Paris Basins, to the Lower Rhine Embayment or to the Upper Rhine graben are hardly more than 200 km, horizontality of river slopes near sea level and slightly brackish conditions are quite conceivable.

Ingression was only possible against the slope of the Eocene drainage system. It is therefore not contradictory if Kadolsky *et al.* (1983) see an influence of the Paris Basin in their fauna, Sonne & Weiler (1984) see a correspondence with the Mainz Basin and Demoulin (1989) sees a transgression from the North. The different influences may give a chance to reconstruct Eocene slopes of the Rhenish shield.

The base-level of erosion in greater parts of the Rhenish shield must have existed near sea level for a very long time. Fish species crossing the Rhenish shield from the North sea basin to the Mainz basin (Martini, 1981) demonstrate that at the moment of the – relative – highest sea level, the western part of the Rhenish shield was completely surrounded by marine or brackish waters, an island only above the today 400 m contour line, with flooded and sediment filled valleys far inland. A flat relief of less than 200 m differences in altitude and a fossilisation of the landscape by a sediment cover - for parts of Luxembourg see Kienzle (1968) - prevented deep weathering and denudation. Formation of bog iron ore and silcretes, dry up events, changing salinity, freshwater sediments and nearly synsedimentary silicification of limestones ("fossiliferous cherts") at Idenheim/Bitburg (Kadolsky *et al.*, 1983) are indicators of more superficial processes, the beach-ridges of Rödelhausen/Hunsrück (Zöller, 1984) and the very well rounded gravel from the Fieberberg/Kröv at the Middle-Mosel area, so-called "Rundschotter" and not the typical "Kieseloolith-Schotter" (Löhnertz, 1982), are indicators of shores of greater lakes with surf waves and corresponding gravel. Sedimentation took place in smaller basins at the top of the valley filling as Upper Oligocene sediments at the Maifeld/Lower Mosel area can prove (Heizmann & Mörs, 1993).

Maps and general

TK25 6105 Welschbillig
Geologische Specialkarte von Preussen und den thüringischen Staaten, Gradabtheilung 80, No. Bitburg und Gradabtheilung 80, No.8 Welschbillig, Berlin 1892 mit Erläuterungen (H. Grebe).
Geologische Übersichtskarte Rheinisches Schiefergebirge SW-Teil, = Hochschulumgebungskarte Trier 1.100 000, bearb.: W.Wagner u.a. Trier 1983; *In*: Negendank J.F.W. (1983), Trier und Umgebung. *Sammlung Geologischer Führer*, **60**, 2. Aufl. Berlin-Stuttgart.
Meyer W. (1994) - Geologie der Eifel., 618 S.,154 Abb., 13 Tab., 2 Beilagen, 3. Aufl. Stuttgart.

On the way (W. Löhnertz)

From Idenheim to Sülm the road follows the cuesta of the Upper Muschelkalk. From Sülm steep down to the river Kyll the profile shows the stratum from the Upper Muschelkalk (mo_1 = Unterer Hauptmuschelkalk) to the Upper Buntsandstein (so_1 = Zwischenschichten).

Speicher (B50 Bitburg-Wittlich) was and is a famous location for pottery and ceramics as findings of Roman potters kilns may prove. The clay used since these times is of Eocene age and is the cover in the Binsfeld-Speicherer-Depression (Löhnertz, 1979). As the ultimate amount of downthrow fault is 80 m (**Fig. 10**) and

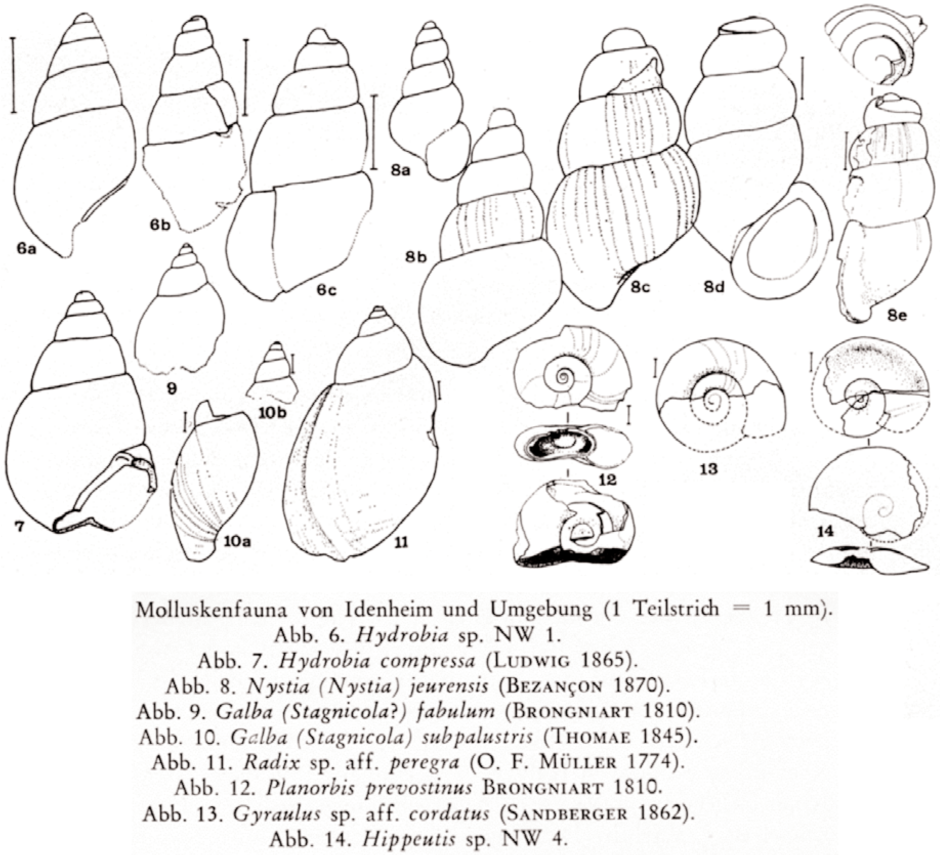


Fig. 9.- Mollusc fauna of Idenheim and surroundings.

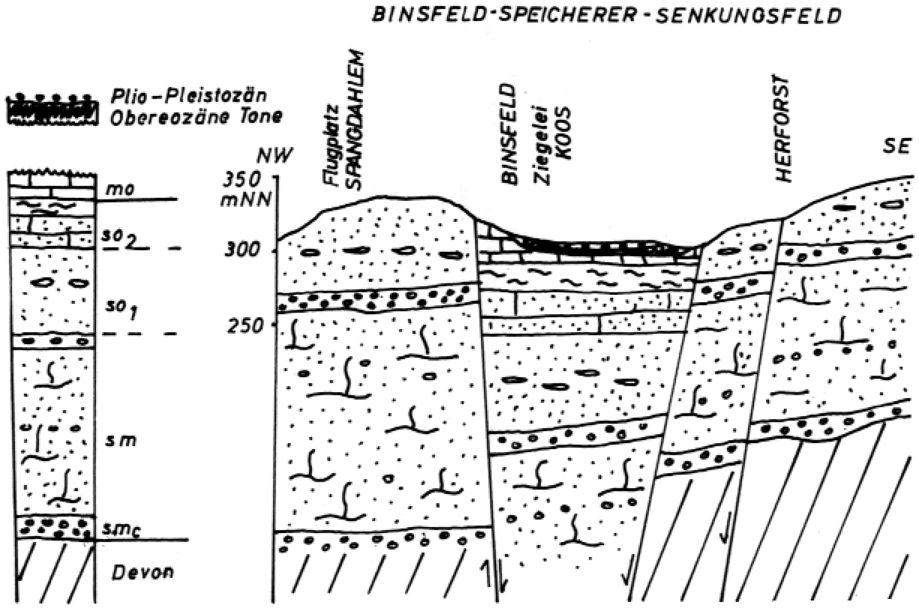


Fig. 10.- Cross section of the Binsfeld-Speicher Basin Depression.

