Neogene–Quaternary Alkali Basalt Volcanism in Central and Southern Slovakia (Western Carpathians)

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ABSTRACT. Alkali basalt volcanism in central and southern Slovakia was active from the Upper Miocene to Quaternary. Its products are mostly located on stable blocks bordering young extensional basins during the thermal stage of their subsidence. Only scarce eruptive centres are known in the area of the Central Slovakia Neogene Volcanic Field dominated by andesites and rhyolites. Alkali basalts and basanites occur here as scattered necks, dykes; lava flows, and a cinder cone. Most of the alkali basalt to basanite volcanic activity took place in the region of southern Slovakia (Lučenec Basin, Cerová vrchovina Hills), extending into northern Hungary. Numerous cinder cones, lava flows, necks, diatremes and maars have been identified.

Results of K/Ar dating and different relationships of volcanic products to morphology indicate that volcanic activity of alkali basalts and basanites took place in seven volcanic phases.

The oldest alkali basalt/basanite volcanic products are those in the area of central Slovakia, which are of the Pannonian age, dated to 8.0–6.6 Ma. Slightly younger are the volcanic products of the Podrečany basalt Formation (several lava flows and two maars) the western part of the Lučenec Basin, dated to 7.2–6.4 Ma. This age is confirmed by biostratigraphical study of sediments of the Poltár Formation (Pontian). Sediments alternate with volcanic products and/or cover them. Phreatomagmatic activity stimulated by the contact between ascending lava and water-saturated sediments or limnic water resulted in the formation of maars. Diatomitic clay and alginite filled maar depressions after the end of phreatomagmatic activity.

Alkali basalts and basanites of the Cerová basalt Formation are younger, Pliocene to Quaternary in age, dated to 5.43–1.16 Ma. Owing to the synvolcanic updoming of the Cerová vrchovina Highland older volcanic products occupy relatively higher positions on ridges, while younger volcanic products occupy relatively lower elevation in valleys. The youngest maars lie at the level of Recent alluvial plains. Their relationship to fluvial terraces indicate activity in the time of the Günz / Mindel glacials or after the Mindel glacial. Internal structures of maars and diatremes indicate transitions from phreatic and phreatomagmatic activity to mixed Surtseyan–Strombolian eruptions and finally to Hawaiian activity.

The cinder cone of Pútikov vŕšok Hill and related lava flows in the western part of the Central Slovakia Neogene Volcanic Field are manifestations of the youngest alkali basalt volcanic activity in Slovakia dated to 0.53–0.16 Ma. As the lava flow overlies the Riss terrace of the Hron River, its age is probably younger (0.13–0.22 Ma).

KEY WORDS: alkali basalts and basanites, volcanic landforms, K-Ar age, Slovakia.

Introduction

Neogene calc-alkaline volcanism in Central Western Carpathians preceded the Plio-Pleistocene alkaline volcanism. Main volcanic structures are preferably located on stable crustal blocks surrouding young sedimentation basins. Central Slovakia Neogene Volcanic Field is formed by andesites and rhyolites. Only few alkali basalt eruptive centres are found in this area, having the form of necks, lava flows and a cinder cone. Most of the alkali basalt to basanite volcanic activity took place in the area of Southern Slovakia (Lučenec Basin, Cerová vrchovina Highland) extending across the state boundary to northern Hungary (Salgótarján area). The principal volcanic forms are cinder cones associated with lava flows, necks, diatremes and maars. Results of K/Ar dating (Balogh et al. 1981), different degree of destruction of volcanic forms and different relationships of volcanic products to paleotopography indicate that volcanic activity took place in seven volcanic phases (V. Konečný et. al. 1995 a, b).

Geological settings

Central Slovakia

The initial manifestation of volcanic activity followed after Neogene calc-alkali andesite volcanism terminated by the activity of high-alumina basalts and/or basaltandesites with radiometric age of 12–8.2 Ma.The oldest alkali basalt volcanic product represents a relict of lava flow at the locality of Devičie (1 km south of Krupina) filling a paleovalley of east–west direction (Fig. 1). Bottom of the paleovalley was incised into the surface of volcanosedimentary complex of Badenian age and lies roughly 25 metres above the present bottom of the Krupinica River valley. Radiometric age of the lava flow of 8.0 ± 0.54 Ma is in a good agreement with the high degree of destruction of the original volcanic form (a supposed scoria cone was removed by erosion).

