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GEOLOGY OF THE SITE KUČLÍN, TRUPELNÍK HILL NEAR BÍLINA IN NORTH BOHEMIA

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Abstract. The overview of the geological structure of the site Kučlín, Trupelník Hill, is given with particular reference to the fossiliferous diatomite famous for various plant and animal fossils. This part of the České středohoří Mountains has been a focal point of geological exploration and Palaeontological activities since 1840, as summarized in this paper. The age of the diatomite was estimated as the Late Eocene, based on radiometric ages of adjacent and overlying intrusion/lava flow. Besides detailed descriptions of the geological section, also Palaeogeographical relationship of the locality of Kučlín and geological development of other parts of North Bohemia and adjacent Saxony are given.

■ Geology, diatomite, Late Eocene

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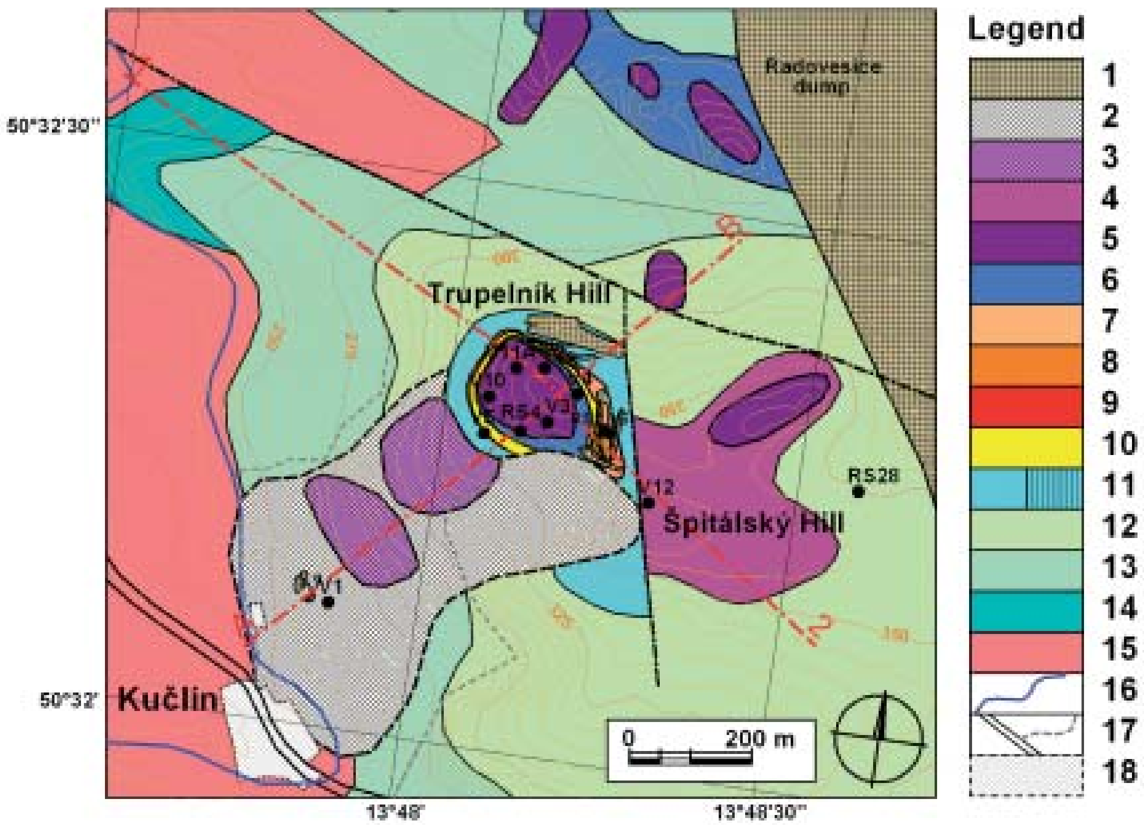
Introduction