today surface is 320 m above sea level, the Eocene clay is proof that the planation surface of the Eocene lies in 400 m above sea level or even lower - not 600 m above sea level (like Quitzow, 1969 and traditional German morphologists before) - and that the region above 400 m sea level is of Cretaceous or Lowest Eocene times. The clay was first dated as Lutetian and as an equivalent to Eckfeld (Stop 4) by van der Brelie *et al*. (1969) and later examined by Löhnertz (1978a; 1978b; 1979) and Gregor & Löhnertz (1984; 1986). There are three points of special interest: (i) in 1978 the only post-Eocene fault of the Eifel, documented in Tertiary sediments up to the present, was to been seen in the clay pit of Binsfeld (**Fig. 11**) and (ii) there was a very intensive tropical weathering zone which had developed in the Lower Muschelkalk underneath the dated clay. Weathering therefore is obviously pre Lutetian. The Eocene clay was eroded by an Old Pleistocene terrace of the Kyll - proved by rare Cretaceous flints in gravels at the top of the Eocene (Gregor & Löhnertz, 1984) - indicating that in Old Pleistocene times the Eocene was still lying underneath the base level of erosion. Incidentally if there is a good exposure in the clay pit of Binsfeld during field trip in May a short stop may be worthwhile.

On the way (W. Löhnertz)

On the B50 Speicher-Wittlich till the end of the village Binsfeld and right in direction of Arenrath. The short way down uses the former steep bank of the Eocene river (**Stop 3**), at the same time the cuesta of the lower parts of the Upper Buntsandstein (so_1). Some old gravel pits and a gravel concrete plant on the left - using the Eocene gravel and sand - and a clay pit on the right.

STOP 2: Arenrath (W. Löhnertz)

Clay pit 700 m E junction B50 Speicher-Wittlich to Arenrath (“Rothheck”)
TK25 6006 Landscheid, (R2552100, H5537700) (**Fig. 12**)

Situation

The clay pit is located (i) at an edge of the wide flat surface upon the Eocene sediments of the Proto-Saar River (Löhnertz, 1994), (ii) on foot of the Upper Buntsandstein cuesta and therefore (iii) on the border between sm and so. This is a clear proof that the differences in altitude between Eocene at the base of the Upper Buntsandstein and the Rupelian on top of the Upper Muschelkalk (**Stop 1**) are - at least - identical with the Eocene relief.

The lowest parts of the Upper Buntsandstein here are the so-called "Zwischenschichten", brown-red sandstone with small violet clay banks. Due to a promontory of the Upper Buntsandstein the Eocene river-bed makes a little curve to the west and the erosion spared a little nose with a highly weathered surface, whereas the Middle Buntsandstein underneath the Eocene gravel is only slightly weathered (Kopp, 1961; Martin, 1962; Löhnertz, 1978, 1980). South and north of the pit the base of Eocene gravel goes down to 280-285 m above sea level and the top of gravel and sand reaches up to an ultimate height of 292-295 m. The little deposit of clay is situated lateral to and slightly higher than the Eocene channel filling (**Fig. 12**).

In May 2003 it is easy to see in the clay pit, how the clay stratum trace the weathered surface thinning out on top of the hill. The eroded surface, for its part, is traced by a brown loam (**Fig. 12**) - the so-called "Höhenlehm" -, an equivalent of the Pleistocene terrace on top of the Eocene in Gut Heeg (**Stop 3**).

Material

Underneath the clay there is the outcrop of deeply weathered Buntsandstein, grey-white sands with a high degree of clay in between (Klebsand, "plastic sand"), but the primary structure of the Buntsandstein is still conserved. In the northern part of the clay pit - some meters below and in April 2003 flooded - there was a zone of about 50-70 cm with very intensive red and violet colours similar to the lateritic weathering surface at Binsfeld clay pit nearby. As there was no mineralogical research of the clay up to today, Dr. Felix-Henningsen (Gieβen) is doing some research in preparation of the field trip. His results should be a point of discussion.

The clay is partially red-violet coloured or spotted and it is to be seen that these spots are bound (i) on the base stratum upon the *in situ* weathering zone and (ii) on deep mud cracks. At some times of dismantlement, when the overlying loam is carefully removed, there is to be seen that the mud cracks forms a polygonal pattern on the surface.

Dating

The clay is due to the failure of findings not dated up to present and there are two possibilities: The great similarity with the dated clays of Binsfeld clay pit nearby and the position upon the deeply weathered surface indicates (i) the Middle Lutetian or even older, the position in a distance of only 100 m and at nearly equal

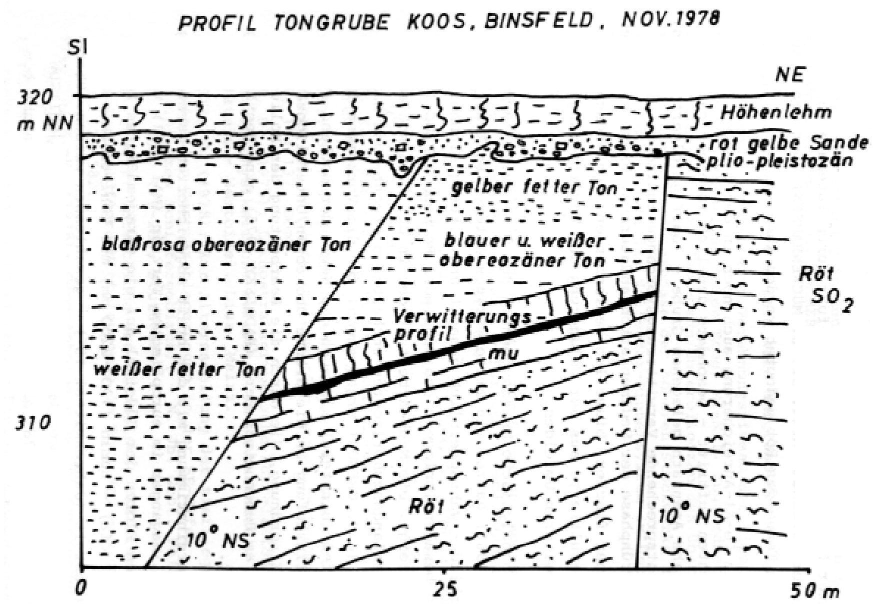


Fig. 11.- Clay pit at Binsfeld with weathering zone, Eocene clay, Old Pleistocene terrace, loam and two post Eocene faults.

