Proposal of lithostratigraphy for the České středohoří Mts. volcanics

VLADIMÍR CAJZ

Institute of Geology, Academy of Sciences of the Czech Republic, Rozvojová 135, 165 02 Praha 6

Abstract. This contribution proposes the lithostratigraphy of the Tertiary volcanosedimentary complex of the České středohoří Mts. The superficial volcanic products of the České středohoří Mts. are divided into three formations. The Ústí Fm. (36.1 - 25.5 Ma) includes basanites and their concomitant volcaniclastics including fossiliferous sediments, and represents products of early rift development - the filling of a rift valley. The Děčín Fm. (30.8 - 24.7 Ma) is composed of trachybasalts and trachybasaltic resedimented tuffs, which are erosional relics of a composite volcano - the product of more advanced stage of rift evolution. The Dobrná Fm. (24.0 - 19.3? Ma), represented by basanitic lavas, was produced as a result of a possible remobilization of the magma chamber. All these formations represent one volcanic cycle (uppermost Eocene - lowermost Miocene, with a maximum in the Oligocene). The basanitic intrusions penetrating the Most Fm. sediments are comprised in the fourth lithostratigraphic unit, the Štrbice Fm. (13.4 - 9.0? Ma). It is most probably a product of a younger volcanic cycle (Middle Miocene) and extends to the Most Basin, too. The Ústí Fm is largely correlated with the Střezov Fm. of the Most Basin.

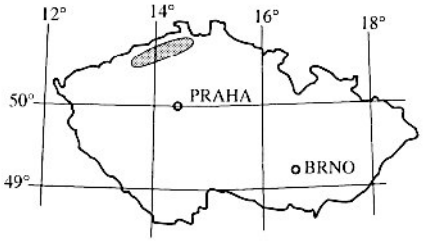
Abstrakt. Příspěvek navrhuje vnitřní litostratigrafické členění třetihorního vulkanosedimentárního komplexu Českého středohoří na následující formální souvrství. Povrchové vulkanické produkty jsou děleny na souvrství ústecké (36,1 - 25,5 Ma), které zahrnuje bazanitové výlevy a doprovodná vulkanoklastika včetně sedimentárních vložek a představuje výplň riftového údolí, souvrství děčínské (30,8 - 24,7 Ma) tvořené trachybazaltickými redeponovanými tufy a lávami, jež je pozůstatkem rozsáhlého složeného vulkánu a představuje další stupeň magmatického vývoje, souvrství dobrnské (24,0 - 19,3? Ma) tvořené bazanitovými lávami, které vznikly patrně v důsledku remobilizace magmatického krbu. Tato tři souvrství vznikla jako výsledek jednoho magmatického cyklu (nejsvrchnější eocén - spodní miocén, s maximem v oligocénu). Čtvrtá litostratigrafická jednotka, štrbické souvrství (13,9 - 9,0? Ma) je tvořené bazanitovými intruzem a proniká sedimenty mosteckého souvrství. Zde je řazena též k vulkanosedimentárnímu komplexu. Je to výsledek patrně dalšího (středně miocenního) vulkanického cyklu a zasahuje i do mostecké pánve. Ústecké souvrství se dá korelovat ponejvíce se střezovským souvrstvím mostecké pánve.

Key words: Tertiary volcanics, the České středohoří Mts., lithostratigraphy

Introduction

The České středohoří Mts. is a regional geological unit (Chlupáč and Štorch eds., 1992) composed of superficial basaltic products (lavas and volcaniclastics), subvolcanic forms of basaltic and trachytic rocks (sills, dykes, stocks, crater vents, laccoliths, etc.) and sediments (Fig. 1). This term partly coincides with the same term used in geomorphology (Demek ed., 1987). The České středohoří Mts. volcanic range extends from Louny - Most in the SW to Česká Lípa - Nový Bor - Česká Kamenice - Děčín in the NE. A general geological review of this area was compiled by Cajz ed. (1996).

The České středohoří Mts. volcanosedimentary complex is a polygenetic assemblage of Tertiary alkaline volcanics and sediment intercalations, situated inside the Ohře Rift in northern Bohemia. Together with the Doupov Complex and volcanic complexes near Zittau (Lusatia) and Marktredwitz (Upper Palatinate), the České středohoří Mts. represent the majority of the Cenozoic volcanics of the Bohemian Massif. The České středohoří Mts. volcanics have so far been classified as a formal stratigraphic unit, which cannot be further subdivided - the Středohoří Complex (sensu Chlupáč and Štorch eds., 1997). However, new knowledge based on geological survey and geochemical investigation (Cajz et al., 1999) allows further subdivision of the volcanosedimentary complex into formations and permits to replace the Středohoří Complex



formal lithostratigraphic unit by the formal formations (sensu Salvador ed., 1994).

The stratigraphic range of the largest volume of volcanic products in the České středohoří Mts. is Upper Eocene - Lower Miocene (Klomínský ed., 1994). The K-Ar data show the following time spans:

i) 36.2 Ma (Shrbený and Vokurka, 1985) to 26.2 Ma (Kopecký, 1987-8) - both data recalculated after recommendation of Shrbený and Vokurka (1985),
ii) 41.9 Ma (Cajz et al., 1999) to 19.3 Ma (Bellon et al., 1998).

Only a small amount of volcanics is supposed to be of the Middle and/or Upper Miocene age (9 Ma in Kopecký, 1987-1988; 12 Ma in Shrbený and Vokurka, 1985 or 13 Ma in Cajz et al, 1999). These volcanics were assigned to the Most Fm. (Klomínský ed., 1994), but they represent an integral part of the volcanosedimentary complex. Their occurrences are still imperfectly known yet and some other volcanics may display a similar age (e.g. Keřový vrch Hill near Most).