The aim of this article is to clearly and concisely summarize the current state of knowledge regarding the geological compositions of the locality Kučlín, Trupelník Hill near Bílina. The Trupelník Hill, 355.8 m above sea level, lies northeast of the village Kučlín (formerly Kutschlin), about 1.5 km southeast of Bíliny. On older maps, the west summit is marked as the Trupelník Hill; the east summit is called Špitálský vrch Hill (Spitalberg). The entire hill was sometimes called the Tripel Mountain (Trippelberg). It is a noteworthy Palaeontological locality of the basal pyroclastics from the entire massif of the Czech central mountain (České středohoří). Fossils found here distinguish the locality at Kučlín from other localities in North Bohemia and clearly document its Palaeogene (late Eocene) age. While the Kučlín locality (Trupelník) represents the beginnings of the neovolcanic phase, other significant Palaeontological localities (Žichov, Roudníky, Bechlejovice) of the České středohoří Mountains are younger. However, neither micro- nor macro-Palaeontology is the subject of this paper.

Source of data regarding the geological composition of the locality of Kučlín, Trupelník Hill

A detailed description of the locality is made possible not only by descriptions published by the geologists of the 19th century (Reuss 1840, Kafka 1911); quarrying of the diatomaceous earth conducted here during the second half of the 20th century allowed Palaeontological research (Bůžek, Holý 1964, Bůžek 1993), as well as extensive geological exploration (numerous drill cores, flutes, probes and shafts) conducted with the goal of ascertaining the extent of the diatomaceous earth deposit (Horáčková 1967). The following description of the locality is drawn primarily from this research. Actual quarrying in this locality proceeded in three locations: in the foothills of a peak north of Kučlín, on the northeast slope and in the saddle between Trupelník and Špitálský vrch. Since the explorations in 1967 did not show any additional deposits of diatomaceous earth suitable for industry of the time, further quarrying was suspended and since then, the locality has been exclusively the domain of amateur and professional Palaeontologists. No further geological explorations have been performed. A more detailed exploration was performed by a team of authors of a geological map 1:25,000 - 02 - 341 Bílina (Kopecký et al 1990) and a less detailed study was published in connection with some Palaeontological studies (Bellon et al 1998, Kvaček 2002). In 2001, the locality was pronounced a nature preserve.

The geological map included here (Text-fig. 1) was produced by digitalization and updating of Horáčková's map from 1967 and a state geological map in 1:25,000 (Kopecký et al 1990). The stratigraphic column (Text-fig. 2) came from a correlation of data and documents attached to Horáčková's report of 1967. The cited sources were used to produce a database of drill cores and probes, which was subsequently used to produce geological cross-sections, with help of Atlas DMT software (Text-figs 3–4). This was also the source for all terminology used in this locality. The authors have also visited the locality many times personally, both to collect fossils and to document all attendant circumstance of the collections.



Text-fig. 1. Geological map of the site Kučlín, Trupelník Hill.
1 – dumpsite body, exploitation faces, 2 – landslide body, 3 – occurrence of the basalt in the landslide body, 4 – tuff, tuffite with gneiss particles, 5 – 11 – Late Eocene rocks. 5 – basalts, 6 – tuff, tufite, 7 – diatomaceous cherts layer enclosing lenses of diatomaceous earth, 8 – diatomitic breccia, 9 – diatomaceous shale, 10 – diatomaceous clays to diatomites, 11 – calcareous diatomaceous clays to diatomaceous limestones and re-deposited Cretaceous material, 12 – Late Turonian marlstone to limestone, 13 – Middle Turonian marlstone, 14 – Middle Turonian organo-detritic limestone to conglomerate, 15 – Late Proterozoic orthogneiss, 16 – Syčivka creek, 17 – road, field drives, 18 – Kučlín village.