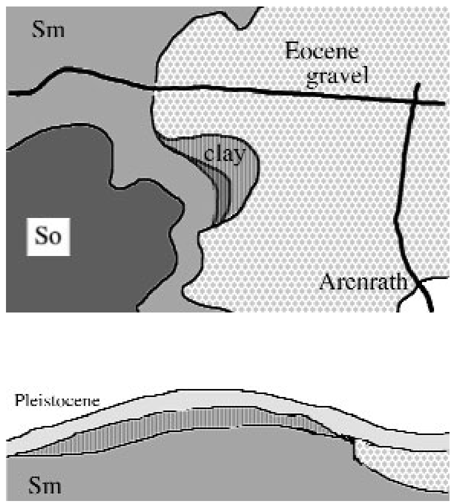


Fig. 12.- Morphology (scheme) at the clay pit Arenrath.

height to the dated river sediments - the extensive floor was recovered out of small clay beds near the base of coarse gravels, but also out of silty sediments on top, may be of a last fill up in a lake environment (Löhnertz, 1978; 1980) - may suggest the Upper Lutetian (Nickel ,1994) or the Lower Priabonian (Kempf, 1993).

Morphological implications

At a private field trip with E. Mückenhausen - at that time the specialist for tropical weathering zones in the Eifel - he suggested an enrichment of Fe-Al-Cr in the mud cracks by lateral waters coming out of the Buntsandstein on the one hand and in the basement by ascending waters out of the weathering mantle beneath on the other hand. In both cases this evolution must have taken place shortly after sedimentation in an early stadium of diagenesis. It may be a point of discussion if the polygonal pattern with an enrichment of Fe-Al-Cr is (i) due to drying-up events during the sedimentation of the clay in a lake with very low water or (ii) due to shrinkage during diagenesis. In any case, as the flooded parts of the clay pit even today easily can prove there is obviously an impermeable stratum in the base.

Maps

Geologische Specialkarte von Preussen und den thüringischen Staaten, Gradabtheilung 80, Blatt 3 Landscheid, Berlin 1891 mit Erläuterungen (H.Grebe).
Geologische übersichtskarte Rheinisches Schiefergebirge SW-Teil, = Hochschulumgebungskarte Trier 1.100 000, bearb.: W. Wagner u.a. Trier 1983; *In*: Negendank, J. F.W. (1983): Trier und Umgebung. *Sammlung Geologischer Führer*, **60**, 2. Aufl. Berlin-Stuttgart.
Martin G. (1955) - Die Geologie der südwestlichen Mosel-Mulde und der benachbarten Strukturen. Diss. Frankfurt, 178 S., 4 Kte., 23 Profile, 7 Tab.; Frankfurt.

On the way: (W. Löhnertz)

Back to the B50 Bitburg-Wittlich and in direction Wittlich till Landscheid, then on the road to Manderscheid, crossing the A 60 to Gut Heeg. Many gravel pits in work and refilled indicate that the way follows the Eocene valley.

STOP 3: Gut Heeg (W. Löhnertz)

Gravel pit at Gut Heeg, 2 km Southwest Groβlittgen
TK25 5906 Manderscheid, (R2555450, H5541450) (Fig. 1, Lutz, Fig.L2)

Situation

The great gravel pit - today nearly exhausted and in most parts refilled - is located exactly on the outcrop of the Buntsandstein. It was Stickel, who first in 1927 recognised that this position of the sediments along the Buntsandstein cuesta - following even some smaller bays (“Saumtal”) - proves the pre-existence of the cuesta.

In the southern part of the pit - now refilled and recultivated - very coarse gravel lies partly on Buntsandstein, partly on Devonian. In the pit today there is only the Devonian at the base and the material - up to 18 m in height (Bange, 1990) - is mostly fine grained gravel, sand and silt (**Fig. 13**). In 1976-1978 the coarse gravel lay on nearly unweathered Devonian slate and greywacke (**Fig. 14**) and the well exposed and steep river bank reached discordant only some meters into the Buntsandstein. On the surface of the Devonian, that is the exhumed pre Permian landscape, silicified sandstone of the Buntsandstein sole - some greater ones are now exposited at the entrance of the pit - often formed a sort of pavement (Quitzow, 1969; Löhnertz, 1978). So it was possible to reconstruct the undisturbed transition between Devonian and Buntsandstein and then it was obvious that there was no possibility for a greater post Eocene dislocation and that the Eocene relief had at least an altitude of 175 m. By the way: As the basis of the Buntsandstein falls south to the middle of the Trier-Luxembourg Basin, a post-Eocene fault would only have diminished this altitude and not enlarged.

Two young and well developed Salm terraces lie discordant on top of the Eocene and show that the Eocene was under the base level of erosion at least to the Old Pleistocene. The Salm terraces with their red and very coarse gravel out of the Buntsandstein are covered by the so-called “Höhenlehm”, obviously Old Pleistocene or younger.

Material

The so-called “Vallendar-Schotter” consists of milky quartz gravels to nearly 100%, in the mass out of the deeply weathered Buntsandstein, and subordinately some quartzite, sandstone and slate. Indicator gravels especially out of the Permian volcanic rocks in the Upper Nahe area permit the reconstruction of a Saar river prototyp running along the southern slope of the Eifel and of some tributaries, above all the N-S orientated so-called “Manderscheider Talung”

(Löhnertz, 1994). There is still some uncertainty about the genesis of the coarse sediments at the base. Although there is a relative unweathered sandy slate underneath the coarse gravel, sharply cut off by the erosion, there are no greater relics of the shale in the sediment itself. Considerations of a post sedimentary descending kaolinization (Negendank, 1977) proved false. There should be a strong compaction destroying the fine stratification as demonstrated by Grimm (1973) for the "Quarzrestschotter" of the Molasse. This question may be a point of discussion.

Observations in the gravel pits over many years allowed the reconstruction of many details of the micro relief of the river channel near the banks. It was often possible to reconstruct the conditions for the conservation of plants, for example of a tree sitting on a bench of rock (**Fig. 15**) or of a great leaf of a palm stranded on a sandbank in the channel.

The coarse and often well rounded gravels are mostly up to 5 m thick and are below a sequence of well sorted fine gravel, sands and silt. This sequence is often eroded. However, in Gut Heeg it is still up to 15 m thick, due to the protection by a promontory of the Buntsandstein cuesta. The fine bedding structures, for example many cross bedding forms, and the fine material indicate a fill up, may be in a lake (**Fig. 13**). This sediments are called "Arenberger–Fazies" by Mordziol (1936). However this differentiation may only be correct with regard to the facies, but there is no difference with respect to the age, as the findings of the Eocene flora even in the uppermost sediments has proved (Löhnertz, 1978, 1980).

Dating

The so-called "Vallendar Schotter" were first dated in 1977 by palynostratigraphic investigations as "Borkener Pollenbild", that is Middle Eocene (v.d. Brelie *in*: Löhnertz, 1978). It was Nickel (1994) who confirmed this stratigraphic position - now Zone SPP 15 D, late Lutetian - that is only little younger than the nearby maar sediments of Eckfeld (Neuffer *et al.*, 1994). Considering the results of an investigation of the Hydropterid floras (Kempf, 1993) which gave Lower Priabonian (Lower Headon Beds, Upper Eocene) there still remains some uncertainty. As the lower parts of Oligocene ("Haselbacher Serie"), an age given by Gregor after investigations of rare paleocarpological material (*in* Gregor & Löhnertz, 1986), can be excluded now, a stratigraphic position in the highest parts of the Middle Eocene may be realistic.

