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Pútikov vŕšok volcano - the youngest volcano in the Western Carpathians

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Abstract: As an independent space- and time-bound volcano, composed of a succesion of lava flows and pyroclastic rocks, the Pútikov vŕšok volcano marks the latest volcanic activity in the Western Carpathians spanning the time between 140 000 and 130 000 years ago (Late Riss, Pleistocene stage). The lava flows, predominated by the Aa types of lava, churned out of the central volcanic crater, while the pyroclastic rocks, generated during the processes of Stromboli, Hawai and/or freatomagmatic kinds of eruptions, have been piled up to form a cinder cone. The volcanic rocks have been classified as alkali basalts and/or basanites.

Key words: Pútikov vŕšok volcano, Quaternary, lava flows, pyroclastics.

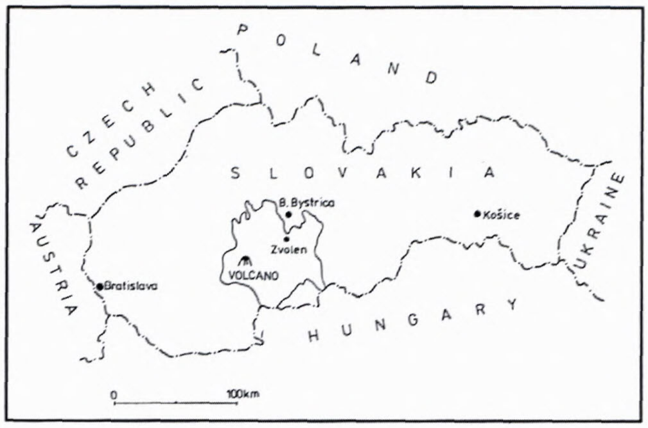


Fig. 1. Location of the Pútikov vŕšok volcano in the Middle Slovakian volcanic area

Introduction

As the earlier studies have not addressed the volcano proper the authors have carried out co-operative petrologic studies and compiled all available information obtained during previous investigations with the objective to classify and to characterise both, the volcanic and the Quaternary rocks of the Pútikov vŕšok volcano and its surroundings. The volcanologic classification and the description are based on geologic map at a scale 1:10 000 (sheet 35-44-20), constructed during past few years by L. ŠIMON, V. KONEČNÝ and J. LEXA and on detailed lithological studies of the volcanic rocks underlying the area between Tekovská Breznica and Nová Baňa/Brehy. The interpretations related to Quaternary rocks are based on geologic maps of the Pohronie (Hron valley) area at scales 1:25 000 and 1:10 000, completed recently by R. HALOUZKA. Most detailed investigations (in the context of the whole alluvial terrace system) were made in the areas of the Hron River terrace accumulations.

Prior to defining the Pútikov vŕšok volcano as a unit its lithologic-petrographic content and stratigraphic position had to be established. The volcano is a discrete, space- and time-bound volcanic body (see geological map and section) situated in the south-western part of the Central Slovakian volcanic region (Fig 1, Photo 1 and 2). It is, in fact, the youngest volcanic feature in the Western Carpathians and if it was not for the volcanoes of the southern end of the Hargita Mts. in Romania it would be second to none in the whole Carpathian-Pannonian region. This paper also describes character of volcanism, lithologic features, origin of rocks, their tectonic position and relation to Quaternary sediments, with the objective to define the statigraphic features and the age of volcanism.

Review of previous investigations

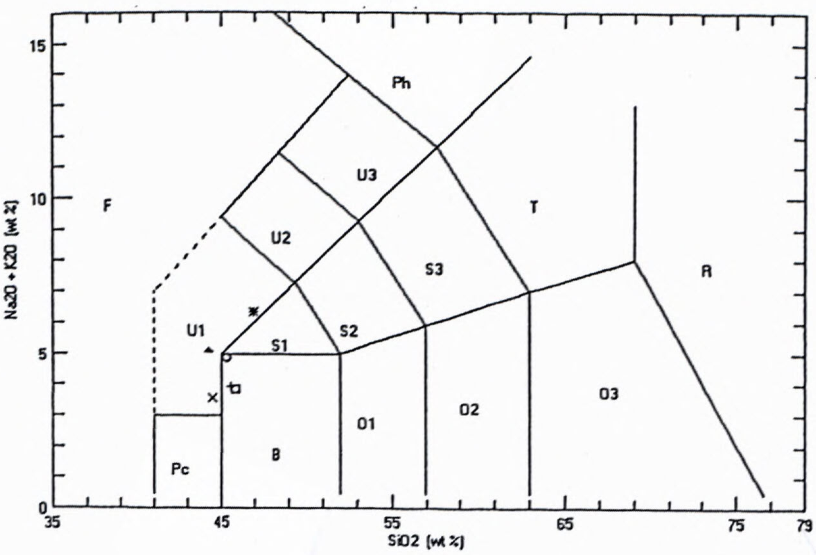
The volcanic rocks exposed in the surroundings of the locality were first referred to as basalts by JONAS (1820 in FIALA 1952). In addition to these basalts BEUDANT (1822, in FIALA 1952) described tuffs and volcanic bombs. FIALA (1952) was the first to make a detailed petrographic analysis of rocks in the surroundings of the Pútikov vŕšok (the name Pútikov vŕšok, used in older maps, coincides with the existing triangulation point 477 m), classifying them as alkaline basalts (basanoites) and recognising three main lava flows, cinder accumulations and volcanic bombs. He assigned them Neogene age. KUTHAN (in KUTHAN et al 1963, pp. 122-123) in his explanations to geologic overview map at a scale 1: 200 000, M-34-XXXI, Nitra sheet used the drill hole logging, prospection reports and geologic map of a basalt deposit, made by KAROLUS. He was the first to assign the basalt at Brehy Late Quaternary age, which he believed was in agreement with its position in the "lowest Hron

River terrace". ŠÍMOVÁ (1965) and MIHÁLIKOVÁ and ŠÍMOVÁ (1989) brought forward a detailed account of petrographic and petrochemical features of the basalts (including the Brehy and Pútikov vŕšok localities (points 1,7,8 in Table 1). The results of long run mapping in the broader surroundings of the locality are summarised in the geologic map of Central Slovakian volcanics on the scale 1:100 000 (KONEČNÝ, LEXA et al. 1984), as well as in the monography of KONEČNÝ, LEXA and PLANDEROVÁ (1983), in which the Brehy locality appears as a cindercone with crater breccias. Three nepheline basanite lava flows of Quaternary age (this age is indicated in the map, too) are shown to have extruded from the crater. According to K-Ar dating of BALOGH et al. (1981) the age of ba saltic rocks of Brehy is 0.53 ± 0.16 Ma. However, previous K-Ar dating of BAGDASARJAN (BAGDASARJAN, KONEČNÝ and VASS, 1970) gave less than 0.4 Ma, a value below the detectability limit of the method. The results of measurements and the assessment of positive polarity of paleomagnetism (see NAIRN and KAROLUS, 1965) are not contradictory to this dating.

Photo1. Pútikov vŕšok volcano- cinder cone, 477 m t.p. and surroundings

Photo 2. Lava plateau of the Pútikov vŕšok volcano.

Table 1 TAS classification diagram according to LE BAS *et al. (1986)*



x – *Plp-1, Pútikov vŕšok,* ŠIMON; + – *PV-1, Pútikov vŕšok,* ŠIMON; Δ – FIALA (1952); o – *1, Brehy,* MIHÁLIKOVÁ – ŠÍMOVÁ (1989); □ – *7, Chválenská dolina,* MIHÁLIKOVÁ - ŠÍMOVÁ (1989); * – *8, Chválenská dolina,* MIHÁLIKOVÁ – ŠÍMOVÁ (1989);

Major oxides

	Plp-1	PV-1	1	7	8	Fiala
SiO_2	44.47	45.54	45.30	45.85	46.90	44.22
TiO_2	2.57	2.48	2.79	2.53	3.45	2.62
Al_2O_3	13.26	12.54	12.52	11.42	14.94	12.02
Fe_2O_3	3.14	3.80	5.91	2.60	3.72	4.05
FeO	7.26	6.87	6.47	8.84	7.83	7.54
MnO	0.18	0.15	0.15	0.16	0.13	0.23
MgO	11.63	11.52	10.71	12.33	5.36	10.74
CaO	10.93	10.36	9.44	10.68	9.56	10.23
Na_2O	2.40	2.58	3.38	2.85	4.47	3.43
K_2O	1.18	1.33	1.49	1.00	1.90	1.69
P_2O_5	0.64	0.68	0.81	0.58	0.76	0.72
	97.66	97.85	98.97	98.84	99.02	97.49
CIPW norms						
Or	6.97	7.86	8.81	5.91	11.23	9.99
Ab	14.19	18.19	20.56	16.10	22.36	11.64
An	21.93	18.71	14.59	15.42	15.09	12.41
Ne	3.31	1.97	4.36	4.34	8.38	9.42
Di	22.35	22.41	21.19	27.07	22.08	26.79
Ol	17.99	16.92	13.72	20.08	6.17	14.73
Mt	4.55	5.51	8.57	3.77	5.39	5.87
Il	4.87	4.71	5.30	4.80	6.55	4.98
Ap	1.53	1.61	1.92	1.37	1.80	1.71