Extensive lava complex of Ostrá Lúka (6 km southwest of Zvolen) consists of several lava flows moving to north over relatively flat topography of a wide paleovalley. Scoria cone at the southern part of the lava plateau is not preserved and can be only presumed. Basalt lava flow near the locality Dobrá Niva was dated at 6.59 ± 0.29 Ma. Damming of the paleovalley on the southern margin by lava flow resulted in the formation of a small lake, filled with silt and clay sediments about 30 m in thickness. Association of the sporomorphs within the sediments indicates ages close to the Miocene–Pliocene boundary (Planderová in Konečný et al. 1983), which is in a good agreement with radiometric dating.

Lava neck of Kalvaria near Banská Štiavnica with an almost isometric shape (90 to 100 metres in diameter) forms a conspicuous hill with a Catholic church at its top (Fig. 2A). The lava neck is dated at 7.29 ± 0.41 Ma. Orientation of the columnar jointing in upper part of the lava neck indicates enlargement of the crater space. High degree of destruction of the original volcanic form (a supposed scoria cone was completely eroded) fits well with the radiometric age.

Lava neck at the locality of Kysyhýbel (2 km east of Banská Štiavnica) exposed by railway (Fig. 2B) was dated at 6.77 ± 0.48 Ma. The lava neck consists of the main body of elliptical shape elongated NE–SW and of small satellite isometric body. Both bodies are separeted by basaltic breccia containing rare, distinctly rounded blocks of the surrounding rocks (hornblende-biotite andesite). These blocks were torn out from the channel walls during eruptive processes. Their rounded shape is explained as resulting from abrasion during vertical movement within fluidized suspension of highly compressed magmatic gases.

The cinder cone of Pútikov vŕšok Hill (near Nová Baňa) has developed in the western part of the Central Slovakia Neogene volcanic field (Fig. 3). Associated lava flows moved generally to the north covering terrace accumulation of the paleo-Hron River attributed to the Riss glacial in age (Šimon et Halouzka 1996).

Southern Slovakia

Volcanism of alkali basalts and basanites in southern Slovakia (Lučenec Basin and Cerová vrchovina Highland) and northern Hungary (Salgótarján area) during the interval of 1–7 Ma covered an area of more than 150 km² (Fig. 4). Volcanism of explosive and effusive type created numerous scoria cones accompanied by lava flows and maars. In the northwestern part of the Lučenec Basin, volcanic activity mostly occurred in fluvio-lacustrine environment, while in the Cerová vrchovina Highland in the south it occurred on a dry land with a scarce local fluvial

Fig. 1. Relics of alkali basalt volcanism in the Central Slovakia Neogene volcanic field: 1 – lava flows and lava complexes of alkali basalts; 2 – a) cinder cone; b) supposed cinder cone/removed by erosion; 3 – lava necks; 4 – fluviolacustrine sediments of depressions dammed by lava flows, a) Riss/Würm, b) Late Miocene/Early Pliocene; 5 – margins of the Central Slovakia Neogene volcanic field; 6 – state boundary.

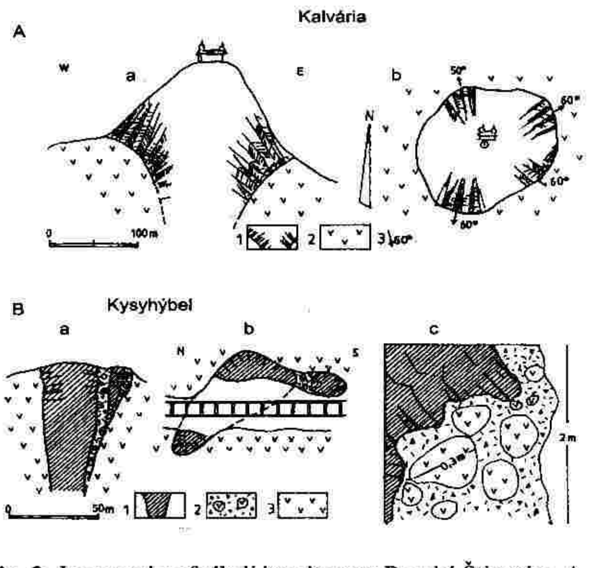


Fig. 2. Lava necks of alkali basalts near Banská Štiavnica. A – Lava neck of Kalvaria (749): a – section, b – planar scheme; 1 – lava body of nepheline basanite with columnar jointing, 2 – hornblende-biotite andesite; 3 – trend and plunge of columnar jointing. B – Lava neck exposed by railway at the locality of Kysyhýbel: a – section, b – planar scheme, c – detail of outrop; 1 – lava body of nepheline basanite with columner jointing; 2 – basaltic breccia with "subrounded" blocks of hornblende-biotite andesite; 3 – hornblende-biotite andesite.