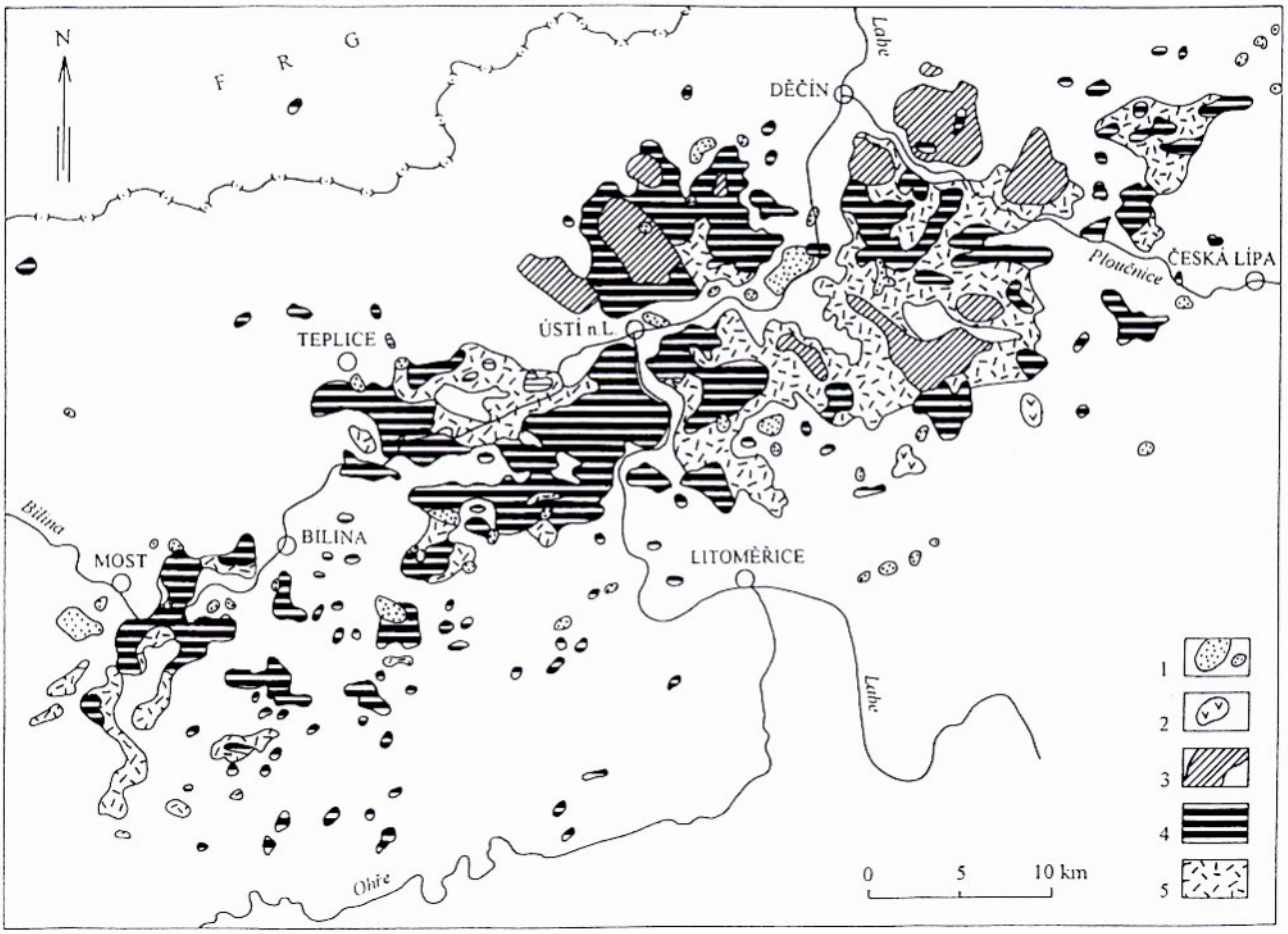


Fig. 1. Volcanosedimentary complex of the České středohoří Mts. 1 - trachytic intrusions, 2 - trachybasaltic intrusions, 3 - trachybasaltic pyroclastics alternating with lavas - the Děčín Fm., 4 - basanitic lavas (and intrusions) - mostly the Ústí Fm. (the Dobrná Fm. and the Štrbice Fm. are hardly distinguishable in this scale), 5 - basaltic volcaniclastics (including sediments) - the Ústí Fm.

The volcanosedimentary complex

This proposal assumes the subdivision of the České středohoří Mts. volcanics into four formations described below. Three formations are composed of the superficial products, the fourth one is represented by intrusions only. The superficial volcanic products were chosen as main markers, with the superposition and different lithologies as the key characteristics. This idea benefited from the studies of Hibsch (1926), using the difference of „basaltic and tephritic tuffs", which correspond to the lavas of adequate petrography (Shrbený, 1968). These volcaniclastics carry very important genetic information, which was not clearly recognized before. Two rather different lithological units were distinguished using volcanological criteria (Cajz, 1990a). The genetic information from volcaniclastics allowed to reconstruct the possible paleoenvironment and to show different stages of rift development. Extended geological survey of this area proved the existence of a third unit composed of superficial products. Based on these results, geochemical methods (bulk rock analyses, trace elements and REE contents, K-Ar age determination and 87/86Sr + 143/144Nd ratios) were used to test the volcanostratigraphy (Cajz et al., 1999). All these data were used for the formulation of this new lithostratigraphic proposal.

Stratigraphic relevance of the intrusive bodies is more problematic but may be solved separately based on the relationship to the superficial volcanic formations (volcanologic position, geochemical affinity, etc.). This proposal also allows further development of the stratigraphic idea based on new data. For example, this might be necessary in the case of the Kučlín - Trupelník Hill tephrite lava probably underlying (Hibsch, 1924) sediments with the oldest flora and fauna of this area (38.3 Ma in Bellon et al., 1998), or in the case of the Všechlapy basanite lava (see bellow).

Lithostratigraphy

I. The lower unit, **Ústí Formation**, is named after the city of Ústí nad Labem. The type localities are concentrated mostly in its vicinity (see Fig. 2).