Since mid-sixties the Quaternary research of Tekovská Breznica - Brehy localities (important in stratigraphic terms) has been repeatedly carried out in several projects realised within the framework of systematic mapping of the Pohronie (or, more precisely, Central Pohronie) area. One of two principal sections running through the Tekovská Breznica village (drill hole HŠ-15, ŠKVARKA, KAROLUS and HALOUZKA) has been made in 1971 as a co-operation venture. Apart from the detailed macroevaluation of Quaternary section, a sedimentary-petrographic evaluation has also been made (MINAŘÍKOVÁ, non refereed manuscript). The second section running through Brehy (loesses and their derivatives resting on the basalts), which was presented as an excursion locality during the international geomorphological symposium held in 1992 (section through loess with fossil soils, prepared by HALOUZKA), has also been investigated. An alternative section of the Brehy locality, in which the litological features and molluscan fauna have been studied in 1995 (HALOUZKA and KERNÁTSOVÁ), is exposed in an outcrop of loessy derivatives.

Finally, we note that a detailed geophysical research using electric-resisitivity method has been made throughout the Hron River valley (1:5 000 maps with geological-geophysical sections published in thematic atlas sets). An expert in Quaternary geology (HALOUZKA in JANÍK, Kanda et.al.,1986) also evaluated the section Tekovská Breznica-Brehy. RAČKO's remarkable geomorphologic publication (1990), which addresses the same problems, must also be mentioned in this context. Most recent information related to the locality was published by present authors in other papers, or in lectures. ŠIMON (1991) described the succesion of several lava flows, overlain by cinder cone with pyroclastic rocks.

In their detailed description of the Nová Baňa -Brehy excursion locality, published as part of the excursion guide to the international symposium on dating in geomorphology (held in Tatranská Lomnica, Stará Lesná, in June 1992), HALOUZKA and ŠIMON (1992a,b) presented a concept of the so called refined interpretation of the Quaternary position of lava flows (end of Middle Pleistocene - late glacial stage) during Late Riss (by HALOUZKA inferred approx. age range from 160 000 to 130 000 y. B.P.), which they base mainly on the results of own detailed lithologic and stratigraphic studies of volcanic and sedimentary rocks, as well as on the above mentioned data. And finally, the same interpretation of the stratigraphic position of lava flows and sediments was presented by HALOUZKA and ŠIMON (1992) as an unpublished lecture at the mentioned symposium. Notably, their concept was appreciated by the participants in the following discussion and during the excursion to the locality.

The Pútikov vŕšok volcano

The rocks making up the volcano represent a discrete volcanic unit referred to as the Pútikov vŕšok volcano. Below we present the definition of the volcano.

Name: After the Pútikov vŕšok hill, located on the map sheet No. 4661 Nová Baňa (old grid), on the sheet No. 35-44-20 (new grid). It corresponds to triangulation point 477 m, located between the Nová Baňa and Tekovská Breznica villages, on western slopes of the Štiavnické pohorie Mts.

Definition: The cinder cone and a set of alkaline basalt and/or basanite lava flows, located between this cone and the Brehy and Tekovská Breznica villages, named the Pútikov vŕšok volcano.

The stratotype (type section): The volcano has stratotype outcrops in the Chválenská dolina, below the triangulation point 477 m (photos 5, 6, 7, 8, 9, 11, 12, 13, 14, 15, 16), near the triangulation point 432 m (photo 4) and in the quarry near Nová Baňa/Brehy (photo 10).

Extension, thickness, boundaries: Located between the Tekovská Breznica - Chválenská dolina sites, below the triangulation point 477 m - Nová Baňa/Brehy, the volcano outrop covers an area of some 4 sq. km.

Stratigraphic data: Volcano is a product of the latest volcanic activity in the Western Carpathian territory. The basement of this formation is made of gravels dating back to latest Riss stage (Middle Pleistocene) (HALOUZKA and ŠIMON 1992a,b), (Fig.2). Most recent update of this dating gave an age of basalt ranging between 140 000 and 130 000 y. B. P. , while the final extrusions were dated roughly at 125 000 y.B.P. ago (HALOUZKA l.c.). The problems of dating will be further discussed in an independent paper, now under preparation.

Rock lithology of the Pútikov vŕšok volcano

The volcano is made of 2 lithogenetic types of volcanic rocks, represented by:
1) lava flows and 2) pyroclastic rocks.

1. Lava flows

Lava flows are produsts of effusive volcanic activity. The extrusions have been discharged from the central volcanic crater. The flows emplaced over the cone are arrayed in a fan-shaped fashion around its centre. Some 90% of the lava mass have flowed in NNW direction towards the Tekovská Breznica and Nová Baňa, part Brehy (the passage of descending flows was controlled by both, the geomorphologic features and the gravity). Lava flows have variable lengths and thicknesses ranging from short, through medium long to very long. The short ones, situated in the crater's surroundings, may be as long as 10 m and up to 30 cm thick. The medium thick flows are 10 - 100 m long (Photo 4) and their thickness ranges between 10 cm and 10 m. The longest flows encroach as far afield as the area of Brehy village. With total length of up to 3.2 km and maximum thickness of 15 m (Fig.10) the individual flows of variable thickness and length overlap and/or intermingle with each other, making the distinction of individual lobes, or counting precisely their numbers, impossible. The main flows are emplaced in the wash-outs, from which the side lava lobes branch out (Fig.3) to make, what we call, the lava plateau sequence. The entire mass of the lava flows extends over an area of roughly 4 sq. km. It fills some 500 m wide valley (originally the Chválenská dolina stream?) located below the cinder cone and overlies Quaternary deposits in the valley, which opens downwards to form a plateau measuring as much as 1.5 km across. The flows represent the products of volcanic activity with variable eruptions and low degree of eruptivity. The eruptions produced lavas of the Aa type and the pahoehoe type (according to WILLIAMS - MCBIRNEY, 1979). The Aa - lavas (photo 3, 4, 5, 8A) are the main types of lava generated during the eruptions. The difference between Aa

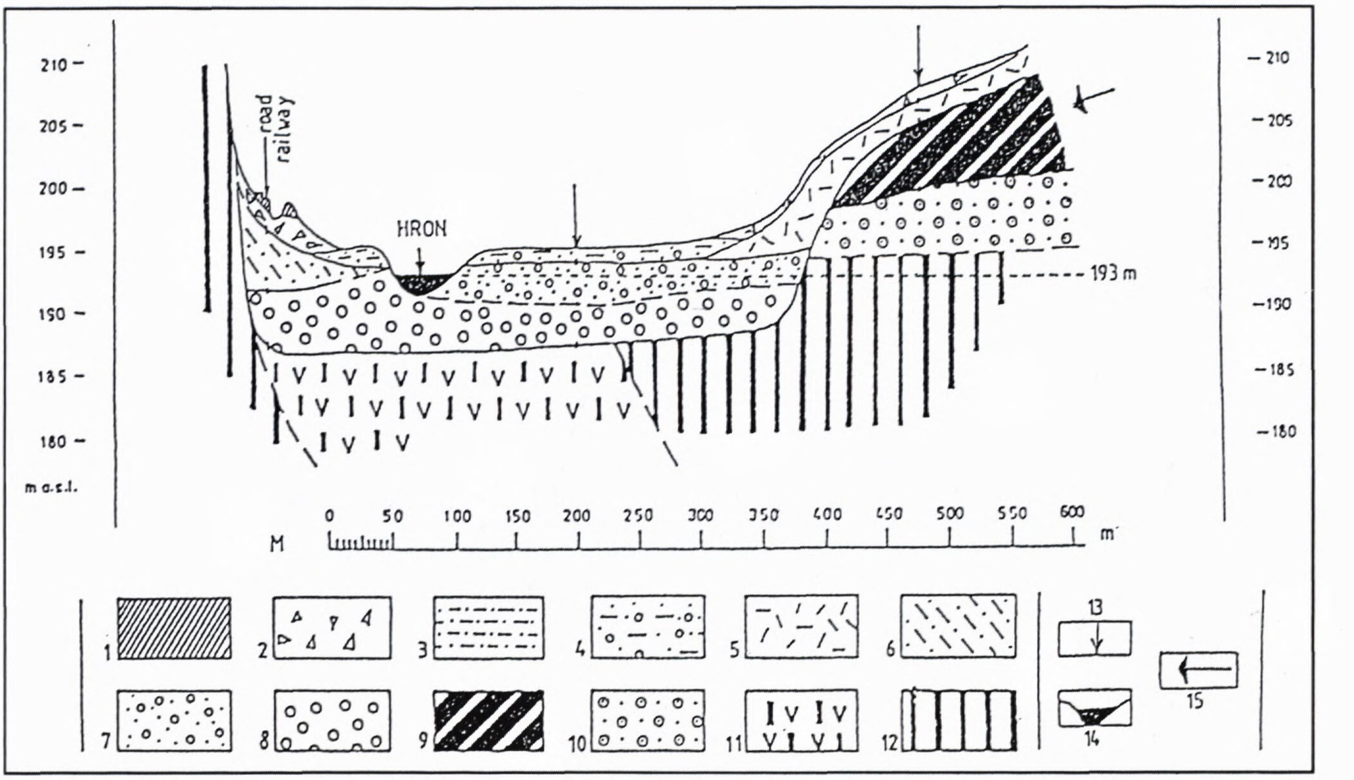


Fig. 2 Geological section through the Hron River valley near Nová Baňa-Brehy (HALOUZKA 1992 - compiled according profile in map 1:5000 - in KANDA et al. 1986)