sedimentation in river valleys. Based on radiometric dating, spatial distribution of volcanic products and the lithologic and petrographic character of rocks two volcanic formations are distinguished (Vass and Kraus 1985):

a) Podrečany basalt Formation of Pontian age occupying the northwestern part of the Lučenec Basin,
b) Cerová basalt Formation of Pliocene–Pleistocene age extending across a relatively wide area including the southern part of the Lučenec Basin, Cerová vrchovina Highland and northern Hungary in area of Salgotarján.

a) Podrečany basalt Formation

Volcanic activity in the northern part of the Lučenec Basin produced several lava flows and two maars having close relations to the development of fluvio-lacustrine basin (Poltár Formation). Association of sporomorphs in clay sediments investigated by Planderová (1986) corresponds to Pontian age.

Lava flows extruded from the supposed eruptive centers (cinder cones?) along the northern margin of the Lučenec Basin, followed southerly-trending paleovalleys and finished in limnic environment. Alternation of lava flows with sediments has been proved by many boreholes. Radiometric age of lava flow near Podrečany 6.44 ± 0.27 Ma (isochrone age 6.17 ± 0.47 Ma) is in a good agreement with biostratigraphic data and correlate with numeric age of the Pontian.

The lava flow near Mašková dated by K/Ar method (Kantor and Wiegerová 1981) showed an older age of 7.15 ± 0.23 Ma. The lava flow at the locality of Mašková itself contains numerous upper mantle and crustal xenoliths and xenocrysts.

Maars of the Podrečany Formation originated by phreatic and phreatomagmatic explosive activity due to the contact of ascending lava column with water-saturated Miocene sedimentary rocks (Fig. 5). Maars, situated generally below the level of

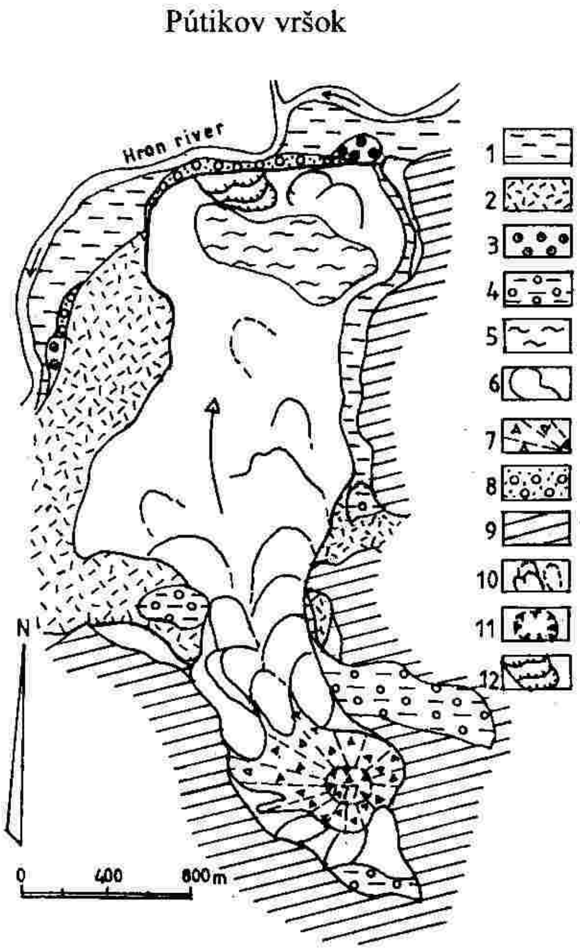


Fig. 3. Pútikov vŕšok Hill – a cinder cone with lava flows (after Šimon et al. 1996, simplified). 1 – fluvial sediments; 2 – polygenetic colluvial sediments; 3 – fluvial sandy gravels and sands (Würm); 4 – fluviolacustrine loams with gravels (Riss/Würm, Wüürm); 5 – aeolian loess fossil soils; 6 – nepheline basanite lava flows; 7 – pyroclasticic rocks of a cinder cone; 8 – fluvial sandy gravels (Late Riss); 9 – underlying volcanic rocks – undifferentiated (Badenian); 10 – margins of individual lava flows; 11 – supposed crater rim; 12 – quarry.