Characteristics:

These rocks are formed by products of mostly effusive olivine-rich basaltic volcanism and now represent the largest volume of volcanics of the České středohoří Mts. The basanitic lavas are widespread, relatively thick, altered to different degrees, very often brecciated and sometimes fos-

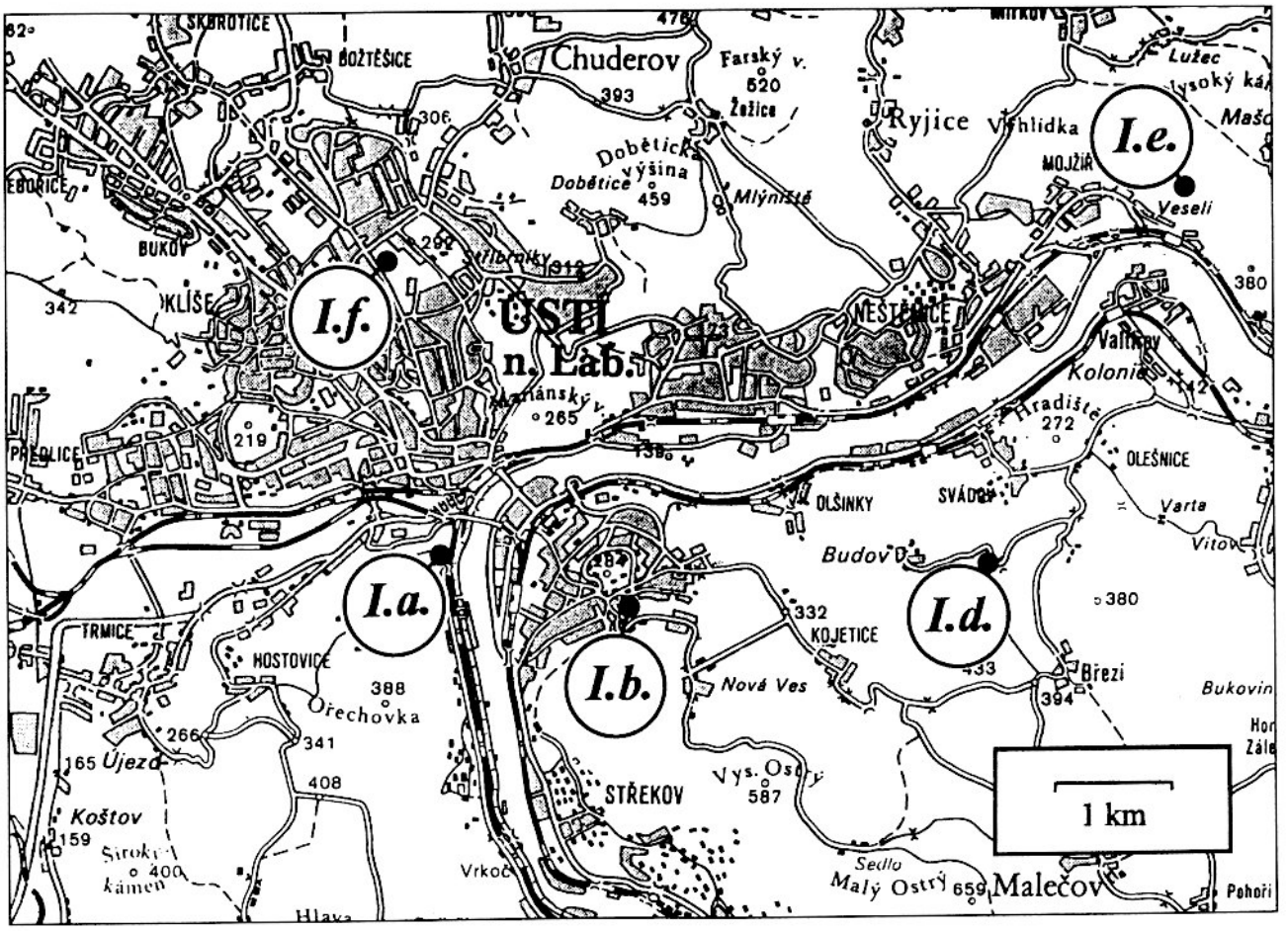


Fig. 2. Positions of the Ústí Fm. type localities (for closer explanation see the following text).

sil-weathered. Associated volcaniclastics („basaltic tuffs" after Hibsch, 1926) range from coarse-grained to fine-grained types, but their origin is not only pyroclastic - the genetic record they contain is the most important information. Intercalations of sands, clays, limestones, diatomites and coal seams, sometimes fossiliferous, are very common in these volcaniclastics. Basanitic lavas are primitive in their magmatic evolution - low differentiated and low crustal-contaminated upper mantle products (Cajz et al., 1999). They cover extensive areas in the form of lava sheets and originated from numerous vents. The relatively high thickness of the low-viscosity lavas is caused by deceleration of their movement. The reason was most probably the formation of frontal breccia due to lava interaction with water-saturated environment - wet sediments, lakes, swamps and streams in the rift valley. The effusions supposed to be exclusively subaerial are developed in the uppermost parts of the Ústí Fm. e.g., Severní terasa-Stříbrníky and Slavošov areas. The interaction of lava and this environment is also the reason for very common alterations of basanitic lavas up to mostly argillized material of almost the whole effusion and also for the appearance of the specific breccia. This hyaloclastic brecciation produced incoherent material of all grain sizes, which was removed by different means of transportation (fluvial, gravity movement, etc.) together with the other clastics as pyroclastics and non-volcanic material. Sediment intercalations containing fossil remains originated in such environment.

Boundaries and thickness:

The Ústí Formation overlies mostly the Cretaceous Merboltice Fm. sandstones and the Březno Fm. marlstones. In the area N of Žitenice and NE of Čeřeniště (N of Litoměřice), the underlying rocks are represented by quartzites. In small areas of Benešov nad Ploučnicí and Slunečná and in the surroundings of Volfartice, the volcanics overlie sands with signs of fluvial redeposition, probably derived from the Cretaceous Merboltice Fm. sandstones. Both rock types are supposed to represent the equivalent of the Staré Sedlo Fm. (Upper Eocene - Klomínský ed., 1994). The upper boundary of the Ústí Fm. is preserved only at several places in the topmost part of the volcanic mountain range. It is, however, not exposed, being covered by the overlying volcanic formation. Fossil weathering (smectite argillization) of volcanics of the Ústí Fm., together with its flat upper relief and also the different lithology of the overlying volcanic formation, indicate an interruption in volcanic activity. The upper boundary is therefore supposed to represent a possible unconformity.