Stratigraphy of the locality

Bedrock

The base of the profile in the Kučlín area is formed of bedrock exposed by erosion in the valley of the Syčivka creek, stretching from Bílina all the way to the village of Kučlín. Generally, it is classified with Krušné hory (Ore Mountains) bedrock and is upper Proterozoic in age. The original material of the Bílina bedrock was pre-Variscan granite. Its metamorphosis created a petrographically monotonic variety of orthogneiss, which in places contains preserved aplite veins.

Mesozoic – Cretaceous

Directly upon the Proterozoic base are layers of Cretaceous marine sediments, beginning with the lower Weissenberg Formation, middle Turonian in age. It is noteworthy in its unusual facies, formerly called the Hippurite layer (Reuss 1844). On the western flank, and in the valley below the Bílina hospital, the sandstone and organodentric limestone transgress directly onto the gneiss. These rocks represent generally a very hard, yellow limestone, on a base of weathered gneiss fragments to gneiss conglomerates. The thickness of their eroded fragments does not exceed 12 meters. According to the data known from a drill core, the organodentric limestones border on a rather abrupt shore of Bílina bedrock, which was dry land during the period of Turonian ocean transgression. After their deposition, the sea regressed and subsequent erosion began. Higher Cretaceous units sit atop these limestones in a discordant fashion.

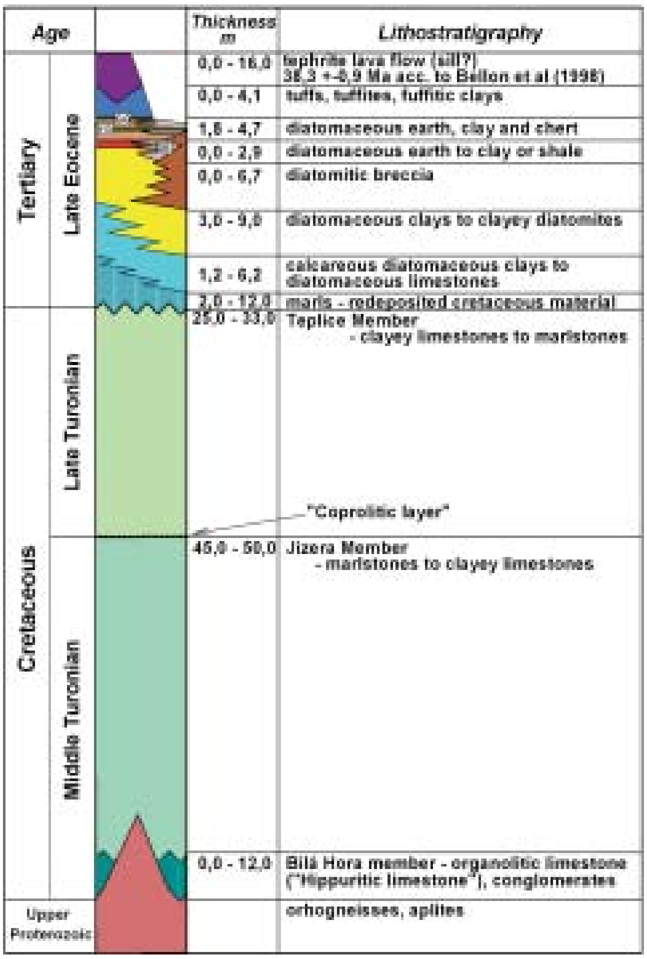
Shallow-sea marl development arises from thin layers of glauconite sandstones and is formed primarily by soft, thin, slightly sandy marl of the Jizera Formation. The layers are subhorizontally deposited and reach a thicknesses in the locality of over 30 meters. Their ceiling is marked by a 10-60 cm thick "coprolite layer" of yellow clayey limestone with glauconite, phosphatized fish bones and coprolites. This layer crops out east of Kučlín in a small quarry, today largely overgrown and filled with rubble.