the original surface, have roughly circular or semicircular shape with diameters up to 2,000–2,500 m. A shallow depression was formed by incipient strong phreatic eruptions. The following phreatomagmatic activity created a tuff-ring around the central depression. Tuffs consist of palagonitized lapilli tuffs and scoria with scattered basaltic bombs and of high amount of fine to blocky material coming from the underlying Lower Miocene sediments. Unconsolidated material accumulated on the inner slope of the maar was often sliding to deeper parts of the central depression. Limnic environment was re-established within the maar depression stimulating the following phreatic explosions. After a cease of volcanic activity limnic sedimentation continued in the maar depression and resulted in the deposition of diatomitic clay (maar Jelšovec) or alginite (maar Pinciná) (Fig. 5). After the end of magmatic activity the maars were overlain and buried beneath sediments of the Poltár Formation which preserved maar fillings from erosion.

b) Cerová basalt Formation

During Pliocene–Pleistocene, volcanic activity spread to the southern part of the Lučenec Basin and the Cerová vrchovina Highland – northern Hungary (Salgótarján area). Southern part of the Cerová vrchovina Highland was uplifted and transformed into a dome structure as indicated by geomorphological evidence and by the change of hydraulic regime during the Early Pliocene to Late Pleistocene (Vass et al., 1986). Volcanic activity resulted in the formation of a number of scoria cones accompanied with lava flows and/or lava complexes built at their foot lava plateaus (Fig. 4). Phreatomagmatic activity resulted in the formation of maars, tuff rings and tuff cones.

The highest level of paleorelief was reached in the southern part of the Cerová vrchovina Highland near the state boundary where the base of lava complexes and scoria cones lies about 550–570 m above sea level. Products of volcanic activity in the initial stage were deposited on a relatively flat relief in the central updomed area (lava plateau of Medvedia výšina and Pohanský vrch Hills). Updomed area was progressively tilted to the N, NW and NE. The northeastern part was dissected by numerous paleovalleys oriented radially relative to the centre of updoming. Subsequently, volcanic activity extended over the updomed area. Lava flows following radial pattern of paleovalleys were directed to the north and stopped at about 220 m above sea level (north of Fiľakovo). As a result of cotemporaneous updoming of the southern Cerová vrchovina Highland, volcanic bodies were destructed and deeply eroded. Many scoria cones were removed by erosion and subvolcanic feeder systems (dykes, necks and diatremes) were exposed. Lava flows originally filling bottoms of paleovalleys and flat depressions now cover the uppermost flat parts of the hills (inversion of relief).

Volcanic forms

Cinder and spatter cones composed of agglomerates, agglutinates alternating with lapilli tuffs and basaltic bombs are accompanied by many lava flows and/or lava complexes (Fig. 6). Sections across some of the cones reveal a transition from phreatic activity in the early stage to phreatomagmatic eruptions and Strombolian and/or Hawaiian eruptions in the final stage (Fig. 7). Only scarce relicts of deeply eroded cinder cones are present in the updomed area (Medvedia výšina, Fig. 8; Dunivá hora, Fig. 6). On the other hand, in the area of Fiľakovo (north of the updomed area), a conspicuous group of cinder cones (Veľký and Malý Bučeň) was preserved, resisting to intensive erosion.

Lava flows of variable thicknesses (10–50 m) represent elongated bodies reaching several kilometres from the source areas, usually from cinder cones (Fig. 4). The shapes of the lava bodies strongly depend on the orientation and morphology of the paleovalleys. Fluvial deposits of the former paleovalleys are preserved beneath several lava flows (Fig. 9A).

Lava flows are dominated by massive lava with platy jointing at the base (conformable to topography), upwards passing to blocky and/or columnar jointing. Lava breccia is often preserved at the bases of lava flows (Fig. 9A–C). Vesicular lava breccia of the aa or block type forms the uppermost and marginal parts of lava flows (Fig. 9ABD).

Due to the huge effusive activity extensive lava complexes or lava plateaus originated at the foot of some cinder cones (or groups of cinder cones). The largest lava plateau of Medvedia výšina in the southern Cerová vrchovina Highland extending to northern Hungary occupies an area of about 12 km² (Figs. 4, 6).

Necks and dykes in more eroded parts of volcanic area emplaced in the underlying Early Miocene sediments represent feeding channels to lava flows or cinder cones. Lava necks and dykes often penetrate through previous breccia filling of diatremes (Fig. 10A–C). The orientation of columnar jointing in the uppermost parts of necks indicates an enlargement of space within the crater and a transition to lava lake body (Fig. 10A). Several necks accompanied with dykes are related to remnants of lava flows (Fig. 10C).