The thickness of the Ústí Formation rocks fluctuates from several metres e.g., in marginal parts of the complex where superficial products are eroded, to over 300 metres

(a cross-section from Mojžíř to Chvojno area). This difference is explained by different subsidence rates of individual tectonic blocks in the rift area. The usual thickness is ca. 100-150 metres.

Chronostratigraphy and paleontology:

The K-Ar ages for these rocks range between 36.1 and 25.5 Ma (Cajz et al., 1999). This chronostratigraphic range for the Ústí Fm. is supported by some paleontological data. The results of microfloristic research, represented by diatomites, were summarized by Řeháková (1985). Their stratigraphic range is supposed from Upper Oligocene up to Lower Miocene (Chattian-Aquitanian). Although the ages based on diatoms are younger than those based on other taxa, paleoecological conclusions based on diatoms correspond with the paleoenvironment supposed from the lithology. All known diatomite occurrences are developed in the Ústí Fm., the only slightly problematic occurrence being the oldest one - Trupelník Hill (see below). The macrofloristic material from intravolcanic sediments was newly revised by Bellon et al. (1998). Their contribution deals with seven localities from the České středohoří Mts. and two other ones from the Lusatian area, also connected with volcanic activity. The paleobotanic correlation was supported by K-Ar age determination of solid volcanics underlying and/or overlying the fossiliferous strata. This means that the lowermost and uppermost limits of the stratigraphic range were noted. This material was taken from either boreholes or surface. The floral succession shows two stratigraphic levels, one of Upper Eocene-Lower Oligocene age and the other one of younger Oligocene age. All these revised localities from the České středohoří Mts. are herein assigned to the Ústí Fm. volcaniclastics. The paleozoological remains do not provide any significant stratigraphic information. The lower vertebrate fauna (fishes and frogs) and insect remains are preserved in the intravolcanic sediments of the Ústí Fm. The Kučlín fish fauna shows again that this locality is the oldest one, and the stratigraphic correlation of the lower vertebrate data is in accordance with the paleobotanical conclusions (Bellon et al., 1998).

Type localities:

I.a. Větruše (holostratotype, Fig. 2, photo 1) is located in the left bank of the Labe River valley, in the southern part of the city of Ústí n.Labem. The old quarry shows solid and altered basanitic lavas. The sedimentary intercalation of bituminous clay up to 25 cm thick is now exposed between two lava flows. The locality yielded diatoms and other paleofloristic remains (Řeháková, 1985). The GÚ-126 borehole situated at this place (Shrbený et al., 1967) reached other intercalations of limestone, diatomites and clastic sediments. Several types of jointing of relatively aphyric basanite are developed. The columnar-jointed solid lava passes across an irregularly jointed and more altered type into practically argillized and partly brecciated basaltic material. As developed at the base of the lava flow, these phenomena represent the primary (syngenetic) type of alteration. This locality proves the presence of water environment during volcanic activity.

I.b. Střekov (parastratotype, Fig. 2, photo 2) is the exposure in an old sandpit in the city of Ústí n.Labem. Cretaceous sandstones of the Santonian Merboltice Fm. underlying the volcanic complex, were quarried and a basanitic lava flow was exposed. Steeply dipping base of the lava flow indicates the fossil surface morphology. The basanite lava flowing down the slope was altered to completely argillized due to the high-gradient thermal shock from the water-saturated environment. Basaltic material penetrated the surface zone of the sandstone, the sandstone was also attacked and its parts were mechanically included into the lava flow. The result is a mixture of totally argillized volcanic material with incorporated irregular-shaped sandy parts - the peperite (sensu Le Maitre ed., 1989).

I.c. Veleň (parastratotype, Fig. 3) is a locality exposed in the erosional cut of a creek flowing into the Ploučnice River between Benešov n.Ploučnicí and Děčín. Medium- to fine-grained well stratified lake sediments are exposed in a narrow valley between the villages of Velká and Malá Veleň. This locality is very close to the famous paleontological site of Bechlejovice and might represent only a different facies of the same intravolcanic sedimentary basin, where clastic input did not allow the expansion of diatomite sedimentation but allowed

Photo 1. Locality Větruše - Ústí Fm., holostratotype I.a.
Two basaltic lava flows are exposed with a layer of bituminous clay between them.

the dissolution of silica from the large surfaces of fine grains of primary basaltic material poor in silicon. Silica originated during this process was used by diatoms for the construction of their tests.

I.d. Budov (parastratotype, Fig. 2) is an outcrop by a small road SE of Ústí n.Labem. It shows stratified graded material redeposited from hyaloclastite breccias of lavas. Larger clasts of argillized basanites are partly rounded, coarser-grained sediments alternate with finer-grained ones. This type represents a more proximal sedimentary facies to the lavas, which were the source of the clasts.

I.e.: Mojžíř (parastratotype, Fig. 2, photo 3) lies in the easternmost part of the city of Ústí n.Labem. This outcrop is located in a landslide area. The Divoká rokle Gorge is the typical locality of the most coarse-grained volcanic sediments of the Ústí Fm. Two different sedimentary cycles are exposed here. The lower one is a product of several subaquatic slides of incoherent volcanic material mixed with destructed blocks of the country rock (Cretaceous sandstones) into a deep depression, possibly a small tectonic graben in the sedimentary basin. Products of the upper cycle were deposited during a number of syngenetic volcanic avalanches by debris flow mechanism. These avalanches were coming down the slopes composed of volcanic material into the originally deep graben. The exposed thickness of these sediments is approx. 200 m (Cajz, 1993). Sediments of the same origin, i.e.: debris flow deposits, are developed also in the Ploučnice River valley on the river bank and in the lower part of the active Soutěsky Quarry.