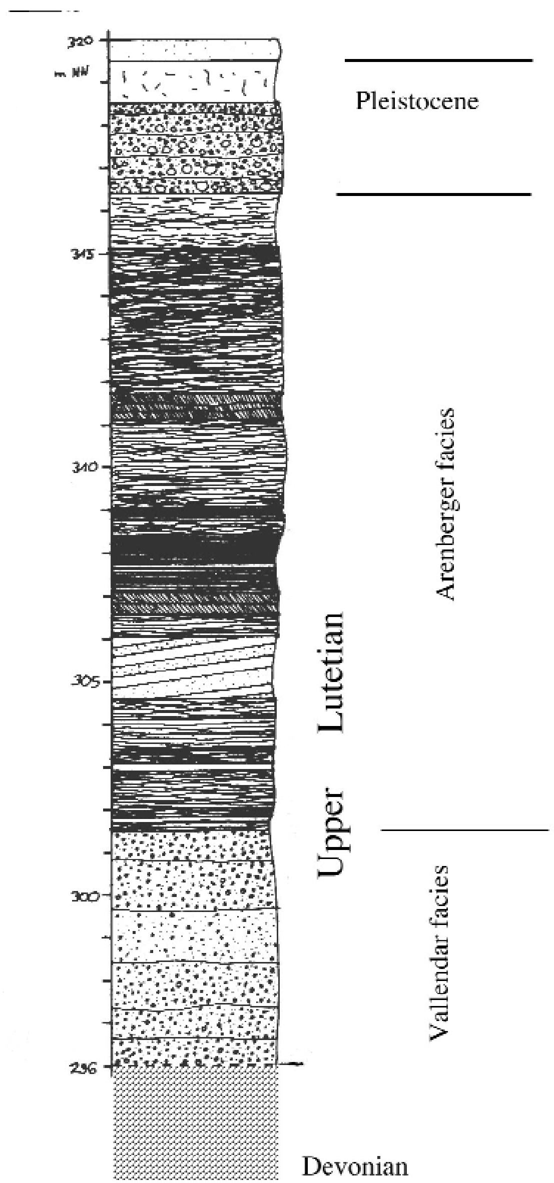


Fig. 13.- Sequence of the Eocene (Bange, 1990) at gravel pit Gut Heeg.

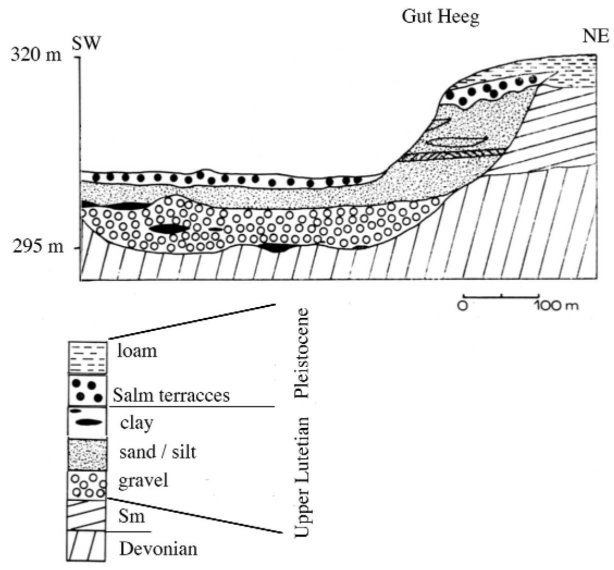


Fig. 14.- Situation in gravel pit Gut Heeg en 1978.

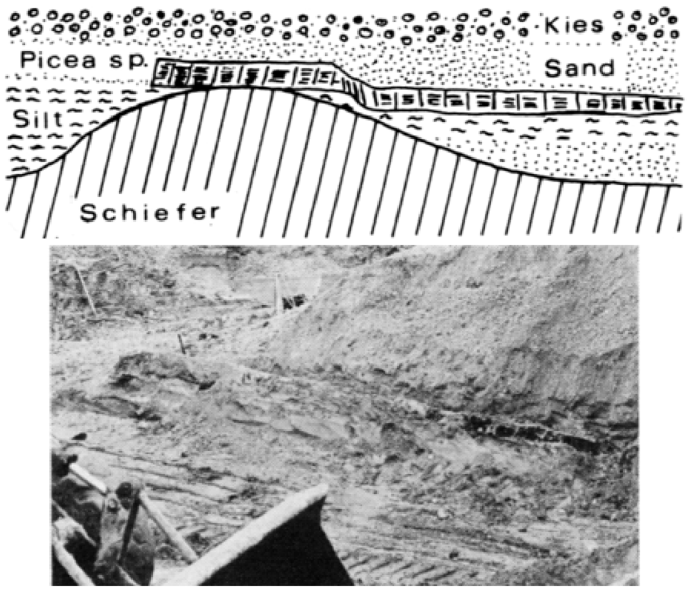


Fig. 15.- Micro relief and plant conservation in 1978.

Morphological implications

Due to the work of Löhnertz (1978-1994) it has been proved by the sediments of Gut Heeg and Arenrath that there were deeply incised valleys in the Lutetian, creating a relief of at least 175 m in altitude. As a consequence all the classical theories of landscape evolution, for example several “Rumpfflächen” or peneplains, ranging from high = old and low = young, are thus shown to be wrong. Since 1978 it has no longer been possible to date neither sediments nor morphological forms only by the position above sea level, as it was the case before (Quitzow, 1969; Pfeffer, 1978).

This also showed that the landscape in the highest parts of the Eifel was formed in the Cretaceous, for example the monadnocks like the Schneifel.

Silicified blocks of more than 1 m in diameter pulled out of the described pavement and rearranged with coarse gravel up to 40 cm in length proves of a high energy of the fluvial erosion, a strange contrast to the theory of pure tropical weathering on nearly horizontal plains.

The proof of Rupelian sediments in short distance to the Buntsandstein cuesta (**Stop 1**) at least about 120 m above the Eocene valley floor led to the conclusion of a great valley filling, as it was postulated first by Louis in 1953. The Buntsandstein cuesta and all other features of the relief were covered by sediments and this fossilisation has not been totally removed. The theory of “valley filling” may be a further point of discussion.

Incidentally if there is fossiliferous Eocene clay or silt in an exposure of another clay or gravel pit in May 2003 the field trip will change the location. This seems possible as the sequence of sediments is very similar all over the Eocene river-bed.

Maps (see Stop 2)

On the way (W. Löhnertz)

In the direction of Groβlittgen following the Proto-Saar River with gravel pits on both sides. At the end of Groβlittgen in direction of Manderscheid with gentle, but clear slope leaving the Proto-Saar valley with a good view over the valley bottom between both banks, gentle in the Buntsandstein in the west, steep in the Devonian in the southeast. To the East the continuation of the Proto-Saar valley into the “Hasborner Talung” (Lutz, **Fig. L2**).

In the direction of Manderscheid now following the so-called “Manderscheider Talung”, a North-South orientated tributary of the Proto-Saar River without the typical guide gravel of the Saar-Nahe Permian (Kurtz, 1932; Louis, 1953; Löhnertz, 1978; 1994).

South of Manderscheid - just in front of the city - an excellent view from the small Eocene valley bottom and bank in front, over the “Trogregion” to the well marked Buntsandstein cuesta (**Fig. 5**) in the background. It is possible to recognise both the minimal extent of Eocene relief (175 m) and the ultimate mass of denudation during the last 40 Ma (2,5 km). Eocene valley and the planation surface are dominated by the very young (17 000 - 28 000 BC) volcanos of the Mosenberg (Meyer, 1994).