1. man-made groud deposits, 2. debris, 3. fluvial sandy loams, 4. fluvial sandy loams with gravel, 3-4. alluvium in the flood plain, 5. polygenetic slope loams (surface wash), 6. polygenetic slope sandy loams (surface wash). 2,5,6. deluvial (slope) sediments, 1 to 6. Holocene, 7. fluvial gravel and sands, 8. fluvial sandy gravel, 7. to 8. Late (Upper) Pleistocene, Wurm (bottom accumulation), 9. nepheline basalts, 10. fluvial sandy gravel (terrace accumulation), 9 to 10. Middle Pleistocene, Late Riss, 11. andesitic volcanoclastics (tuff), 12. andesites, 11. to 12. Miocene (Badenian), 13. resistivity sounding probes (geophysical survey), 14. river channel, 15. lava flow direction

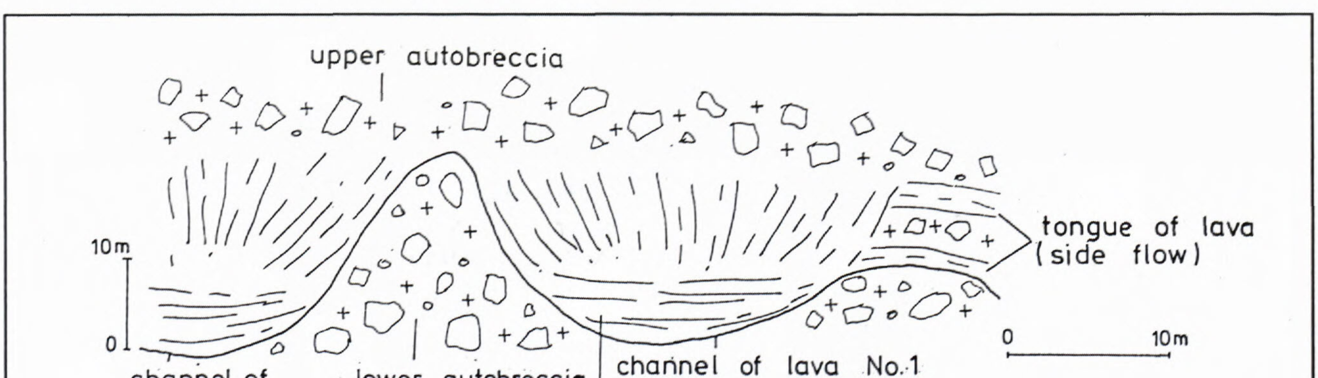


Fig. 3. Sketch of geological setting in the Brehy quarry (to be compared with photo 10 A. - 10H.).

and pahoehoe lavas is demonstrated by the surfaces of their bodies (Fig. 4). Besides, no breccias form in the pahoehoe lava flows. Their surfaces are fine, smooth and porous, although, the porosity may vary. Some of the pahoehoe lava flows have become subject of bubble cracking processes, similar to those described by BLACKBURN (1976), involving accumulation of gas bubbles inside the lava body and subsequent bursting of small local eruptions outside the central crater of the volcano, accompanied by destruction of the surficial crust of the flow, followed by churning of lava over a short distance around it. The fragments accumulate next to the sites of bursting (deformation), on top of the lava flow. Essential part of the lava mass, which makes up the lava

Photo 3. Medium long lava flow - measuring 100 m in diameter and 10 m thick.

Photo 4.Lower part of the Aa type lava flow with traces of brecciation with cauliflower surface.

plateau, is representad by the lava flows of the Aa type. The Aa lavas are composed of massive lava and lava breccias and have coarse surfaces. As a consequence of movements and subsequent cooling of the lava mass the lava breccias develop mainly within the lower and upper parts of the lava flow. Their colour is red, pink, or brown-red, altough, some red-yellowish, or ochre-yellow-pink portions can also be found, particularly in the lower parts. The red, brown-red, or even yellow-red coloured breccias, consisting of angular, spherical or cindery fragments, measuring 1 to 60 cm across, are cemented with brecciated ground material from the above quoted variegated lavas. Yellow tint of a breccia is indicative of the presence of water during eruption. Having originated

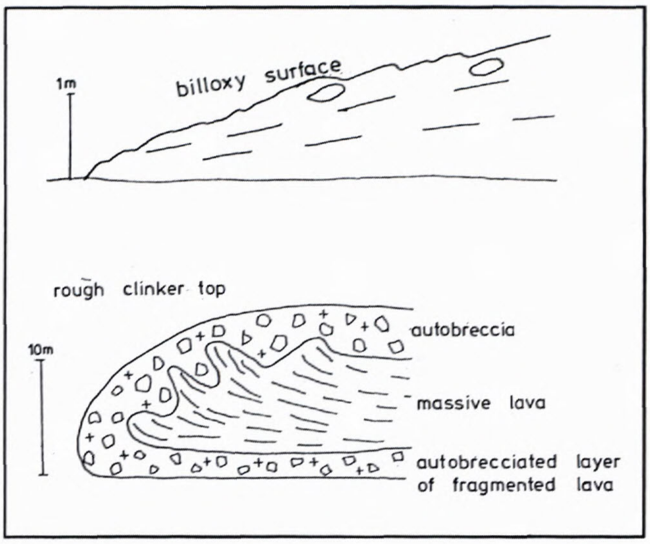


Fig.4. Differences between pahoehoe and Aa lavas: adapted, after LOCKWOOD, I.P., LIPMAN, P.W.1980

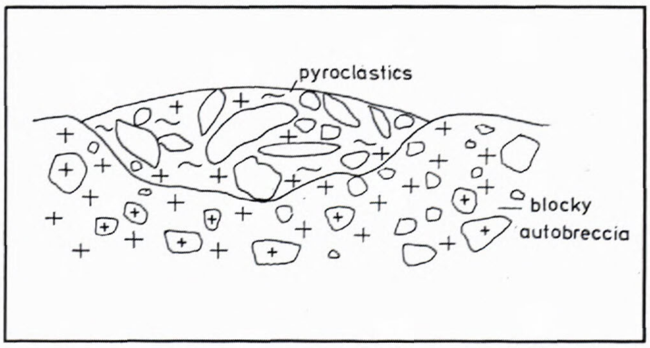


Fig.5. Pocket filled with pyroclastics in the Brehy quarry.

Photo 5. Massive lava flow in the central zone of the volcano.