Maars are generally situated in low depressions roughly 100–130 m below the original surface (the base of the near lava flows). Early phreatic explosions initiated by contact of the ascending magma with water-saturated Miocene sediments (at a depth of probably 1000 m) created maar depressions subsequently filled with lakes. The following phreatomagmatic activity controlled by decreasing water/magma ratio (dominantly Surtseyan – wet surge type of eruption) produced tuff rings and tuff cones. Products of phreatomagmatic activity deposited on internal slopes were sliding down into maar centres due to their gravitational instability (Fig. 11).

In some cases, the destruction of an older tuff cone by violent explosion and its consequent covering by younger volcanic products can be observed (Fig. 12). This later volcanic stage indicates a transition towards mixed Surtseyan–Strombolian eruption (palagonite tuffs of proximal base surge deposits are mixed with basaltic bombs) and finally to Hawaiian eruptions (agglutinated scoria and bombs in the uppermost part of the section in Fig. 12).

Emplacement of shallow intrusions interrupted the evolution of the Bulhary maar (Fig. 13). The early maar fill consisting of palagonite tuffs was intruded and strongly deformed by lacolith-like basalt body. Hyaloclastite and peperite breccias are present at contacts (Fig. $13b_2$). The intrusion eventually penetrated the maar fill and hyaloclastite breccia was formed at the direct contact of magma with water of the maar lake (Fig. $13b_3$).

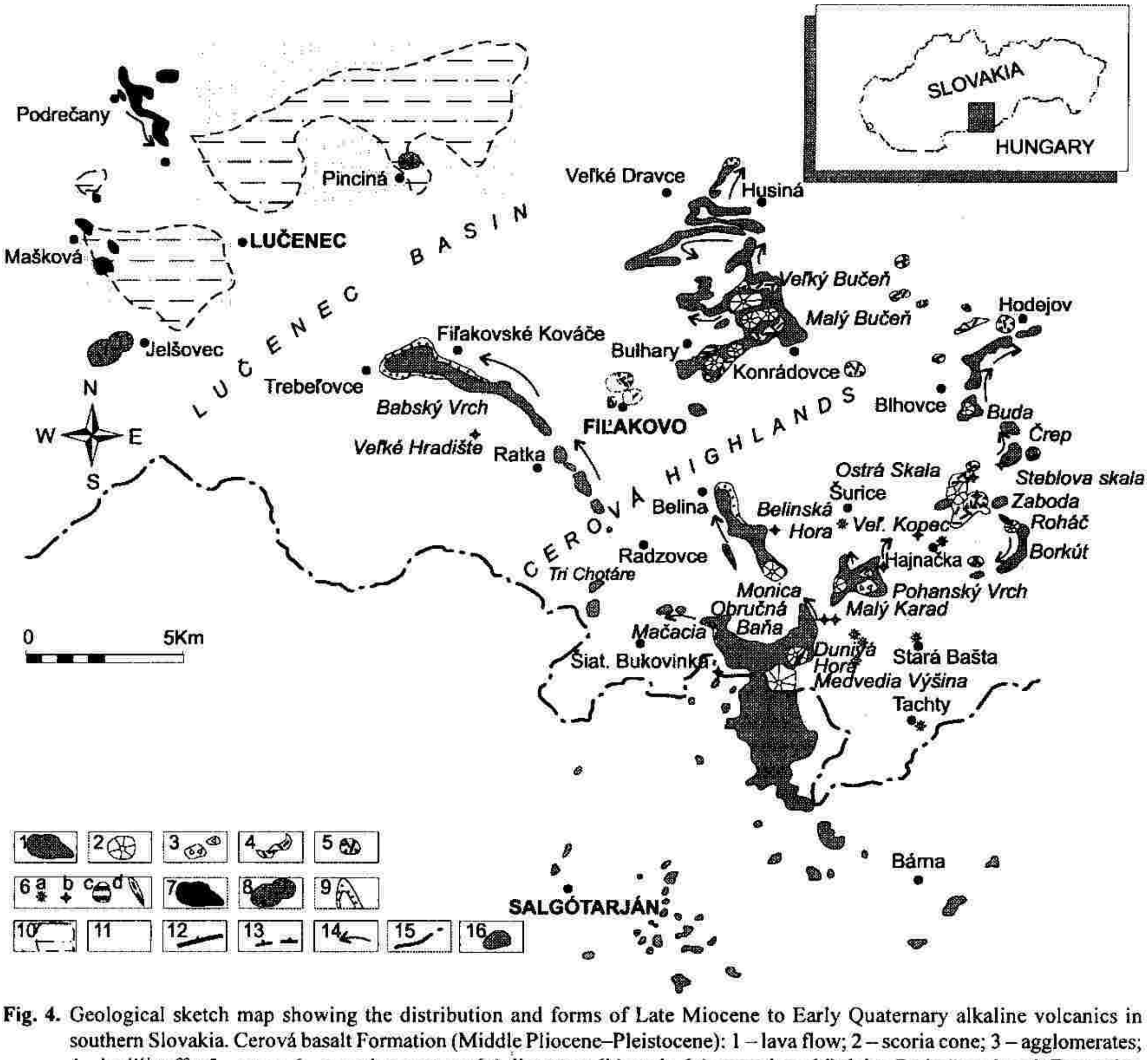
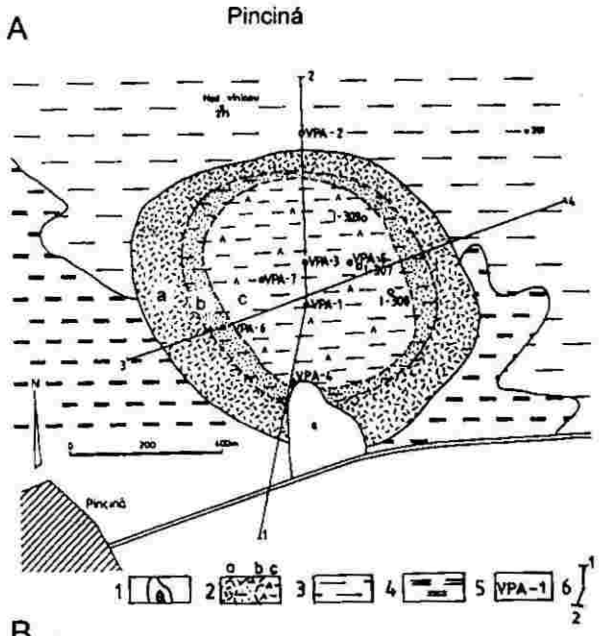