I.f. Severní terasa (parastratotype, Fig. 2) is an exposure located in the NW part of the city of Ústí n.Labem. A special type of volcanic sediments is visible here. Medium- to fine-grained hyaloclastic material of Veleň or Budov type was first deposited, and this partly incoherent sediment was possibly transported by gravity-conditioned movements from the slope of the sedimentary basin margin. Now, larger clasts and blocks of the primary stratified material are incorporated in unstratified clastic matrix of the same origin, showing no grading.

II. The middle unit, **Děčín Formation**, is named after the city of Děčín. The type localities are concentrated in its near SE vicinity (see Fig. 3).

Characteristics:

Erosional relics of a formerly large composite volcano

Photo 2. Locality Střekov - Ústí Fm., parastratotype I.b.
The NE wall of the old sandpit shows the fossil relief of the Merboltice Fm. sandstones, covered by basaltic peperite.

Photo 3. Locality Mojžíř - Ústí Fm., parastratotype I.e.
The upper part of the Divoká rokle Gorge, coarse-grained sediments of volcanic gravity flows or debris avalanches. The size of a basaltic block on the horizon reaches over 2 metres.

Photos 1-3 by Vladimír Cajz

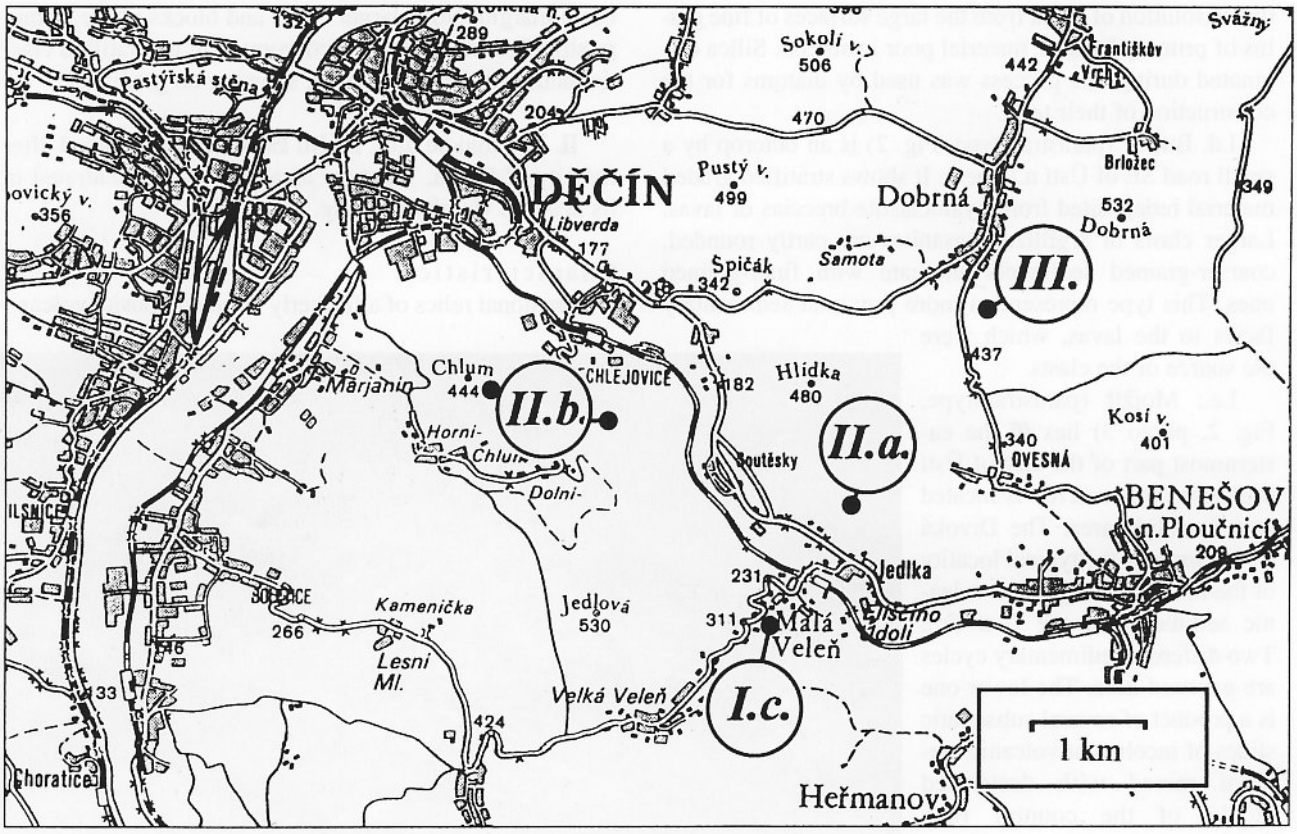


Fig. 3. The Děčín and Dobrná Fms. Situation of type localities.
I.c.- Veleň (Ústí Fm.), II.a.- Jedlka (Děčín Fm.), II.b.- Chlum (Děčín Fm.), III.- Dobrná (Dobrná Fm.)

(stratovolcano), now represented by several smaller areas usually located at the highest parts of the volcanic range, are preserved at the NE part of the České středohoří Mts. The relics are composed of mostly retransported pyroclastics (tephritic tuffs after Hibsch, 1926) intercalated with thin trachybasaltic (sensu Le Maitre ed., 1989) lava flows and sheets. The trachybasaltic lavas are more evolved products of the magmatic process, more differentiated and higher crustal-contaminated (Cajz et al., 1999). The locally developed aa-brecciation indicates the subaerial origin of the effusions. The lavas constitute minority in the composite volcano products. Much larger volume is represented by clastic material of primary pyroclastic origin. All the preserved lapilli- to ash- grained material is redeposited, with admixed clasts mostly coming from destructed lavas. This formation overlies basanites and associated volcaniclastics of the Ústí Fm. and represents an entirely different stage of volcanism - more explosive, more spatially restricted and less connected with the rift valley itself.