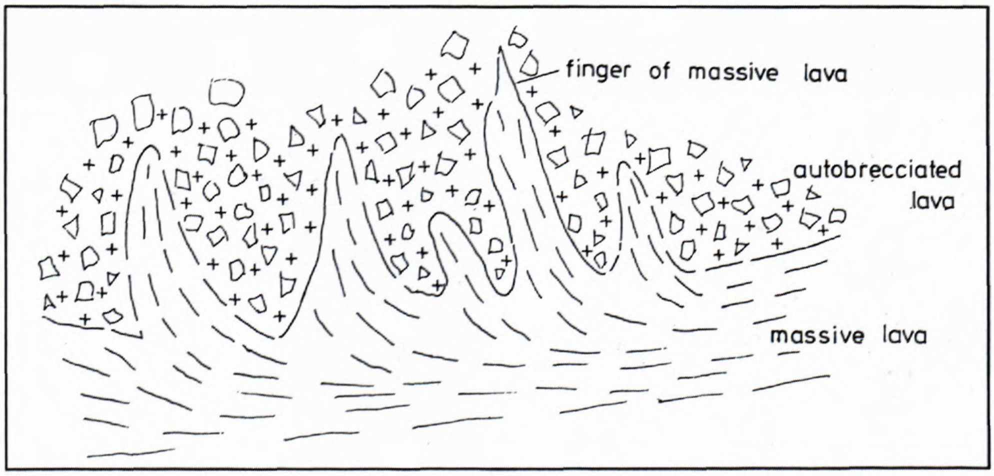
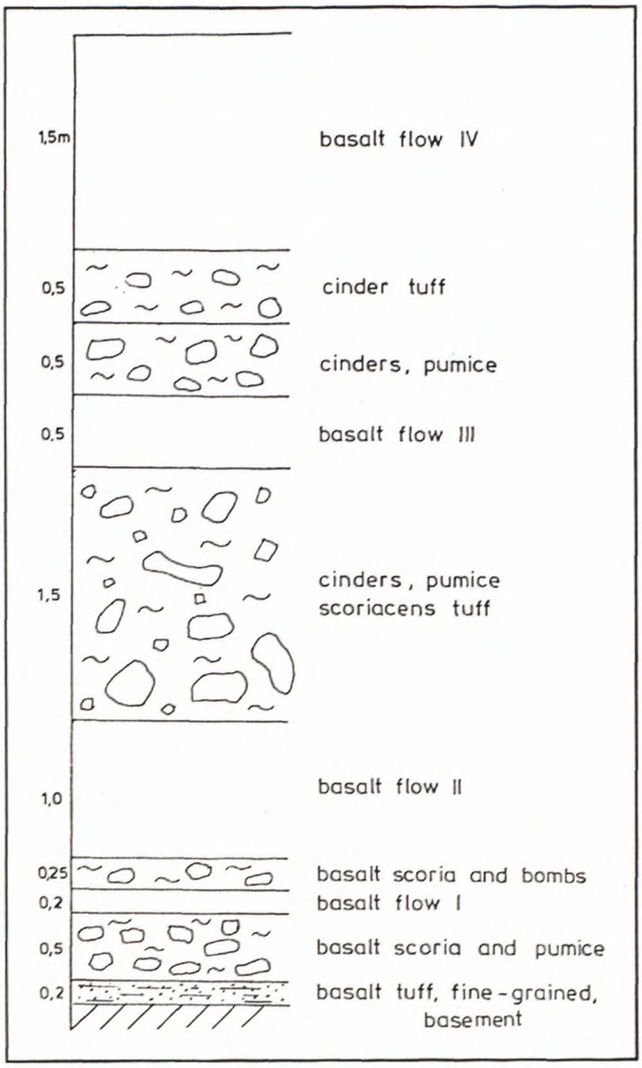


Fig 6. Injection of lava into the lava breccia (Brehy quarry).



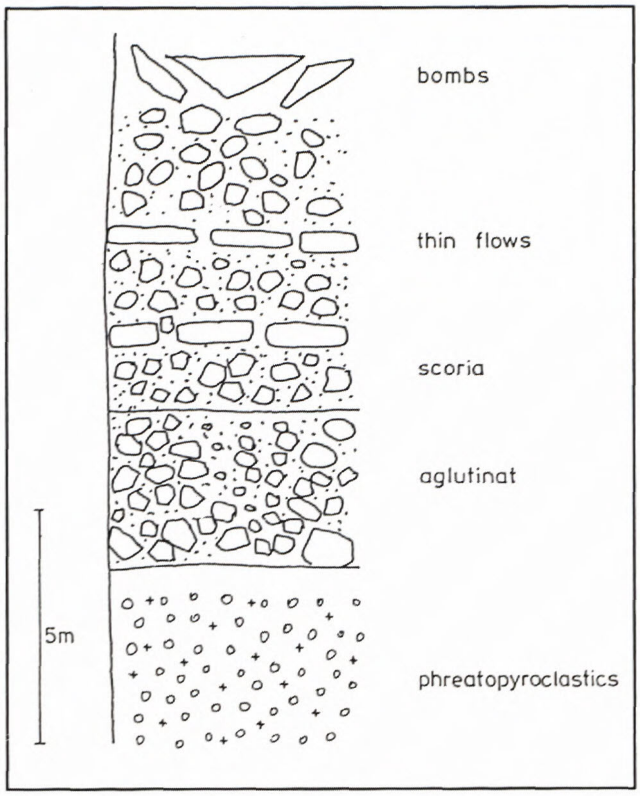


Fig.8. Sketch section through a cinder cone

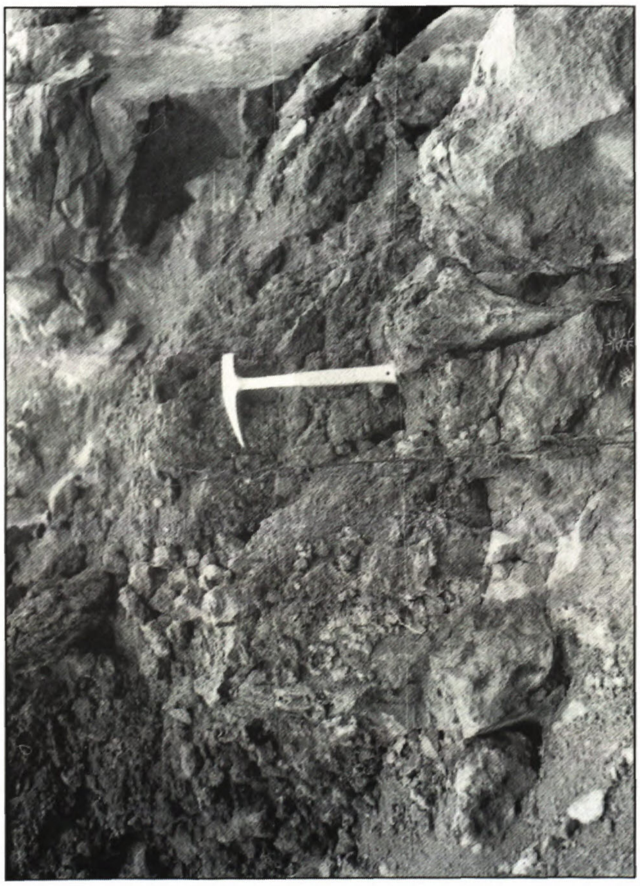
Fig. 7. Alternation of lava flows with pyroclastics at the 303 m triangulation point: adapted, after FIALA (1952).

Photo 6. Lava flow - an example of "sonnen brand" type of weathering - pea-shape -spherical desintegration of the body.

either underground, or at the surface (the Hron paleoriver), the water causes weak freatomagmatic eruptions, which take place at the contacts with lava, as indicated by the change-over from red-hot lava desintegrating into red (+tints of red) and yellow (+ tints) fragments. Yellow-growing colours are characteristic of the palagonitisation processes. Occurrence of pyroclastic pockets, found on tops of lava flows (on the upper lava breccia) (Fig.5), testify that the lava flow eruptions are syngenetic with the explosive pyroclastic eruptions. The pockets filled with pyroclastics developed as the flows run down the slope. Cinder material produced during the Stromboli type eruptions has been strewn over the surrounding grounds whilst a part of it landed on the flowing

Photo 7. Fragments of broken thin lava flows in pyroclastics of the cinder cone (central zone of volcano).

Photo 8 A-8E. Lava flows in Nová Baňa - Brehy quarry.
Photo 8A. Lava plateau - lava wash-out No.1, overall view - see Fig.3.



lava (see in the Brehy quarry). Syngenetic origin of both eruptions can best be demonstrated in the surroundings of the 303 m triangultion point. FIALA (1952) described alternation of thin flows (0.5-1.5 m thick) with pyroclastics (0.2-1.5 m thick) (see FIALA p. 17, Fig. 7, 8). The signs of grinding and the development of quasi brecciated texture with cauliflower features in both, the lower and the upper parts of the flows, have been observed on the surfaces of some of thin Aa lava types of flows (Photo 4). If located in the upper parts of the volcano these types of lava flows have tabular jointing and show signs of columnar jointing. Irregularly columnar, fan-shaped tabular and tabular-bench-like jointing was observed in peripheral zone of the volcano (e.g. in the quarry near Brehy) (photo 8A, 8C). The lava injections into the upper lava breccias (Fig.6) have also been observed. The lava flow bodies, which spilled over the upper and middle parts of the volcano, impounded and diverted existing streams. These events had favourable effects upon Quaternary sedimentation. Quaternary paleolakes formed along the southern and south-eastern margin of the volcano (see geologic map).