In Manderscheid the new and famous Maar Museum with a modern demonstration of maar genesis and a fine presentation of the findings of the Eocene Eckfeld maar (**Stop 4**). Behind the building a little outcrop of Eocene gravel lying at about 50 m higher than the Eocene gravel south of Manderscheid and thus indicating a greater fault and the transition zone to the strongly uplifted “Hocheifel” area (Löhnertz, 1994; Pirrung, 1994, 1998).

From Manderscheid in the direction of the motorway 48. Shortly behind the village a panoramic view of the Lieser valley with two castles of the Earls of Manderscheid built on top of two fine and steep meander cores.

Lunch in Gasthof “Höfchen” near Eckfeld, not only by chance the former residential of a local teacher, Pauly, who was 1839 the initiator of “geological” research in the Eckfeld maar and who had to emigrate from Germany to America after his failure to exploit the “browncoal” in the maar successfully (Löhnertz, 1978c; see also **Stop 4**).

STOP 4: Eckfeld Maar (Middle Eocene) (H. Lutz)

Introduction

Some of the most spectacular continental “fossillagerstätten” of the European Tertiary have been deposited in maar lakes. The Eckfeld Maar is one of these outstanding localities. The spectrum of fossils includes almost everything from organic molecules to articulated mammals with “soft tissue“ preservation and contents of the digestive tract. But the Eckfeld maar lake sediments do not only yield a highly diverse taphocoenosis allowing for detailed reconstructions and analyses of its former aquatic and terrestrial biocoenoses. They also provide unique data for paleoenvironmental and paleoclimatological research. From maar lake sediments in general these informations are available with an unrivalled high resolution as in many cases the lamination turned out to be varves that are reflecting annual or even seasonal periodicities. This makes maar lake sediments suitable for analyses of environmental changes and climatic variations and their impact on the biota.

NB: It should be noticed that Eckfeld Maar is under protection. Any sampling or excavations without official permit are strictly forbidden!

History of investigation

The oilshales of the Eckfeld Maar have been discovered by Pauly, a local teacher, in 1839 and in 1854 he started to mine what he called ”browncoal“. However, because of technical difficulties he soon had to give up his enterprise. Steininger, who in 1819 introduced the local idiom ”Maar“ into scientific literature, shortly mentioned this isolated outcrop of ”browncoal“ in 1853 and in the same year Weber described it in more detail and listed the first finds of dicotyledonous leaves comparing them with species of the Rhenish browncoal. After this initial phase of investigation the locality was widely ignored by palaeontologists for more than a century.

A maar origin for this structure was for the first time suggested by Löhnertz (1978) and his opinion was strongly supported by evidence from a core drilled in the centre of the outcropping oilshales (Negendank *et al.*, 1982). Additional geological, geophysical, and sedimentological data later confirmed these results (e.g. Pirrung, 1998; Fischer *et al.*, 2000; Pirrung *et al.*, in press).

Field work by the Naturhistorisches Museum Mainz/Landessammlung für Naturkunde Rheinland-Pfalz started in 1987. Since then more than 35.000 macrofossils have been extracted from approximately 1200 m^3 oilshale, and the respective taphonomic data have been gathered with high resolution (Lutz & Neuffer, 2001).

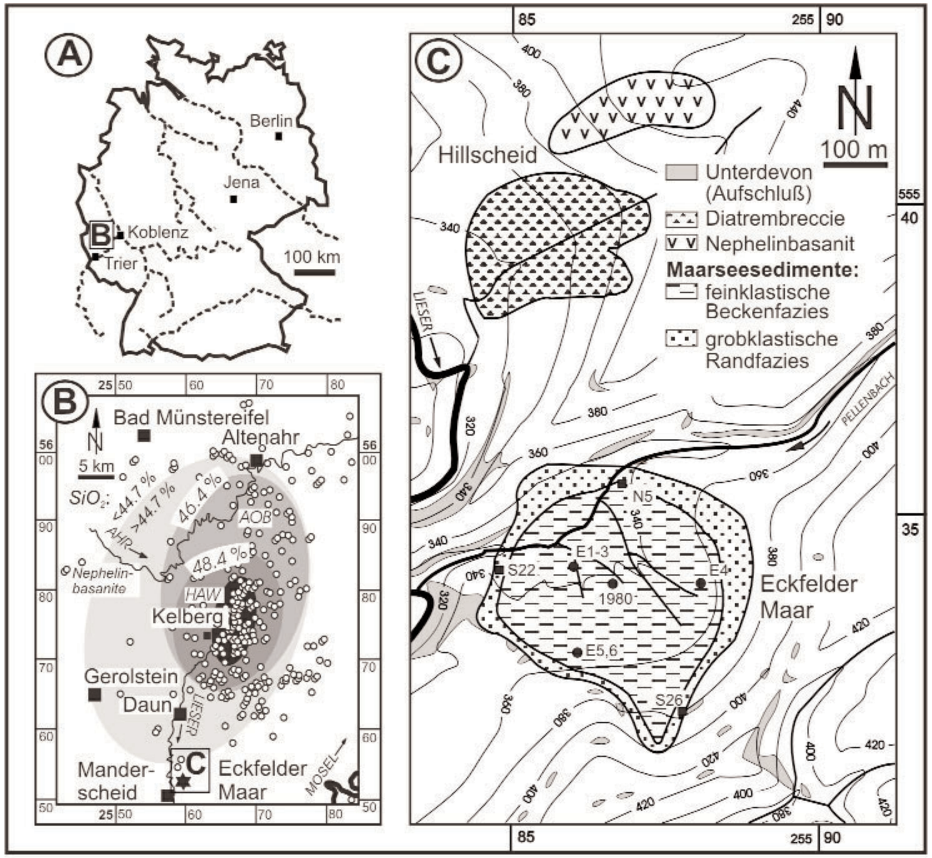


Fig. L1.- Tertiary High-Eifel Volcanic Field and simplified geological map of Eckfeld Maar and its surroundings showing the drilling locations 1980 an E1-6 (after Fischer, 1999).

Geological setting and local paleogeography

The Eckfeld Maar and two neighbouring volcanic structures (**Fig. L1**) are surrounded by marine sand- and siltstones of Lower Devonian age and are aligned along a NNE/SSW trending fault (Meyer *et al*., 1994). They are situated near the southern margin of the Tertiary High-Eifel Volcanic Field (THV). Its centre, the so-called Kelberg High, is located approximately 20 km NNE of Eckfeld and was considerably elevated in late Palaeogene times (Büchel & Pirrung, 1993). The THV consists of about 400 distinct volcanic structures. According the THV was active from 45 to 24 Ma (Cantarel & Lippolt, 1977; Müller-Sohnius *et al*., 1989). However, current studies using $^{40}Ar/^{39}Ar$ laser fusion technique revealed that all volcanoes dated so far erupted in the Middle to Late Eocene (Fekiacova *et al*., 2003).

The Middle Eocene relief of the West-Eifel region and its drainage system have been reconstructed by Löhnertz (1994) and Fischer & Pirrung (*in*: Fischer, 1999 and Pirrung *et al*., in press): Presumably less than 4 km W of the Eckfeld Maar the Buntsandstein formed a 200 m high escarpment. A small river that originated on the elevation of the THV near Kelberg followed its margin southward - along the so-called Manderscheid valley - to the Arenrath basin where it joined the Proto-Saar River (**Fig. L2**).