Boundaries and thickness:

The base of the formation is characterized by a supposed quiet period in volcanic activity associated with magmatic chamber evolution. In this period, peneplenation and fossil weathering is supposed to take place. Products of the trachybasaltic composite volcano regularly overlie the rift valley filling - the Ústí Fm. rocks. These rocks are absent only from the area of Huntířov (ENE of Děčín), the Česká Kamenice Fault Zone (sensu Herčík et al., 1999). Here, the Děčín Fm. pyroclastics overlie the Cretaceous Merboltice Fm. sandstones. The pyroclastics of the Děčín Fm. are covered by subaerial basanitic lava flow only in the area of Dobrná village and at Matrý Hill. This boundary is not exposed but is supposed to represent an unconformity.

The maximum thickness of the Děčín Fm. is almost 200 metres (Božtěšice-Chuderovec cross-section), but the usual preserved thickness reaches several tens of metres.

Chronostratigraphy and paleontology:

The K-Ar data taken from lavas show a time span of 30.8-24.7 Ma for the composite volcano development (Cajz et al., 1999). This formation also includes a trachybasaltic (tephritic) sill dated by Bellon et al. (1998) at 26.3 Ma from Bechlejovice borehole.

Only paleofloristic remains are known from the trachybasaltic pyroclastics, but they are not so common as in the Ústí Fm. The paleontological locality „Rabenstein bei Höflitz" (see type locality Jedlka) and fossiliferous beds in the area NE of Valkeřice were mentioned by Hibsch (1915) with a paleobotanic identification by Engelhardt. The newly found flora from excavations at Božtěšice and Kočkov was described and assigned to the Eger regional stage (Bůžek and Kvaček, 1989). Other plant remains, which seem to be some of the youngest in the intravolcanic sediments, were found in the fine-grained trachybasal-

tic pyroclastics in the Matrý Hill area, NE of Sebuzín (M. Radoň, pers. comm.).

Type localities:

II.a. Jedlka (holostratotype, Fig. 3). The Jedlka village is located in the Ploučnice River valley just opposite the Veleň locality, between Děčín and Benešov n.Ploučnicí. The rock set deposited in the distal part of the composite volcano, crops out in a very steep slope N of the village. The Quaternary slope movements exposed large succession of volcaniclastics. Volcanic mudflows (lahars) coming down the volcano swept the loose material and the vegetation. More distally, their kinetic energy diminished. It was the marginal part of the volcano where shallow lakes with swamps developed, being presumably interconnected with streams. These streams may have washed out fine-grained material of the lahar deposits. Now, coarse-grained, not graded and not stratified lahar products alternate with very fine, well stratified sediments. An admixture of air-fall tuff in the fine-grained layers is also possible. Plant fossils (leaves) and trace fossils are preserved in the fine-grained beds; empty holes after smaller trunks are present in some lahar accumulations.

II.b. Chlum (parastratotype, Fig. 3). Two outcrops S to SE of Děčín demonstrate typical trachybasaltic lava flows. Both of them show coarse-grained redeposited pyroclastics (possible lahars), too. The small outcrop located NNE of Horní Chlum village shows very porous facies of lava rich in gases. The vesicles reach 1 cm in size, show flow-induced imbrication and some of them are filled with zeolites and/or calcite. The second outcrop is located NNE of Dolní Chlum village, in the topmost part of the Bechlejovická stěna Wall - just above the famous paleontological site (Ústí Fm.). This outcrop shows subhorizontal platy-jointed trachybasaltic lava with vesicles concentrated mostly in its upper part. Small phenocrysts of clinopyroxene are present in the relatively aphyric groundmass and some vesicles are partly filled with calcite.

II.c. Mukařov (parastratotype) is a locality showing the products of an another type of redepositional process of clastic material assigned to the Děčín Fm. A roadcut in the topmost part of the volcanic range near Mukařov shows a succession of fluvial sediments. The pebbles of different volcanics (trachybasaltic types prevailing) and consolidated Cretaceous sediments represent the coarse fraction in the matrix of sand-sized material of mostly volcanic origin. Erosional surfaces in the sediment document changes in flow direction in the upper reach of a river flowing through the marginal part of the composite volcano.

III. Upper unit of superficial volcanics, the **Dobrná Formation**, was named after the type locality of Dobrná, where it was distinguished for the first time.

Characteristics:

A lava flow of olivine-rich basaltic rock overlying the Děčín Formation is exposed near Dobrná village, E of Děčín. Its geochemical characteristics shows low magma differentiation and weak crustal contamination, indicating a primitive character (Cajz et al., 1999). The comeback of magmas of primitive chemistry can be explained by the supposed change in tectonic stress regime (Adamovič and Coubal, 1999) which could have caused a rejuvenation of the magma chamber. No volcaniclastic products were found in connection with this lava flow, but their production associated with Dobrná Fm. lavas is possible, especially the formation of spatter and cinder cones. Superficial products of the Dobrná Fm. were rather prone to erosion due to their high position and their preservation is therefore less probable. Nevertheless, several radiometric data published by Bellon et al. (1998), such as the Kundratice surface sample (ca. 20 Ma), the Stadice surface sample (19.3 Ma) and the upper part of the Suletice borehole (19.8 Ma) may represent lava flows of the Děčín Fm., too. If some other lavas of the Dobrná Fm. are developed overlying the similar chemistry products of the Ústí Fm., i.e.: the Děčín Fm. trachybasaltic unit is primarily missing or eroded, their stratigraphic assignment is very problematic and can be estimated on the basis of geochronological data only. A similar situation should occur where the Dobrná Fm. is developed immediately overlying the Cretaceous sediments. Such cases are supposed especially in the SW part of the České středohoří Mts.

Boundaries and thickness:

Only the base of the lava flows is preserved at Dobrná and Matrý Hill. As the Dobrná Fm. flows are the uppermost preserved superficial volcanics of the České středohoří Mts., the original thickness of the whole formation is unknown. The thickness of individual flows is estimated at max. 30 metres.