2. Pyroclastic rocks

Pyroclastic rocks (= pyroclastics) of the Pútikov vŕšok volcano developed in a process of explosive eruptions described by FISHER -SCHMINCKE (1984), BLACKBURN et. al. (1976), Self et. al. (1974) and WALKER (1973). The cinder cone, situated in the central zone and composed predominantly of fallen freatomagmatic pyroclastics, has been piled up during intense Stromboli-type to Hawai-type eruptions (Fig. 4). The deposited cinder cone is made of non-consolidated to ignimbritised pyroclastic rocks. We presume that the cone, composed of well defined beds commencing in its lower part with palagonitised yellow-ochre lapilli tuffs (= freatopyroclastics - defined by ŠIMON, 1995) (photo 9), has been partially eroded away and that these rocks were produced during a freatomagmatic eruption, when the magma came into contact with water coming either from the Chválenský potok, or from a lake created due to impoundment of the Chválenská dolina valley. This contact triggered a strong, principal eruption and initiated subsequent formation of the cone. FIALA (1952) reported the occurrence of similar rocks in the area around the triangulation point 303 m. These rocks, composed of fine grained basaltic tuffs (FIALA, 1952, p.17, Fig.7) deposited on the slope of the volcano are termed, using modernej terminology, as base surge freatopyroclastics. They overlie a thin (20 cm) sandstone unit at the base of the volcanic complex. On the other hand, the above quoted palagonitised lapilli tuffs are represented by conspicuous freatopyroclastics, deposited near the crater of the volcano. Strongly ignimbritised agglutinates and red to brick-red spatter rocks (photo 10) occur in the overlier. There are coarse ignimbritised agglutinates with textures of flowage and massive, crust-free, very thin lava flows, deposited in the upper part of the cone (photo 8, 23, Fig.8). The dip angle of the beds in the cone ranges between 6° and 30°. Larger and smaller, brick-red, dark-red, brown-black, or black volcanic bombs measuring 1 to 50 cm across (photo 12-16) are randomly emplaced in the cone. Their shapes are spherical, fish-like, amygdaloidal, cylindric, cow's stool-like, or shell-like with a tail. In the cone there predominate medium to strongly ignimbritised, massive and herogeneous agglutinates (photo 10-11), composed of irregular, spindle-shaped and spherical spatter rocks, large and small bombs and cinder lapilli (as fallen pyroclastics). The agglutinates, composed of fallen pyroclastics of the size of lapilli and agglomerates, have porous structure. Although some cindery may rarely occur, it is most likely completely absent. Rare blocks and megablocks, measuring 70 to 120 cm across, also occur in them. Strongly ignimbritised variety contains scarce beds of ignimbritised, elongated and flattened bombs, which could have formed as the agglutinate flewed down the slope (gravitation effect). This could, however, have only taken place when the agglutinate was hot enough and the slope of its deposition was steep and nonstable. Flattening of the fragments could have been produced as the flying objects hit the volcanic mass. Due to their fancy shapes the volcanic bombs, attracted the attention of old geologists. The bombs represent lava fragments which, after having been blown out of the volcanic crater, landed on the ground. Following genetic types of bombs were distinguished: type 1 - bombs blown out from the crater in rigid state - fragments from older lava flows (block bombs), type 2 - bombs blown high enough into the air to allow for their cooling before hitting the ground, or flown in a form of comet bombs attaining, at the moment of landing, amygdaloidal, shelly, or similar shapes (stromboli eruptions), type 3 - bodies blown to small heights due to week eruption, forming fish-like, cow stool-like bombs, some of which are twisted, cracked and broken due to the impact (Hawaian eruptions - lava fountains).

B C
D E

Photo 8B. Detail of lava breccias in a hump.
Photo 8C. Upper part of the lava wash-out - massive lava with transitions to lava breccias.
Photo 8D. Left hand side of the quarry - lava injection into the lava breccias. 8D. The upermost, right-hand side of the quarry - thin, 1 m thick lava flow between lava breccias in the lava plateau.
Photo 8E. Pockets filled with pyroclastics in the uppermost left hand side of the quarry - they overlie the lava breccias - geological hammer indicates the boundary between lithofacies.

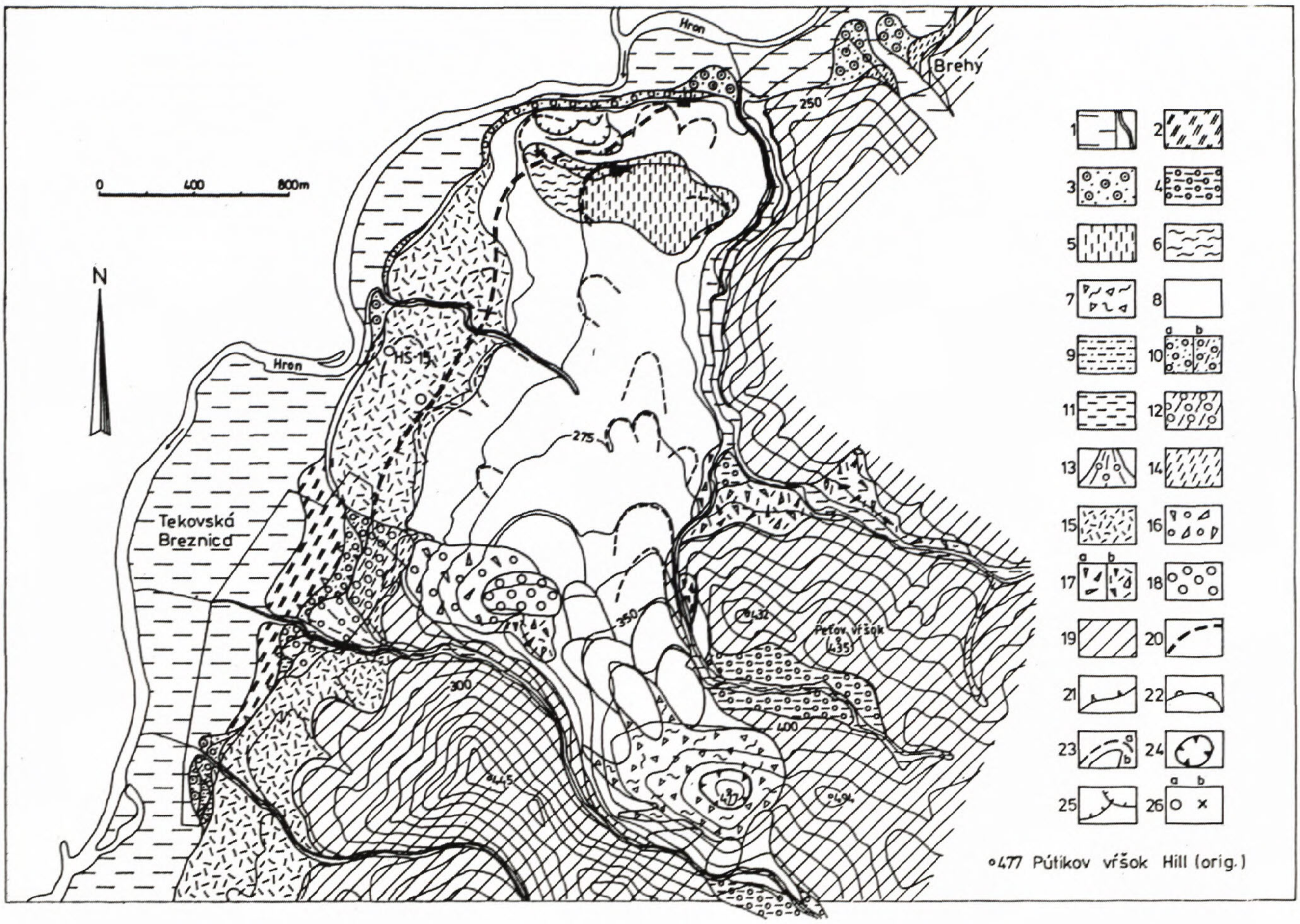


Fig. 9 Geologic map of the Tekovská Breznica - Brehy area (compiled by HALOUZKA *and* ŠIMON *1995)*

1. fluvial and alluvial plain loams and sandy loams, loamy gravely sediments (Holocene) in stream alluviums; 2. deluvial-fluvial, predominantly loamy outwash and rainwash sediments (Wurm/Holocene) in the overlier of fluvial sandy gravels (Wurm); 3. fluvial sandy gravels and sandy (Wurm); 4. fluviolimnic loams with gravels (Riss/Wurm-Wurm; 5. Aeolian loessy fossil soils, loessy loams at the base; 6. a series of loessy loams, limy, or lime-free (resedimented loess and fossil soils); 5.-6. Upper Pleistocene; 7. pyroclastic volcanic rocks - undifferentiated; 8. alkaline basalt to nephelenilic basanite lava flows; 7.-8. final period of late Riss - basal part of Riss/Wurm; 9. fluvial aleuritic loams and/or sands; 10. fluvial sandy gravels (a without cover, b - with a younger outwash loam cover); 9.-10. Late Riss; 11. fluvial loams to sandy loams; 12. fluvial gravels and sandy gravels, with younger outwash loam cover; 13. proluvial gravels and loams with semirounded clastics (alluvial fan); 11.-13. early Riss; 14. deluvial-fluvial, predominantly loamy outwash and rainwash sediments; 15.-17. deluvial sediments; 15. polygenetic deluvial loams; 16. gravely-blocky stony screes to periglacial solifluction flows; 17. screes a) stony and b) loamy-stony. 14.-17. Quaternary undifferentiated; 18. fluvio-limnic desintegrating conglomerates and gravels, polymict (Banská Bystrica, or Hron gravel formation, Upper Pleistocene); 19. underlying andesitic volcanics - undifferentiated (Middle Miocene - Badenian); 20. concealed geologic boundary (with Quaternary fluvial sediments); 21. boundary of riverine terrace; 22. terminal boundary of the alluvial fan front; 23. lava flows a) volcanologically identified b) geomorphologically identified; 24. Quaternary of the volcano; 25. Brehy quarry wall; 26. drill holes study sections.