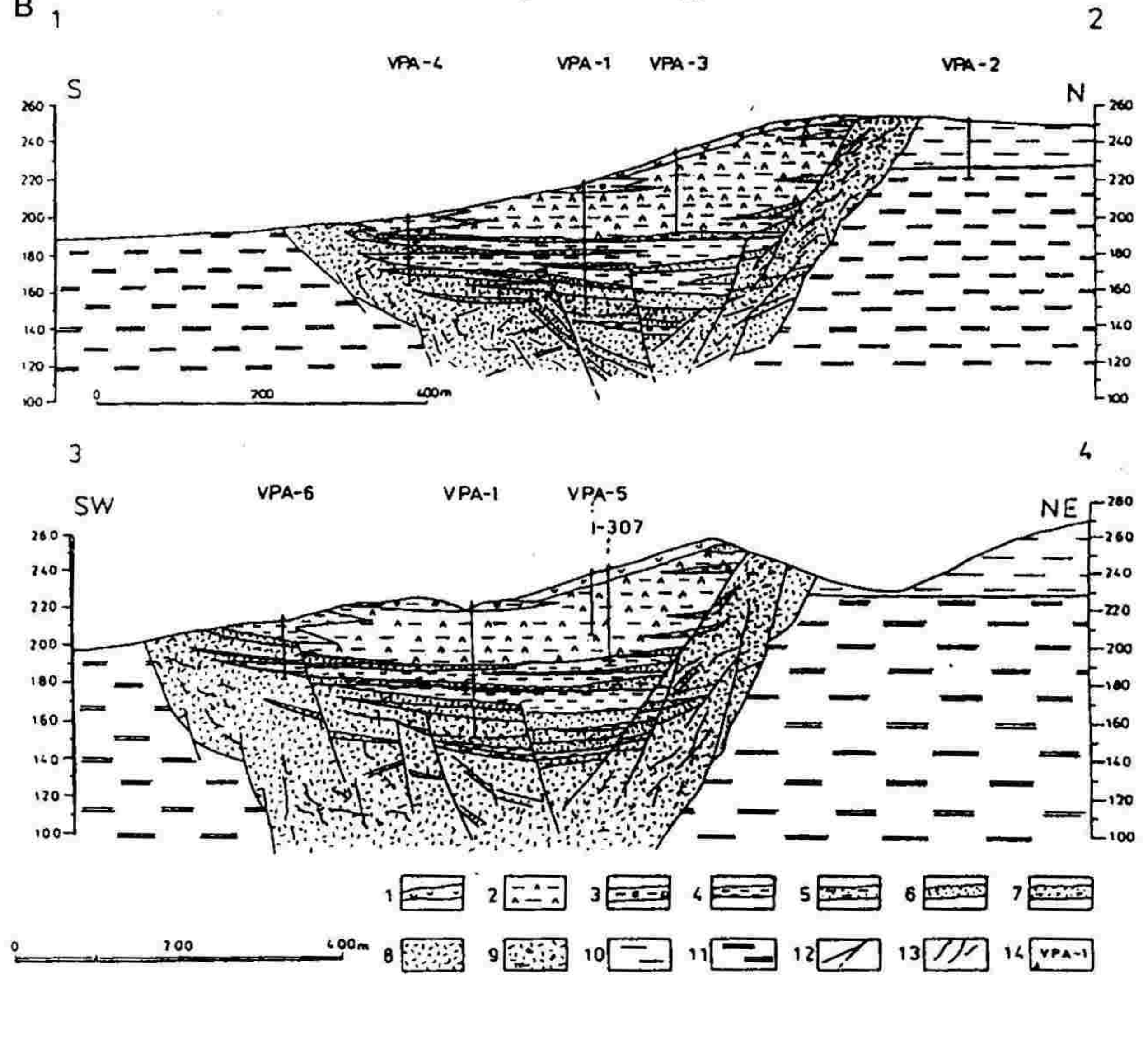
Fig. 4. Geological sketch map showing the distribution and forms of Late Miocene to Early Quaternary alkaline volcanics in southern Slovakia. Cerová basalt Formation (Middle Pliocene–Pleistocene): 1 – lava flow; 2 – scoria cone; 3 – agglomerates; 4 – lapilli tuffs; 5 – maar; 6 – eruptive centres: 6a) diatreme; 6b) neck; 6c) extrusion; 6d) dyke, Podrečany basalt Formation (Early Pliocene); 7 – lava flow; 8 – maar; Belina Member (Romanian?); 9 – gravels, clays, sands, Poltár Formation (Pliocene); 10 – clays, sands, gravels, rare lignite lenses; 11 – Early Miocene sediments, other signs; 12 – updomed area; 13 – local scale elevation; 14 – direction of lava flows; 15 – state boundary; 16 – undifferentiated basaltic rocks.