Marl and limestone in the Teplice Formation of the upper Turonian to Coniacian age are also exposed in an old open-pit quarry in the foothills of Špitálský vrch, near the eastern edge of the village. The lower portion of the Teplice Formation comprises mostly firmer limestones and was termed the "body" the Teplice Formation. Due to its high concentration of limestone, it was often quarried for lime production. The higher portion of the upper Turonian limestones was again formed predominantly by clayey varieties limestone, even marl. The thickness of the Teplice Formation varies from 35 to 55 meters.

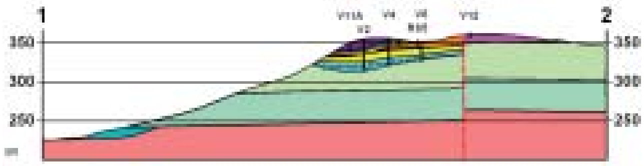
Tertiary – Palaeogene

The most significant portion of the locality represents a quite limited area (cca 97 000 m^2) of Tertiary volcano-sedimentary deposits, characteristic in their content of various types of fossiliferous diatomitic admixtures. The set of Tertiary layers is covered by an erosional remnant of a basaltic lava flow (or a horizontal vein), whose existence prevented the erosion of the entire unique set of layers below. The basaltic rock has been ascertained to be sodalitic tephrite. Considering the dating of the basaltic layer to 38.3±9 million years (Bellon at al 1998), the Tertiary volcano-sediments below have been dated to the late Eocene. During the Quaternary, erosion by the Syčivka creek led to repeated landslides on the western flank of the hill. This caused secondary outcroppings to form at the base of the hill of both basaltic and volcano-sedimentary character. Diatomitic rocks in the slump have also been the target of both quarrying and Palaeontological research.

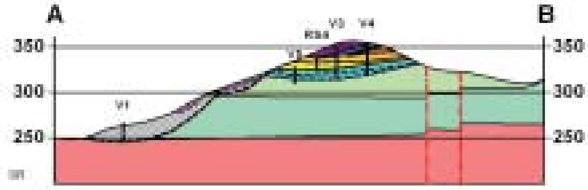
The actual section of the Palaeogene deposits starts with the 2-12 meters thick layer described as transported marl. Large variations in thickness indicate filling of a weathered, eroded Palaeogene relief. These sediments are characteristic in their wide variability of texture and color; they are routinely found cross-bedded, pointing to alluvial sedimentation, with carbonized plant remnants and broken-off pieces of wood. Besides limestones, gypsum is commonly found here, in the form of tiny connected layers and concretions. Deposition of weathered Cretaceous material with an admixture of bedrock and volcanic material, together with the first thin layers of diatomitic limestones shows that this was an area of gradual pan formation, although it may have been one that periodically dried out. The actual onset of wetter lake or marsh sediments with the presence of at least temporary standing water with diatoms is documented by both lateral and vertical gradual transition of transported marl to layers of calcareous diatomitic clay and clayey diatomite. This layer continues with a marked variety, both lateral and vertical; there are nodes of diatomitic chert, diatomite and diatomitic limestones. Color of the rocks varies from various shades of brown to beige. Diatomitic claystones show an agate, slightly banded texture. Diatoms are present in practically all types of rocks. Clayey diatomites and diatomic clays form 80% of the content. The diatomites are generally hard minerals. Gypsum is found in the form of concretions and thin layers, and plant remains are found as well. The layer is 3 to 9 meters thick.



Text-fig. 2. Stratigraphic column of the Trupelník Hill: (GG) – green-gray diatomaceous clay, (YG) – yellow-green diatomaceous clay, (DE) – diatomaceous earth.