Chronostratigraphy:

The age of the Dobrná basanitic lava flow was determined at 23.7 Ma (Cajz et al., 1999). The close geochronological data obtained for the intrusion from the Prackovice old quarry (20.6 Ma in Cajz et al., 1999) and the data of Bellon et al. (1998) taken from surface occurrences (Kundratice 20.1-20.8 Ma, Suletice 19.8 Ma and Stadice 19.3 Ma) allow the present author to set the stratigraphic range of the Dobrná Fm. to the interval of 24.0 - 19.3 Ma, i.e.: the uppermost Oligocene to Lower Miocene. This stratigraphic range corresponds to some radiometric data obtained from basaltic rocks of the central part of the rift zone (e.g., Měcholupy 20.9 Ma), Bavaria (19.2 - 23.4 Ma in Lüttig, 1998) and Krušné hory Mts. (18.1 - 24.3 in Pfeiffer et al., 1984). Hence, the Dobrná Fm. volcanism does not seem to be restricted to the České středohoří Mts. only.

Type locality:

III. Dobrná (holostratotype, Fig. 3) is an outcrop of a lava flow S of Dobrná village lying at the margin of a forest. The outcrop shows solid irregular blocky-jointed

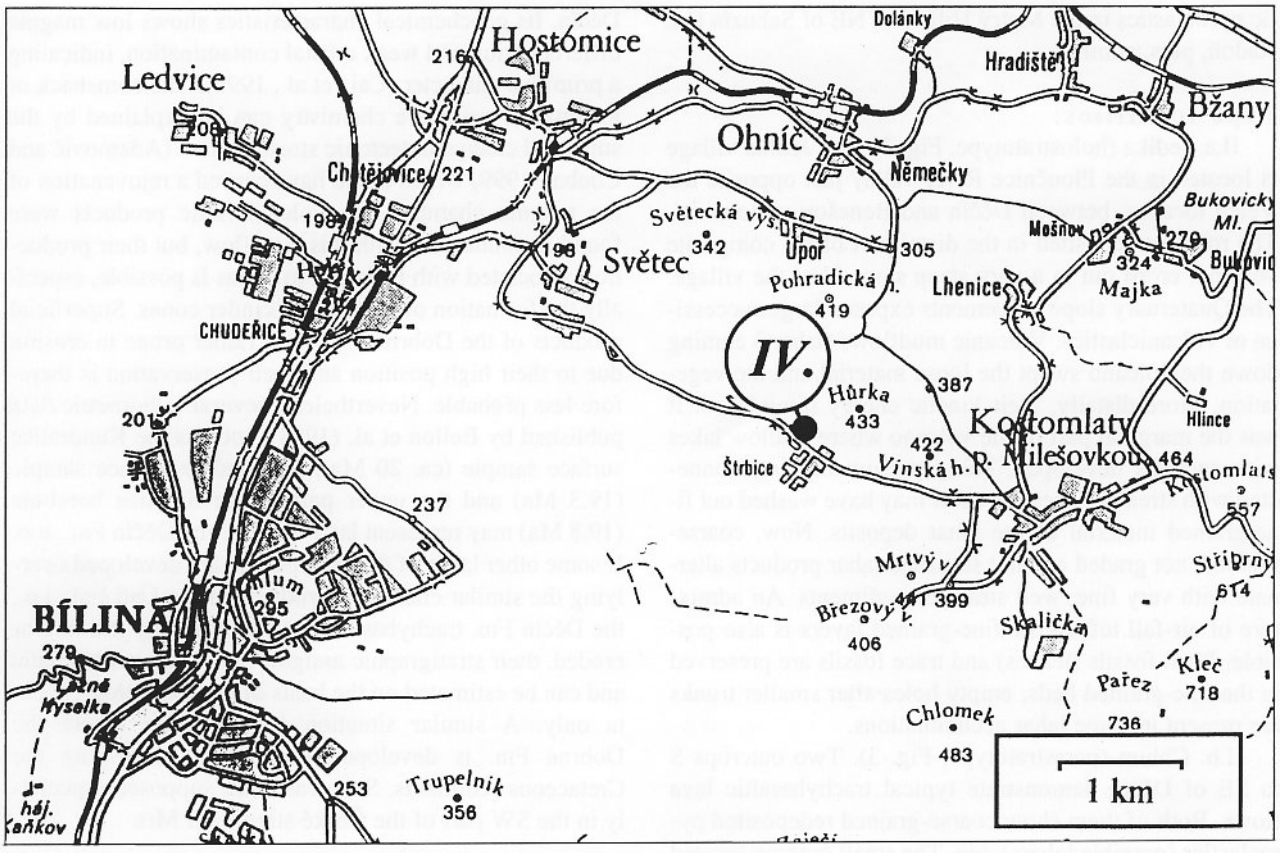


Fig. 4. The Štrbice Fm. Location of the type locality. IV.- Štrbice.

nepheline basanite with relatively fresh olivine phenocrysts (up to 5 mm) and small clinopyroxene ones (up to 1 mm). Columnar-jointed facies is preserved in an old quarry further N and NE, with irregular columns 10-30 cm in diameter. The axes of the columns show deviations from vertical line thus documenting the paleovalley topography. The present prominent positive morphology of the flow is caused by selective erosion.

IV. The Štrbice Formation was described using a different criterion - its unconformable position in Miocene basinal sediments. With respect to the geological position of known occurrences, it can be spatially assigned to the Most Basin. But the geomorphological division (Demek ed., 1987) also allows its assignment to the České středohoří Mts. It cannot be excluded that some of the volcanic occurrences of unknown age may represent the Štrbice Fm. products, also developed in the area of the volcanosedimentary complex itself.

Characteristics:

The Štrbice Fm. is represented by basaltic intrusions penetrating the Most Fm. sediments (Neogene - Hokr, 1985). The first record of these rocks was published by Pelikan (1895 in Hibsch, 1924) from the Emeran brown coal mining area N of Bílina. Also Hibsch (1924) described the elliptical intrusive body of basaltic breccia with dyke apophyses penetrating these sediments in the same area. These localities have been destroyed by open-cast mining, however, an another site originated by exposure of the Štrbice sand pit. Further studies revealed another volcanic bodies belonging to this formation, too. The geochemical characteristics of these basanites are similar to those of the Ústí Fm. The Štrbice intrusions can be characterized as low differentiated primitive magmatic products, but somewhat more strongly crustal-contaminated. A few other volcanic bodies can be probably attributed to the Štrbice Fm., but reliable evidence is still missing (geological position, age). The occurrence of such bodies is anticipated particularly in the Most and Bílina areas.