Genesis and pyroclastics

In 1996 and 1999 seven new cores were drilled at four locations within the crater by the Landessammlung für Naturkunde, the Geologisches Landesamt Rheinland-Pfalz, and the GeoForschungsZentrum Potsdam. The subcentral core E1 comprises a 123 m long sedimentary record which has been divided by Pirrung (1998) and Fischer (1999) into six lithozones: D2: bituminous laminites (5-33.5 m); D1: grey laminites (33.5-41.3 m); C2: turbidites (41.3-60 m); C1: turbidites with pumice (60-87 m); B: grain-supported breccia, rich in pumice (87-113 m); A: syneruptive, grain-supported, lithologically monotonous breccia of basement rocks (113-123 m; **Fig. L3**). Comparable sequences had already been described from maars of Quaternary age (Pirrung, 1998). Thus, final proof for the maar hypothesis is now based on sedimentological and petrographical evidence as well as on additional geophysical data (*e.g.* Wonik, 2000). Considering all information the morphometry and the early sedimentary history of the Eckfeld Maar can be summarised as follows.

Initially the crater (**excursion site 1**) had an estimated diameter of 900-1000 m and a maximum depth of 210 m. After volcanic activity had ceased the crater walls and its surrounding tuff ring stabilised by mass movements towards the central crater floor. At the same time groundwater rapidly filled the crater. The uppermost pyroclastics have already been deposited under water as is proved by graded bedding **(Fig. L4**).

Lake sediments

In the rather flat, central area of the basin an initial 8 m thick sequence of minerogenic grey laminites (lithozone D1) is followed by bituminous laminites (“oilshales”; lithozone D2). This pelitic central facies is surrounded by a coarse marginal facies (tuffite) consisting of fragmented Devonian sandstones and juvenile basanitic lapilli (**excursion site 2**). During the early development of the lake mass movements occurred frequently. Thus debrites and turbidites of varying composition (extra- and intraclasts, organic debris) are intercalating with the laminites. At the excavation site which is located ca. 100 m NW of the centre of the outcrop (**excursion site 3**) the thickness of distal debrites and turbidites ranges from less than a millimetre to approximately 20 cm. Abundant plant debris, internal moulds of molluscs, and disarticulated vertebrates show that some of them originated from photic and oxygenated near-shore areas (Lutz & Neuffer, 1994).

Besides evenly laminated sequences, several other subtypes of oilshale can be distinguished with respect to structure (*e.g*. turbiditic oilshale *sensu* Goth, 1990) and composition (*e.g.* contents of authigenic siderite and pyrite). The evenly laminated oilshale consists of alternating light (100-150 µm thick) and dark (150-250 µm thick) laminae. The darker ones mainly consist of mineral detritus, terrestrial plant debris, green algae (mostly *Botryococcus* and *Tetraedron*), and siderite, whereas the lighter ones mainly comprise clay minerals (illite, montmorillonite, kaolinite), and quartz (Mingram, 1998; Bullwinkel & Riegel, 2001). During the earlier phases of oilshale deposition longer sequences of diatomites are present (Negendank *et al*., 1982; Wilde *et al.*, 1993; Zolitschka, 1993).

The Eckfeld maar lake

Remnants of dark pelitic sediments near the upper edge of the crater prove that the initial water depth exceeded 110 m (Pirrung, 1998). In this deep lake trophic conditions rapidly changed from oligo- to eutrophic and permanent meromixis

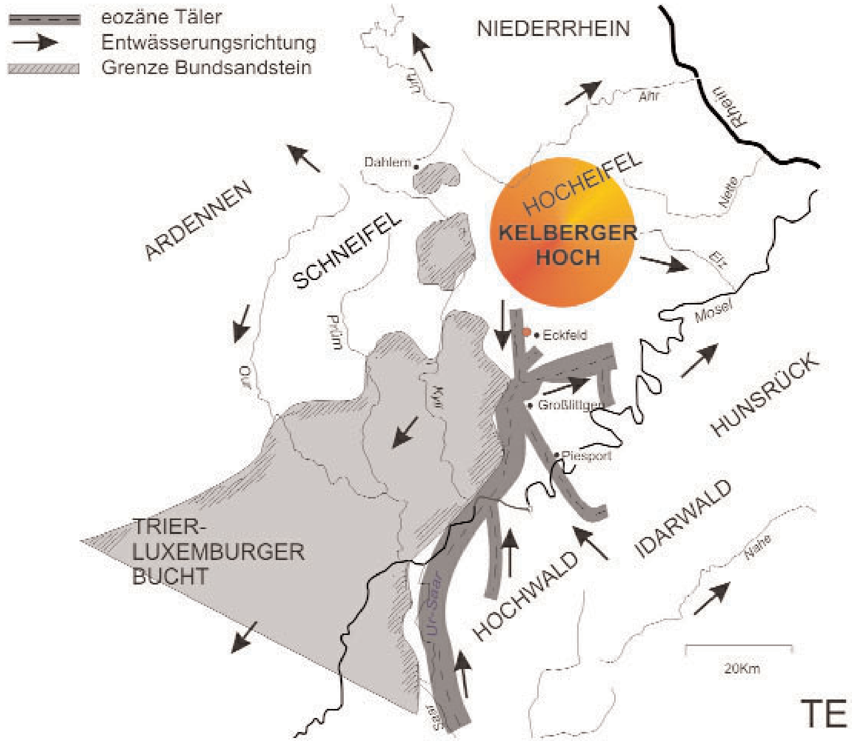
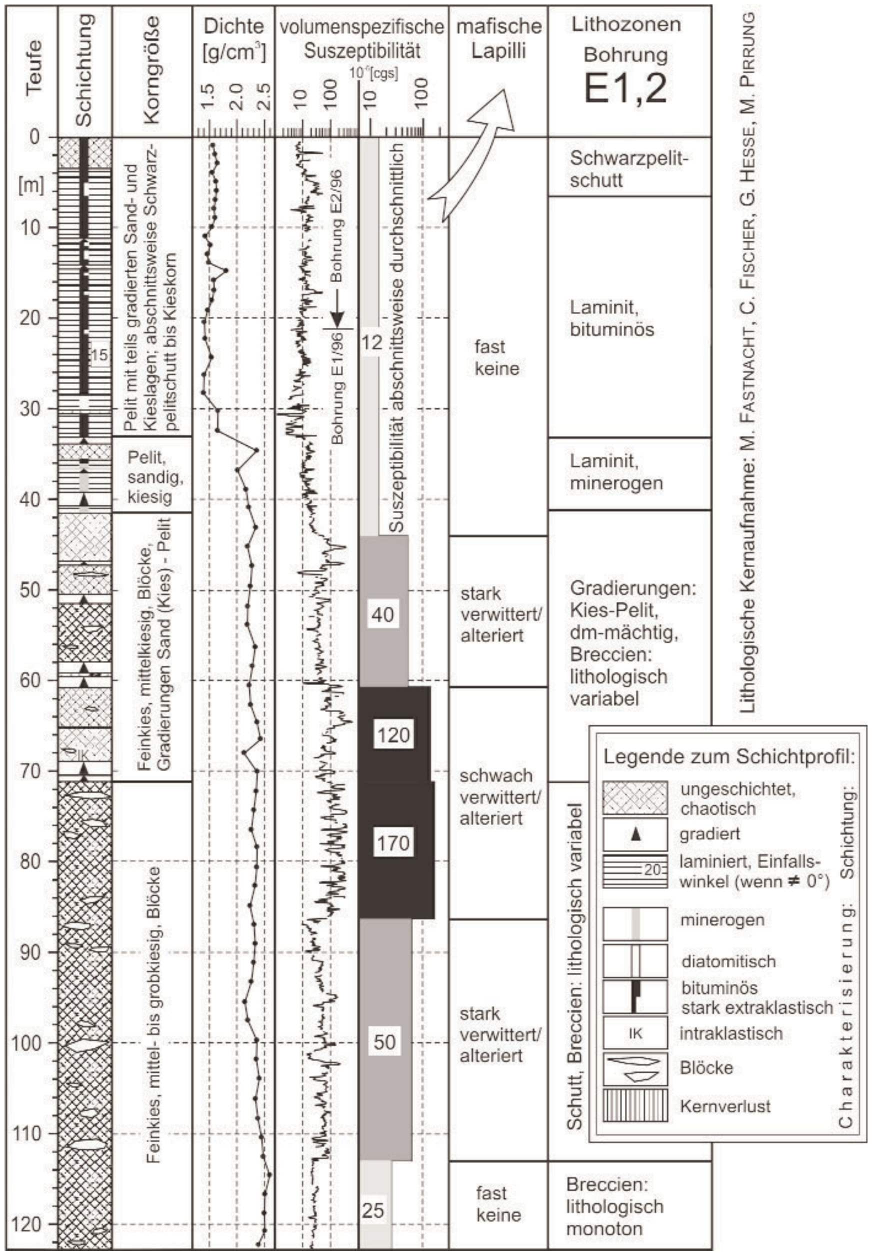