Petrographic a petrochemic characteristics of volcanic rocks

FIALA (1952) and MIHALIKOVÁ - ŠÍMOVÁ (1989) characterised petrographic features of volcanic rocks in detail. We supplement their eleborate results by our petrographic description of to date unknown, once southwards running lava flows (see geological map) with characteristic black, or grey-black colour and compact, or porous texture. They are composed of macroscopic phenocrysts of green amphibole, black pyroxene and glassy lustrous feldspar needles and the matrix, made of plagioclase, olivine, pyroxene and ore pigment and nepheline. Analcime and volcanic glass occur in only accessory amounts. In petrogeochemical terms the Pútikov vŕšok volcano is made of rocks ranging from alkali basalts to nephelinic basanites (Table 1).

Discussion and comparison with the global volcanism

1.The volcanic activity of the Pútikov vŕšok volcano is the youngest of its kind in the Western Carpathians. The volcano was formed during Pleistocene stage (Late Riss) between 140 000 and 130 000 years ago, this time span baving been inferred from detailed lithostratigraphy of Quaternary sediments, overlapped by the lava flows of the volcano. The above age cannot be supported by radiometric dating (as none of the methods allows for reliable dating of volcanic materials younger than 200 000 y. B. P., KRÁĽ pers. comm.). The first of two recent age determinations made on basalts from the volcano (BALOGH et.al. 1981), gave the radiometric age of 530 000 years, while the second (RAČKO,1990), based on geomorphological features, gave an age ranging from 50 000 to 70 000 years (early Würm). An independent and complex study (relation analysis) is needed to solve this problem.

2. Stratigraphic division and dating of the Pútikov vŕšok volcanism is compatible with the youngest volcanic activity of other volcanoes in the Central European realm. We refer to the dating using pedostratigraphic method of a silty tuff located in the sequence of loesses in Komjatice, Lower Nitra region (VAŠKOVSKÝ and KAROLUSOVÁ, 1969), which gave Mindelian age. Although the

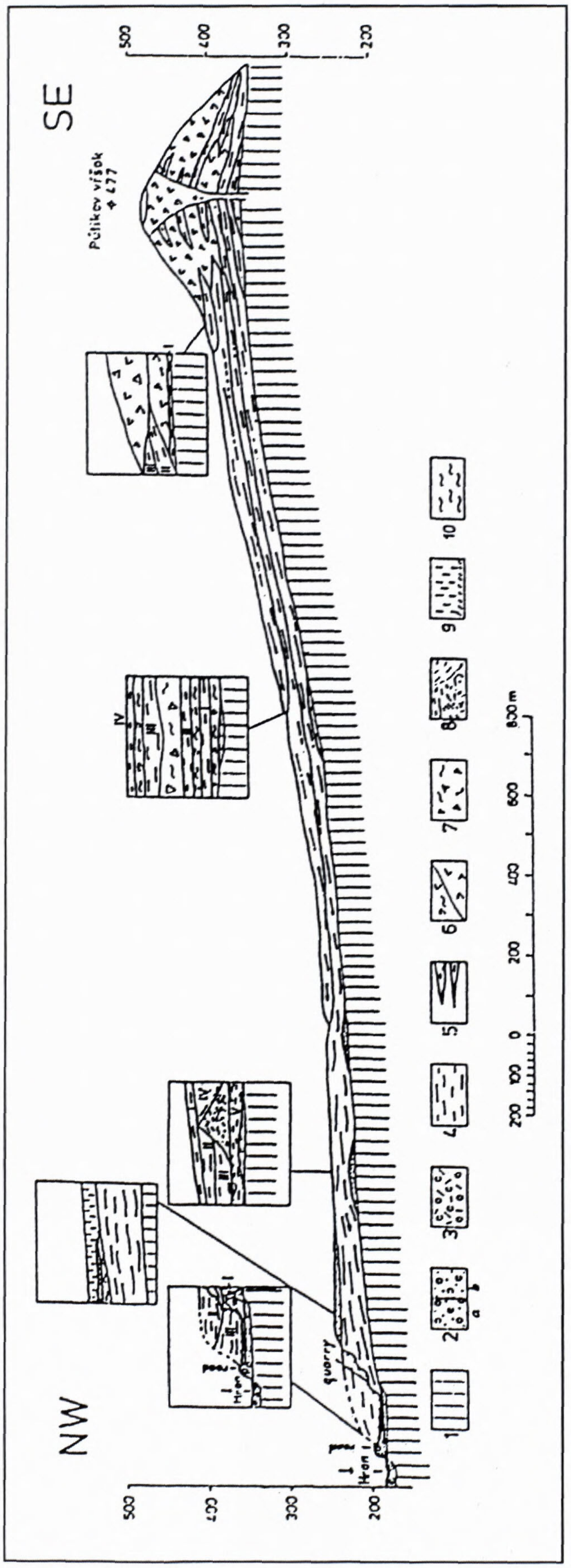


Fig.10. Longitudinal geological section through the area studied (Pútikov vŕšok-Brehy quarry,compiled by ŠIMON, HALOUZKA, 1995). 1.Underlying andesite volcanics undifferentiated (Middle Miocene - Badenian). 2. fluvial sandy gravels (a - Wurm, b - late Riss). 3. fluvial loamy sandy stream gravels (on the bed of initial old valley) - late Riss. 4. lava flows in transitional and peripheral zone of the volcano. 5. thin lava flows in central zone of the volcano. 6. pyroclastics a) in transitional zone of the volcano b) in central zone of the volcano. 7. freatopyroclastics. 8. lava flows in the lava plateau (lava flows and their breccias - lava wash-outs and tongues). 4. -8. late Riss (final part) -Riss/Wurm (basal part). 9. aeolian loess and loessy fossil soils. 10. loessy loams (resedimented loess). 9. -10. Upper Pleistocene.

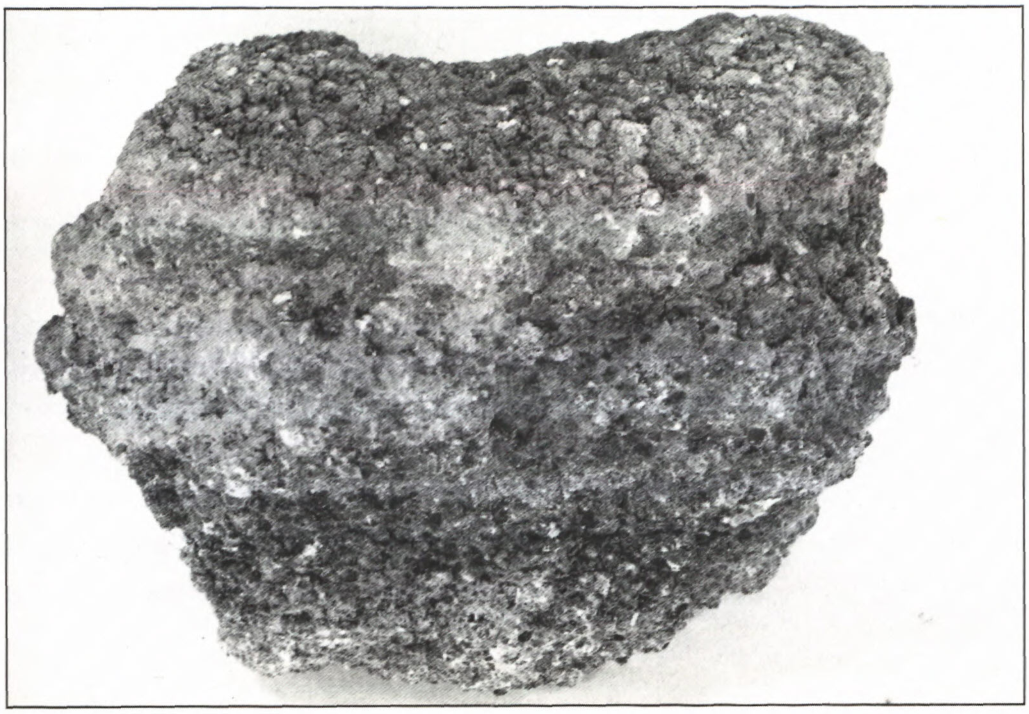


Photo 9. Deposited down fallen pyroclastics - lapilli tuff (freatopyroclasticum).