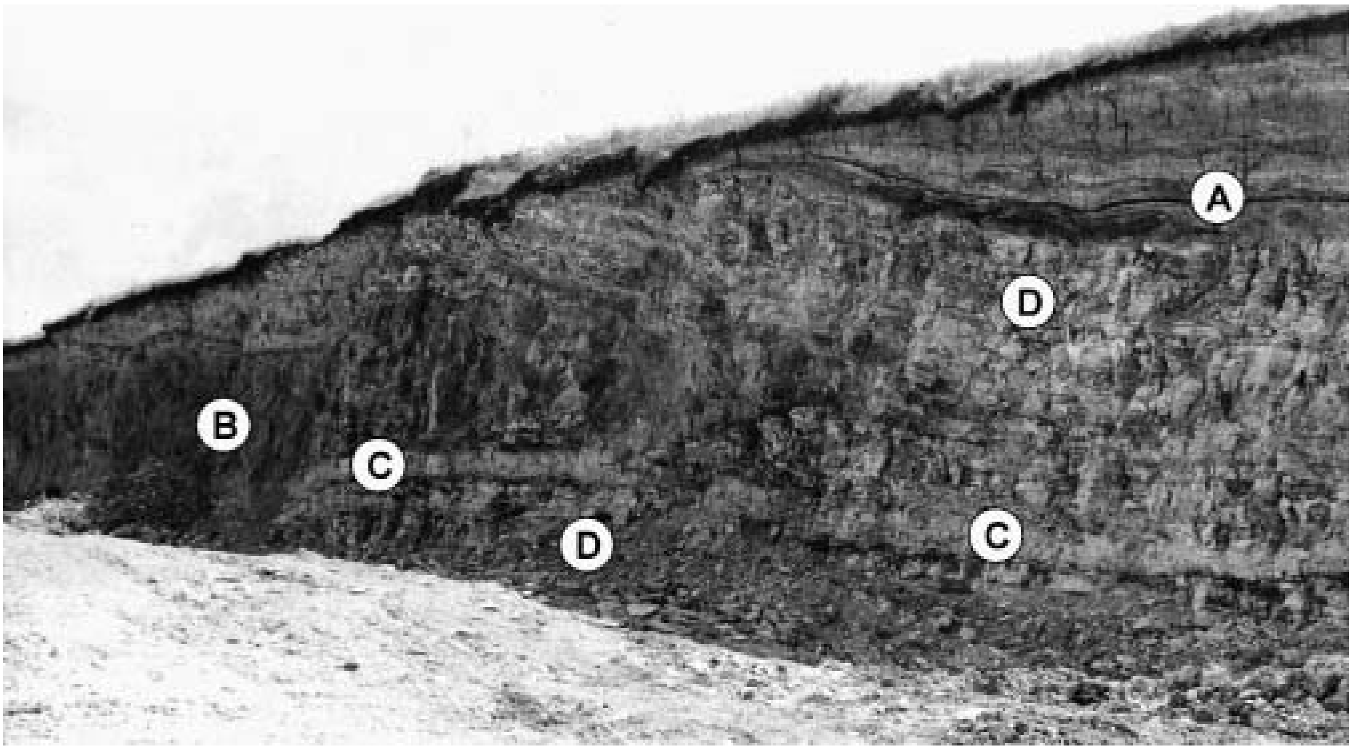


Text-fig. 3. Geological cross section 1 – 2 (for legend see text-fig. 1).



Text-fig. 4. Geological cross section A – B (for legend see text-fig. 1).

The upper portion of the diatomitic clays and diatomites is intruded from the south to southeast by a wedge of brown-purple diatomitic breccia. This is a rock whose light brown color with hint of purple is formed by diatomitic clay. In the thickest portions, the layer contains breccia blocks of Cretaceous marls up to 40 cm in diameter, while in areas closer to the upper and lower contacts, the layer tends to contain smaller fragments and the rock tends to assume the character of a grainy tuff. Among the fragments, rounded light-colored inclusions of soft clayey diatomite, around 10 cm in size are most numerous. The maximum verified thickness of the breccia wedge is 6.7 meters. Where the top of the diatomitic clays is not covered by diatomitic breccia or diatomitic opal chert, there is a continuous layer of brown to purple polish shale, 0.9 meters thick. The rock is characterized by a lamination to layering, caused by changes in the amount of clay and opal from dissolved diatoms, likely due to seasonal variations of organogenic sedimentation. Opal predominates in the mineral content. This layer represents the first appearance of lake sediments in the stratum. To the southeast, the layer is splitted by a wedge of diatomitic clay, which marks the possible source direction of clastics, concurrent with the source direction of