Fig. L2.- Reconstruction of the Middle-Eocene valley system of the Westeifel (modified after Löhertz, 1994).



established (Wilde *et al.*, 1993). Anoxic, alkaline conditions (Micklich & Wuttke, 1988) and the accumulation of electrolytes (mainly iron-II-bicarbonate, comp.: Bahrig, 1989; Felder *et al.*, 2000) and toxic gases (*e.g.* methane) in the monimolimnion prevented bioturbation. This explains the perfect preservation of both, lamination and individual fossils. Additionally, recycling of organic matter was limited as is proved by the preservation of complex organic molecules of *e.g.* bacteria, algae, and terrestrial phanerogams (Zink & Püttman, 1994).

Taphonomy, Flora and Fauna

The exceptionally rich fossil record is documenting a highly diverse terrestrial flora and fauna (*e.g.* Neuffer *et al.*, 1996; Lutz *et al.*, 1998). In contrast, aquatic life was rather poor in species. Taphonomic data revealed that the number of individuals of fish and molluscs seems to correlate negatively with the contents of siderite in the oilshale. As an accumulation of dissolved iron bicarbonate is an essential prerequisite for the synsedimentary precipitation of siderite, one may assume that a partial turnover of mixo- and monimolimnion, caused *e.g.* by subaquatic slumping, led (at least locally) to an episodic poisoning of the mixolimnion. This explains both, the low diversity of the aquatic biota and the presence of euryhaline species that in some layers appear in great numbers (Lutz, 1997, 1998, 2000; Gruber & Schäfer, 2000).

The flora comprises algae, fungi, bryophytes, ferns, gymnosperms, and mono- and dicotyledonous angiosperms. Up to now more than two hundred taxa have been identified (Nickel, 1996; Wilde & Frankenhäuser, 1998). Thousands of leaves, fruits, and seeds of angiosperms dominate the macrofossil record. Besides, more than 700 flowers and inflorescences with pollen *in situ* are of outstanding importance. They are of great relevance in clarifying the systematic position of isolated pollen grains and in deciphering the evolutionary level of Middle Eocene angiosperms in more detail. Furthermore, aspects of insect-plant interaction may be studied. The exceptional potential of that kind of preservation is demonstrated by a honeybee that is carrying its last pollen load still *in situ* (Lutz, 1993; Wappler & Engel, in press).

Animal life in and around the Eckfeld Maar Lake is documented by rhizopods, sponges, gastropods, bivalves, crustaceans, spiders, insects, fish, amphibians,

Fig. L3.- Well section of the subcentral drillings E1, 2 with indication of lithozones (after Fischer, 1999).

reptiles, birds, and mammals (*e.g.* Gruber, 1994; Neuffer *et al.*, 1996; Schiller, 1999; Wappler, in prep.). Among the mammals first discoveries of primates (Franzen, 1998), a tiny Artiodactyl with the size of a hedgehog, and six articulated skeletons of *Propalaeotherium* are most spectacular. One of these is a pregnant female that has its digestive tract still stuffed with leaf-cuticles. Equally important are uncompressed skulls of the same genus (Franzen, 1994). Many fishes with little dark spots on their back (melanophores) or *e.g.* a specimen of *Propalaeotherium* with part of its fur being preserved, and feathers prove that "soft tissue" preservation is a common phenomenon in Eckfeld. First investigations of fish with a SEM revealed that at least in some cases this has been caused by phosphatized bacteria (Micklich & Wuttke, 1988).

Age of the Eckfeld maar

Biostratigraphically, Eckfeld represents the Upper Middle Eocene, mammal level MP 13, which is located just below the top of the European Land Mammal Age Geiseltalian (Franzen, 1993). This is confirmed by palynological data (Nickel, 1996). Its flora and fauna are thus representing a paleoecosystem near the end of the Eocene climatic optimum. In core E1 angular fragments of alkali basalt were recovered from the diatreme breccia below the lake sediments. These could be dated by $^{40}Ar/^{39}Ar$ technique yielding a plateau age of 44.3 ± 0.4 Ma (1sigma). This age agrees with the biostratigraphical estimate and is suitable as a first numerical calibration mark for the European Eocene time scale (Mertz *et al*., 2000).

Paleoclimate

Many bio-indicators like *e.g.* palms and crocodiles are available that are pointing towards a humid paratropical climate. First studies of oxygen- and carbon-isotopes of siderite and diatoms revealed considerable climatic variations and, as a consequence, changes in hydrology (Bahrig, 1989; Felder *et al.*, 2000; Sabel *et al.*, 2000). First results from spectral analysis revealed, besides some minor ones, two prominent peaks: The 11 years Schwabe-cycle (sunspot-cycle) and the ca. 22 years Hale-cycle of the magnetic activity of the sun (Mingram, 1998; Vos *et al*., 2000; Vos & Mingram, 2002). This, together with pronounced seasonality due to the paleolatitudinal position of Eckfeld (ca. 42° - 44° N), makes it very likely that the lamination of the Eckfeld oilshale does represent varves (Mingram, 1998). This means that the laminites allow for time sequence analyses to detect short and medium term trends in climatic changes rendering Eckfeld a