Photo 10. Agglutinates with scarce megablocks (75 cm).

Photo 11. Strongly ignimbritised agglutinates composed of irregular, spindle-like and spherical bombs and spatter rocks.

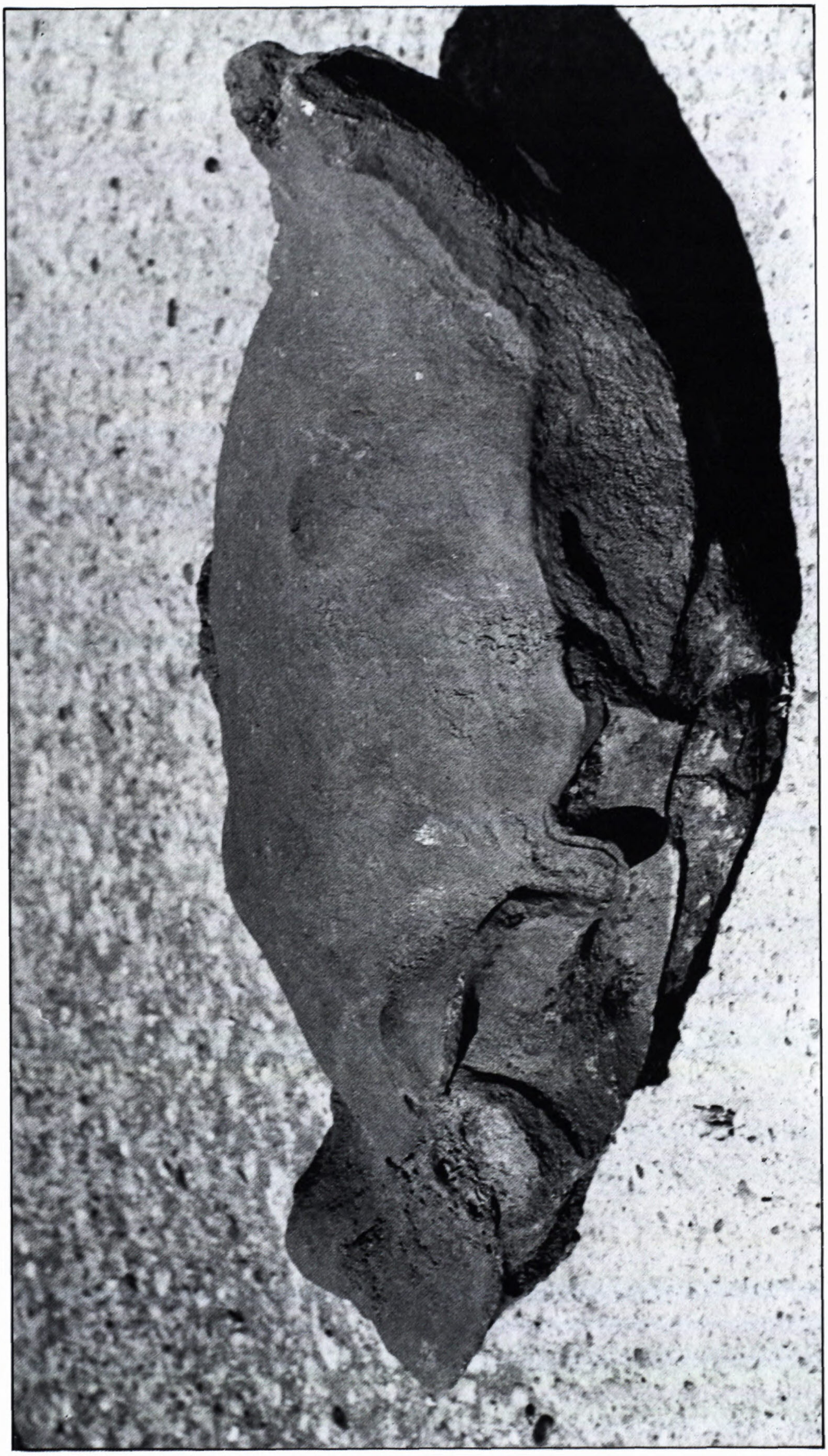


Photo 12. Shell bomb - a side view.

analysis of molluscan fauna found in Komjatice section SCHMIDT, 1973) does not contradict this dating, a younger, Rissian age of the loessy bed with tuff seems to be more plausible. Moreover, KAROLUSOVÁ found out that the origin of the Komjatice tuff should be sought in volcanic regions of northern Hungary, near the Austrian border, where there occur isolated basaltic bodies of the latest (even Quaternary) volcanism, for which the Pleistocene age has been indicated by several authors (corresponding roughly to Riss). We also note that a tuff

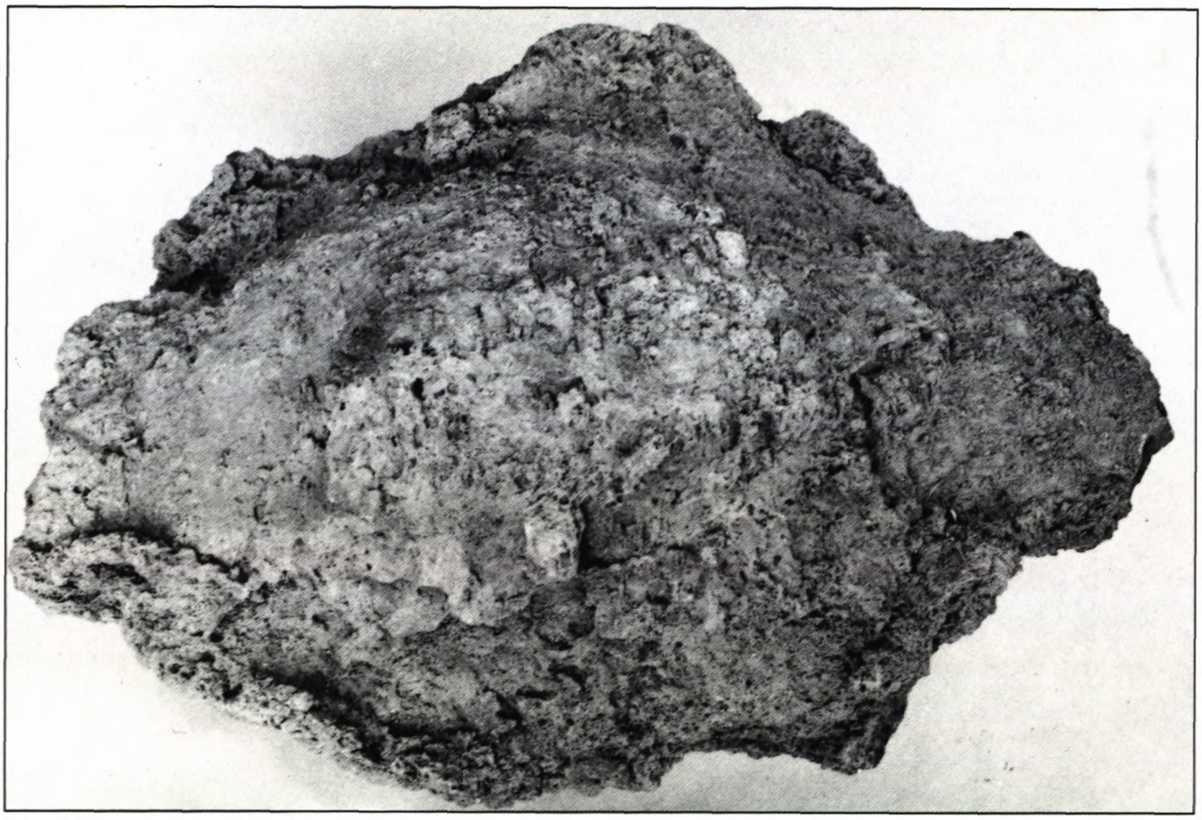


Photo 13. Amygdaloidal bomb.