Text-fig. 5. Exploitation section on the northern slope of the Trupelník Hill. Photo M. Čada 1963. Height of the section ca. 2.5 m. a) – coaly clay, b) – diatomaceous breccia, c) – yellow-green diatomaceous clay, d) – diatomaceous chert.

the diatomitic breccia material. The layer contains both fish and plant fossils.

In the overburden above the polish shale and all throughout the seam runs a layer of diatomitic opaline cherts, into which intruded the wedge of diatomitic breccia described above (Text-fig. 5). Even though cherts predominate in the layer, they routinely alternate with layers of other types of diatomite with variable clay content, amount of opalization and type of layer splitting. Color of the sediments generally ranges from light brown to cream to purple. In any case, it is clearly another layer with internal layered to laminated structure, originating in lake conditions. The layers of diatomitic cherts can reach a combined thickness of 4.7 meters. We assume that this layer of diatomitic opaline cherts was the source of most Palaeontological material collected in the past. The layer is divided by a clearly distinguishable 0.35 to 0.5 meter thick layer of yellow-green diatomitic "clay". This layer may be considered as one of the stratigraphic markers of the seam. To the east, this layer disappears beneath a body of diatomitic breccia and subsequently terminates. Photographs of walls of the quarry in the north flank of Trupelník show the relationship between the layers and the above-described wedge of diatomitic breccia (Text-fig. 5). The layer of yellow-green diatomitic clay is younger to concurrent with the breccia wedge. Petrographically, it is not clay, but a breccia of fragments from solid and split-layered diatomites; apparently this level represents an eroded depression in the seam, associated with a drop in water levels of the sedimentary basin – intraformation breccias.

In the overburden of diatomitic cherts, there is a continuous layer of dark brown to green-brown diatomitic clay, transitioning to diatomite. The top surface of this 0.1 – 0.2 meter layer is crusted by a several-centimeter thick layer of coaly clay, which essentially ends the diatomic sedimentation of the seam. The southeast portion of the quarry, above the diatomitic breccia wedge, inside the layer of diatomitic cherts, there are irregular nodes of diatomaceous earth in three vertical bands of thicknesses 0.3 to 3.9 meters. Transitions from cherts to diatomaceous earth are abrupt.

Between the basalt body and the diatomite, there is a layer ranging from 0 to 4 meters thick of brightly colored tuffites, tuffs and the tuffogenic clay montmorillonite – kaolinitic composition with rare occurrences of diatomitic clay nodules. These clays with rare occurrences of diatomitic clays and a ceiling of clayey tephritic tuff support the theory of the end of sedimentation by volcanic activity, which peaked with the extrusion of a tephritic lava flow. This sealed and preserved the diatomitic sedimentary strata.

East of the north-south fault near Špitalský vrch is a layer up to 9.5 meters thick of light green to gray clayey, bentonitic tuff with numerous chunks of gneiss up to 10 cm in diameter, and fragments of aplite. These rocks do not occur west of the fault.