Boundaries:

The Štrbice Fm. rocks are known as intrusions only, penetrating basinal sediments of the Most Formation. Generation of superficial products is possible but their preservation is less probable. Its boundaries in common sense cannot be therefore described.

Chronostratigraphy:

The first K-Ar age from Štrbice was published by Srbený and Vokurka (1985): 12 (9?) Ma. Kopecký (1987-8) reported the age of 9 Ma. The samples from the Štrbice locality were processed again recently (10.3 and 11.4 Ma, M. Wilson, pers. comm.). Another data, close to the above mentioned ones, were obtained from Pohradická hora Hill (13.0 Ma) and Keřový vrch Hill near Most (13.4 Ma in Cajz et al., 1999).

Type locality:

IV. - Štrbice (holostratotype, Fig 4) exposure is located near the Štrbice village NE of Bílina. The wall of an old sand pit shows altered basanitic sill intrusions emplaced in the Miocene sands with typical alteration of volcanic rock caused by syngenetic interaction of magmatic material and water-saturated host rock. Argillization and brecciation of basanite was caused by the interaction of hot magma and cold and wet sediment during magmatic activity. The sill is conformable with the sediment stratification. This documents the type of emplacement mechanism, which employs a mixture of gases and overheated water vapour for making the way along more clayey intercalations in sand-dominated sediment.

Stratigraphic relationships to other units

As it has been mentioned above, there is a discrepancy in the understanding of limits of the regional units (geology vs. geography). Such inconsistency produces the problem of assignment of some volcanic bodies. Especially the volcanic bodies situated outside the limits of continuous occurrences of the České středohoří Mts. superficial volcanics, in the area of the Most Basin sediments, can be assigned with some difficulty only. They are a part of the Střezov Fm. but may also represent an isolated relict (or an uncovered part) of the superficial volcanics of the České středohoří Mts. volcanosedimentary complex. A similar problem is met in the assignment of volcanic rocks of the Lužické hory Mts. and Šluknovská pahorkatina Highland. Development of some of these occurrences parallels that of the Ústí Fm. volcanics e.g., the origin of the volcaniclastics, sedimentary intercalations with correlable fossils, etc.

The Střezov Formation (Upper Eocene - Upper Oligocene, Klomínský ed., 1994) is the stratigraphic unit used to describe rocks of volcanic origin overlain by the Most Fm. coal-bearing sediments in the subdivision of the Most Basin fill. These volcanics are mostly of basaltic composition (Kodymová, 1985) and include solid rocks as well as volcaniclastics and superficial products as well as intrusions. If covered by sediments, they are mostly altered (argillized) thus not able to provide the K-Ar data. Their extent is not continuous and their genesis is not clear enough. The name „Basin-underlying Volcanic Complex" has been also used for this formation (Cajz, 1990b). As a result, only three K-Ar datings were obtained from basaltic occurrences near the margins of the Most Basin. The Roudníky basanite flows yielded the age of 35.4 Ma and 37.1 Ma (Bellon et al., 1998) and the Měcholupy basanite lava 20.9 Ma (result of K. Balogh, ATOMKI Debrecen).

Based on the available K-Ar age data, lithology, geochemistry and paleontological results, the Střezov Fm. (Most Basin) can be partly correlated with the Ústí Fm. Only the Měcholupy occurrence can be correlated with the Dobrná Fm. No parallel exists for the Děčín and the Střezov Fms. The Ústí Fm. seems to have analogues in the areas of the Lužické hory Mts. and the Šluknovská pahorkatina Highland. The possible correlation of the formations of the České středohoří Mts. and the Doupov Complex lacks basic necessary information.

Summary and discussion

The internal lithostratigraphy of the České středohoří Mts. volcanics was proposed and four formations were described, including their type localities/areas, chronostratigraphy and paleontology. Three of them (Ústí, Děčín and Dobrná Fms.) were newly constituted based on the lithology of the superficial volcanic products. They are supposed to represent different stages of magmatic evolution of one volcanic cycle, which can be correlated with the Second (main) volcanic phase of the Bohemian Massif (Kopecký, 1987-8). Only a name Štrbice was given to the fourth formation, the existence of which has been evident for a long time. It is supposed to represent the next volcanic cycle and corresponds to the Third volcanic phase of Kopecký (1987-8).

The radiometric datings obtained from the products of the first volcanic cycle are characterized by intervals, which are close to one another. The ages of the Ústí Fm. (36.1-25.5 Ma), Děčín Fm. (30.8-24.7 Ma) and the Dobrná Fm. (24.0-19.3 Ma) are similar, therefore, the time intervals alone are not fully indicative for a specific formation. This may be caused by problems arising from geological criteria (imperfectly defined position or absence of products of another formation - missing superposition characteristics) and/or inaccuracy in age determination (whole rock analyses, rock alteration). The nearly simultaneous evolution of the superficial products of the volcanic cycle is a less probable possibility, as it follows from geological data.

The biggest problem seems to be the definition of the oldest volcanics of the České středohoří Mts. The Všechlapy basanite was dated at 41.9 Ma (Cajz et al., 1999) and the Trupelník Hill tephrite at 38.3 Ma (Bellon et al., 1998). In contrast, the range for the Ústí Fm. is assumed at 35.5 - 28.6 Ma. The processed Trupelník Hill tephrite sample was taken from the topmost part of the hill, but not from an outcrop. The same rock type possibly underlies the fossiliferous sediments, so its age may only indicate the lowermost age limit of the paleontological remains, which are most probably a part of the Ústí Fm. Nevertheless, the tephrite itself may represent an older volcanic product.

The Ústí Fm. can be partly correlated with the Střezov Fm. of the Most Basin and some isolated relics in the NE continuation of the Ohře Rift. The Děčín Fm. has no other equivalent. The Dobrná Fm. seems to be widespread along the Ohře Rift structure and the Štrbice Fm. is located only in the areas of the České středohoří Mts. and the

Most Basin. The Doupov Complex has not been described in detail yet, so the correlation is not possible.

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