Photo 14. Block bomb - elongated shape

bed similar to that encountered in Komjatice, for which Mindelian age was assigned before (Kukla), has been found in loess near Levice (brick kiln Monako). Thanks to progress in geologic mapping a revision of the section and re-dating of the loessy bed in Levice to Riss age (HALOUZKA,1982) could be made. As far as the age and the origin of the tuff are concerned, the most likely asssociation was with the latest maar basaltic volcanism in Fiľakovo (Cerová vrchovina upland). Anyway, to compare the age of the Pútikov vŕšok volcano with the other

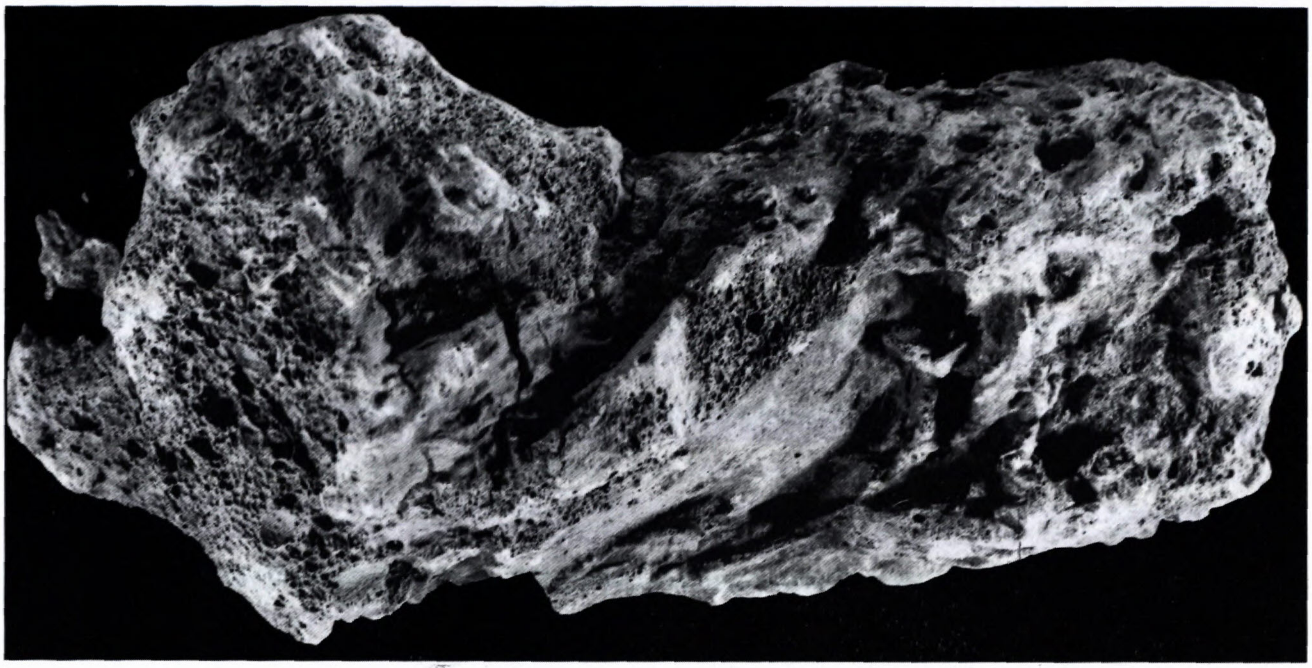


Photo 15. Spindle-like bomb.

Photo 16. Cow's stool bomb.

Photo 17. Lava flow 1992, Etna - a lava tongue of Aa lava type (coarse surface) with scarce pahoehoe lava tongues (smooth surface), separated from the lava plateau

Photo 19. Recent cinder cones - western slope of the Etna volcano.

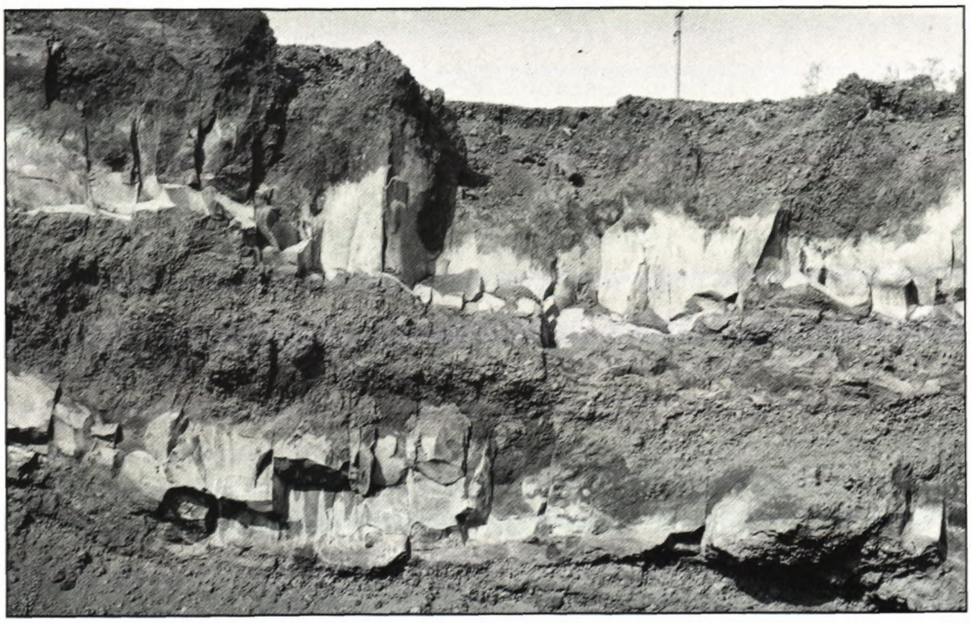


Photo 18. Lava flows Etna 1983 Etna, Aa -type made of massive lava with lava breccias (2 flows).

European volcanoes, the only reliable younger fossil remnant of volcanism dating back to Pleistocene, is in the Eifel region of western Germany (late Pleistocene -Wurm).

3. The crater of Pútikov vŕšok volcano surrounded the 477 m triangulation point (called Pútikov vŕšok). Altough the cinder cone has developed in its centre, most of the volcanic material have churned from the centre NW, filling up a paleovalley. A feature analogical to that of the Parícutin volcano in Mexiko, (1943 - 1945, see topographic maps showing the situation before and after the eruption) has been reported by FOSHAG and GONSALES (1959). The lava flows have poured down to fill in suitable depression (paleovalleys, trenches, gullies).

4.The Pútikov vŕšok volcano produced mainly the lava flows = effusive eruptions. Two types of lava flows occur - the Aa lavas and pahoehoe lavas. The lava flows join together to form a lava plateau. The position and character of flows is reminiscent of that of the Hawai islands (USA) volcanoes, described by WALKER (1990). A similar feature has been observed (ŠIMON) during the Etna (Sicily) eruption in May 1992. Starting on 14 December 1991 this eruption produced anastomosing lava

Photo 20. A view into the Etna cinder cone crater.

Photo 21.Volcanic bomb from Etna - recent.

flows running through channels and forming lava tongues. Out of the mixture of lava masses (plateau) the Aa lavas made up to 90 - 95 % (photo 17,18), while the pahoehoe lavas (tongues) were of scarce occurrence (photo17). The eruption produced the rocks of hawaite composition strewn over an area of 7 sq. km (before 31 October 1992, BARBERI et.al.1993).

5. Investigation into volcanic features of the Pútikov vŕšok volcano allowed to distinguish three types of explosive eruptions: the Stromboli, the Hawai and the freatomagmatic ones. As medium explosive types of the Hawai - Stromboli eruptions the Pútikov vŕšok volcano produced the basaltic magma material and the Stromboli and Hawai type pyroclastic rocks, both being deposited side by side depending on the eruption dynamics. These eruptions were responsible for piling up of the cinder cone composed of poorly bedded cinders and volcanic bombs (Stromboli type) and spatter rocks, thin lava flows and clinkers (Hawai). SELF et.al.,1974 described the Heimaey Island - eruption (1973), lava fountain eruption (Hawai type), with transitions to Stromboli type explosions, which produced a cinder cone. The klinker cones developed on slopes of the Etna stratovolcano. The cones are made of Stromboli type pyroclastics (photo 19 - author's observation). The shape of the 20th century cones are well preserved. Some of the 19th century (or older) cones are, on the other hand, more or less affected by erosion (photo 20). The third type of eruptions, the freatomagmatic ones, are less widespread in the structure of the Putikov vŕšok volcano. The eruption products are made of thin beds situated in the centre, and on slopes of the volcano. These explosions were either caused by waters coming from the Chválenský potok creek, or from a paleolake (which formed due to impoundment of the above creek by streams at the southern side of the volcano), or by groundwaters from underlying rocks. HOUGHTON and SCHMINCKE (1989) described the Rotherberg volcano (Eifel, Germany) as a complex of Stromboli and freatomagmatic eruption. The volcano is made predominantly of Stromboli type pyroclastics with thin beds of freatomagmatic eruption products, and the freatomagmatic eruption, as part of the Stromboli type eruption, was initiated due to suitable hydrogeologic conditions in the environment.

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