The following phreatomagmatic and effusive activity gave rise to the overlying complex of palagonite tuffs and lava flows (Fig. 13c).



Diatremes are exposed conduits of maars removed by erosion. Their filling reflectes evolutionary stages of maar structures. The early stage is represented by megabreccia of Lower Miocene sediments cemented by sand-sized matrix with small tuffaceous admixture (Fig. 14A–C). Products of phreatomag-

Fig. 5. Geological map (A) and cross-sections (B) of the Pinciná alginite deposit. Geological map of the Pinciná maar: 1 – Quaternary sediments; 2 – maar structure: a – tuff wall (lapilli tuff with scoria and basalt bombs); b – transitional zone (lapilli tuff, volcanic sandstone, sandy clay, tuffitic clay); c – internal zone (prevailingly alginite, subsidiary claystone and sandstone); 3 – Poltár Fm. – Pontian (clay, sand, gravel); 4 – Lučenec Fm., Szécseny schlier, Upper Oligocene–Lower Miocene (schlier); 5 – well; 6 – line of geological cross-section. Geological cross-sections 1–2, 3–4 of the Pinciná maar: 1 – Quaternary sediments; 2 – alginite; 3 – diatomitic clay; 4 – tuffitic clay (claystone); 5 – sandy tuffitic clay; 6 – tuffitic sandstone; 7 – tuffitic sandstone with conglomerates; 8 – lapilli tuff; 9 – lapilli tuff with basalt scoria and bombs; 10 – Poltár Fm. (clay, sand, gravel); 11 – Lučenec Fm. – Szécseny schlier Upper Oligocene–Lower Miocene (schlier); 12 – fault; 13 – slide structures; 14 – well.