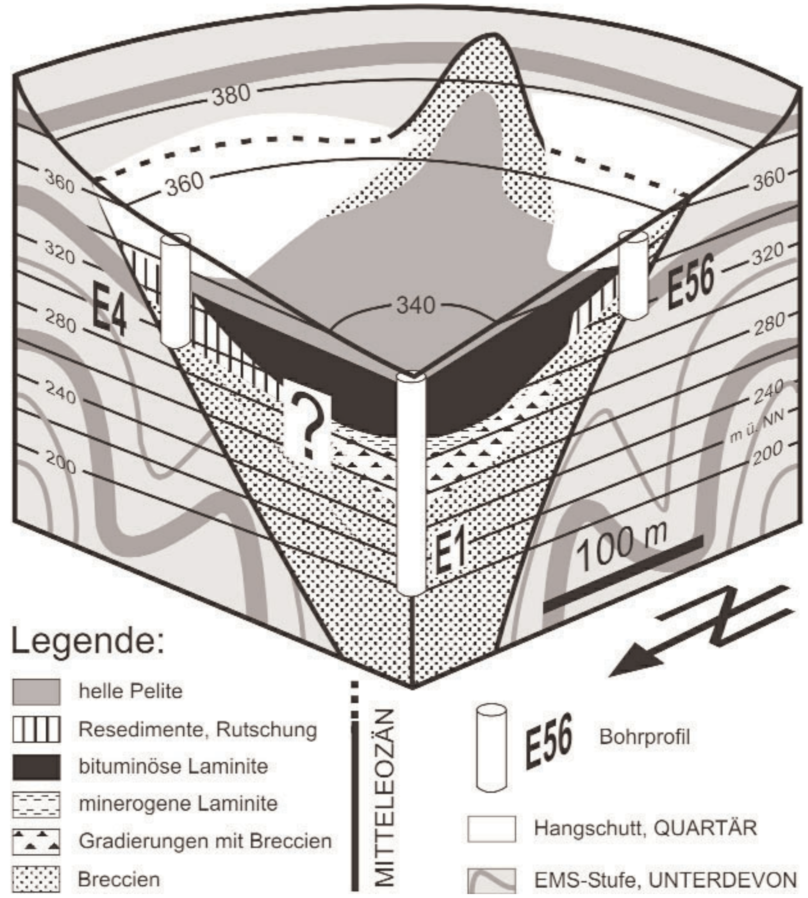


Fig. L4.- 3D-diagram of the extant Eckfeld Maar. Reconstruction based on core-drillings (after Fischer, 1999).

suitable object for an analysis of Eocene solar-terrestrial relationships and their impact on the paleoecosystem.

On the way back (W. Löhnertz)

From Eckfeld to the A48 in the direction of Trier over the planation surface of the 400 m - level ("Trogregion"). From Laufeld - a small village to the right - with gentle gradient down to the Eocene "Hasborner Talung" (Lutz, **Fig. L2**; Quitzow, 1969; Löhnertz, 1978; 1994), which will be crossed at a right angle exactly at the Exit Hasborn. Then immediately climbing the southern bank and slope of the Eocene river, up to the "Trogregion". Well rounded quartz gravel on this surface, for example around "Grünewald" (8 km North of Wittlich), are also proof of the "valley filling".

Uphill into the "Wittlich Basin", a depression of the Permian, whose mostly soft sediments are largely eroded, leaving a very gentle morphology. Reaching the foot of the steep slope there are on the left two typical cones ("Neuerburger Kopf" and "Lüxemberg"). They are volcanoes respectively silicifications due to volcanic activities in the Cretaceous (108 Ma; Negendank, 1983), dissected out of the Permian sediments in the Pleistocene.

After the Exit Wittlich a good exposure of the Permian ("Kreuznacher Fazies") by the cut of the motorway (Sneh & Binot, 1982; Stets, 1990). After the Exit Salmtal just to the Exit Schweich a fine overview about the Pleistocene landscape formed by the Old Pleistocene gravels and sands of Salm and Mosel. Extensively discussed problems of (i) a bifurcation of the Mosel or (ii) large meanders of the Mosel reaching the "Wittlich Basin" and of (iii) post-Pleistocene tectonic etc. have not yet been solved convincingly (Kremer, 1954; Müller,1976; Negendank, 1978; 1983; Löhnertz, 1982; Hoffmann, 1990).

Where the motorway crosses the Mosel there is to the left and in front a view over the terraces of the Mosel (Kremer, 1954) and to the entrance of the Mosel "canyon" into the Devonian, rising up the question: "why not use the Wittlich Basin?" On both sides of the Mosel the 400 m level of the "Moselberge", relics of the "Trogregion". Changing the motorway to the A602 in the direction Trier now on the right hand the view back into the "Wittlich Basin" with its wide and gentle landscape. On the right further the high and steep undercut bank of the Mosel following a fault cliff between Buntsandstein and Devonian (Negendank, 1983).

Final changing of the motorway in direction Luxembourg (A64) it needs a long and steep rise up - crossing the profile Buntsandstein (sm_2) to Muschelkalk (mo_1) - to reach the starting point on the B51.

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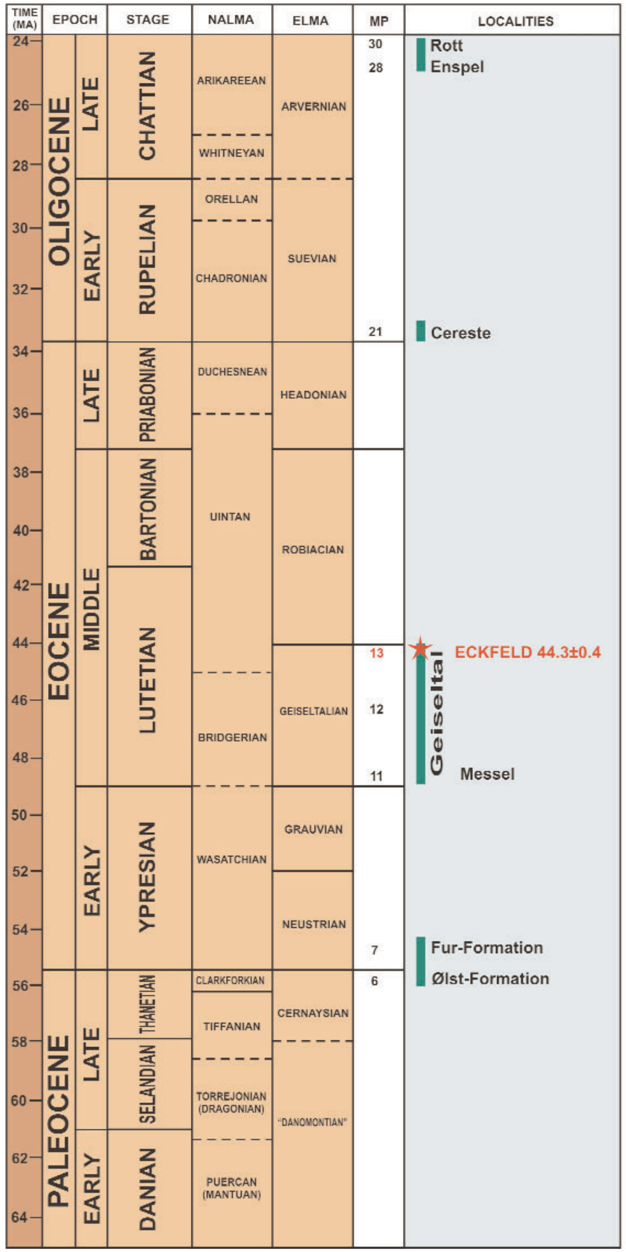

Eckfeld Maar within the Paleogene time frame with tentative correlation of European (ELMA) and North-American (NALMA) Land Mammal Ages. Radiometric age for Eckfeld Maar from Mertz et al. *(2000). Compiled by T. Wappler, 2001.*