Quaternary

In the Quaternary extensive erosion took place in the landscape, during which the bend of the Syčivka creek caused intensive erosion of the slope built by Cretaceous marl, which led to repeated landslides on the southwestern face of the hill. Massive slump formations arose here, in which there are chaotic occurrences of fragments of the tephrite body, difficult to separate from debris, as well as large chunks of underlying diatomites. The thickness of the slump body at the foot of the hill reaches up to 17 meters. A secondary seam of diatomite at the foot of the hill north of Kučlín has also been quarried. To the east of Trupelník in direct contact with Špitálský vrch there is a widespread, 30–140 meter thick body of the Radovesice waste heap, composed of rocks of Miocene age, transported there from the working brown-coal open-pit quarry Bílina during the years 1969–2003.

Main features of the geological structure

The entire bedded Eocene body is situated on an uneven eroded relief, formed in the Palaeogene on underlying the subhorizontally deposited Cretaceous marls. Together with a tephrite extrusion, the diatomite layers are tilted at an angle of about 7° to the west. The thickness of the layer varies from 20 to 35 meters. The most typical aspect of the sedimentation body is the presence of diatoms or their decayed remains. As we see clearly from the description of its internal structure, it is sharp and apparently asymmetrical with the main gradient of change, perpendicular to the north-south fault line limiting diatomitic rocks, i.e. to the west, according to the layer tilt. The parameters of the fault are not clearly understood; its position is only possible to estimate from the construction of various geological sections. The fault was apparently active during the formation of the diatomite seam; the blocks to the east rose and contributed material into the basin to its west. This is most apparent in the case of diatomitic breccia wedge , which contains large fragments of marl. To the east of this fault, instead of diatomites and limestone minerals, there is a layer of rocks described as tuff with numerous fragments of biotitic-muscovitic metamorphosed gneiss. The description of this rock does not correspond with any sort found on the west side of the fault. So this is clearly a much older relic, or contrariwise, a much younger unit. The maximum thickness of the unit is also not known. A later origin is more probable – for example, it might correspond with the explosive phreatomagmatic breccias from the same period as the origin of the phonolitic bodies (the closest phonolite hill is Bořeň), which arose in the Oligocene, ca. 27 – 33 mya. To the north of the locality is another fault, east-west, identified only from geologic maps, with its south side descending. Clearly, its existence also positively affected the preservation of the locality.

Diatomitic rocks are currently uncovered in the remains of the quarry in the saddle between the hills Trupelník and Špitalský vrch, and in the two-level abandoned and re-filled quarry on the north side of the hill.

Summary of Eocene geological development of the locality

During the late Eocene in the area west of the north-south fault, a basin slowly developed, whose extent is not documented by any other evidence. Initial erosion of the underlying Cretaceous rocks, older volcanics, was accompanied by the first deposition of alluvial to lake sediments, called transported marls. Gradual deepening of the basin led to occasional permanent surface water, and eventually sedimentation of fresh-water limestones and the first diatomitic rocks. Especially in the early stages, sedimentation probably took place in a non-outflow and salty basin. Clastic acquisitions and sedimentation of clay together with diatoms then continued in a calmer, probably fresh-water lake and gradually transitioned to primarily diatomitic deposits. This was interrupted only by clastic events, more likely landslide or mudflow deposits from the east edge of the pan, which formed the wedge of diatomitic breccia with fragments of Cretaceous marl. Diatomitic sedimentation was interrupted by occasional episodes of drying out of the basin, during which layers of gypsum formed, or unusual intraformation breccias. The measure of communication of the basin with the open ocean via rivers, which would simultaneously provide water to the basin, is unfortunately impossible to ascertain, due to inadequate similar locations in the area. The closest ocean shore in the late Eocene was somewhere in Saxony between Zeits and Jena, and inflow to the „Leipzig Bay“ from the direction of today's Krušné hory mountains cannot be ruled out (Standke 2008, Suhr 2002). The only possible proof of such a link is the remnants of fish of the genus *Morone* occurring at Kučlín (Micklich and Böhme 1997) known for its ability to migrate from oceans to rivers. Eocene sedimentation strata terminate by colorful tuffitic and tuffic rocks, signaling the onset of volcanic activity, which culminated in spilling tephritic magma.

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