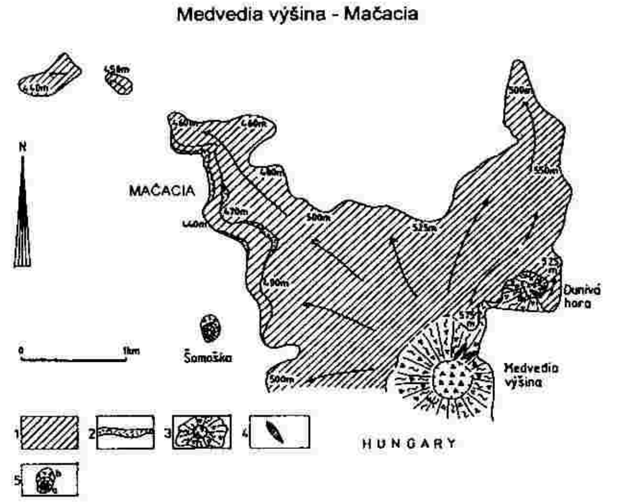


Fig. 6. Lava complex of Medvedia výšina–Mačacia with cinder cones. 1 – alkali basalt lava flows; 2 – beds of lapilli tuff and breccia; 3 – cinder cones (Medvedia výšina, Dunivá hora); 4 – dyke; 5 – Šomoška lava neck.

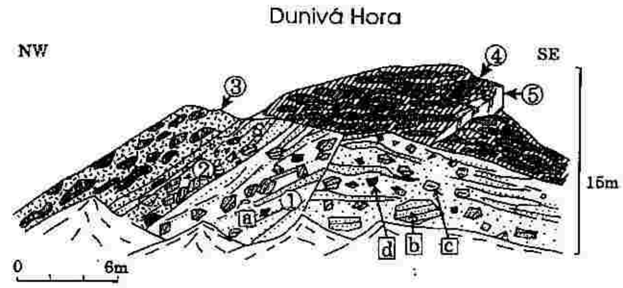


Fig. 7. Dunivá hora Hill – composite volcanic cone. 1 – phreatic eruption products: a) beds composed of sand material derived from underlying sediments, b) blocks of Lower Miocene sediments, c) fragments of crystalline rocks, d) polygonal blocks of glassy basalt, 2 – phreatomagmatic eruption products with scoria and bombs, 3 – cinders with scoria and bombs, 4 – spatter and agglutinate bombs, 5 – basaltic dyke.

matic activity filling the diatreme form palagonite tuffs with pieces of vesiculated basalts and sand-sized admixture with fragments of the underlying Lower Miocene sediments (Fig. 15A, B). A transition towards Strombolian eruptions is indicated by breccia of scoriaceous basalt fragments intruding through palagonitized tuff–breccia (Fig. 15B). Feeders of the younger stage of Hawaiian activity are basaltic dykes penetrating the breccia of earlier stage (Fig. 15B). In the uppermost part of diatreme Šurice, a subsided block of maar structure with stratified material of phreatomagmatic activity is present finishing with the Strombolian eruptions (Fig. 15A). The maar fill and the subsided block are intruded by a younger basaltic dyke.

Time evolution of volcanic activity

According to radiometric data (Balogh in: Konečný et al. 1995), biostratigraphic evidence from interbedded sediments, paleomorphological and paleovolcanic observations, the evolution of alkali basalt volcanism in Central and Southern Slovakia occurred during seven volcanic phases (V. Konečný et al., 1995)

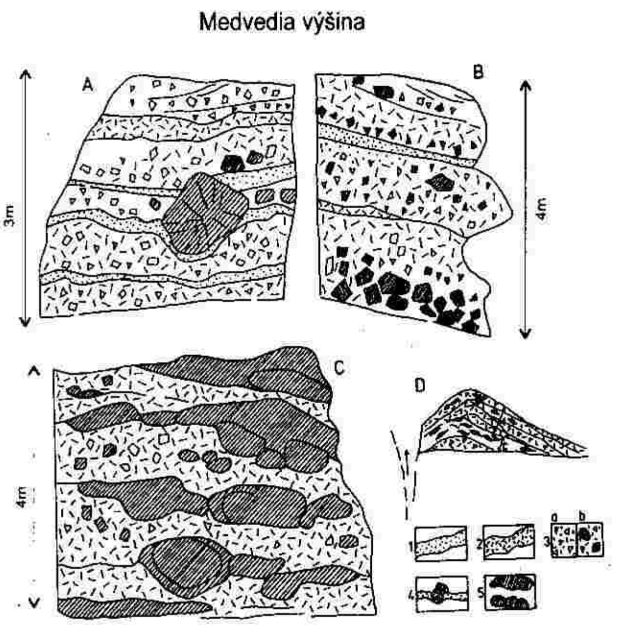


Fig. 8. Sections across the cinder cone of Medvedia výšina Hill. A, B – upper part of the cone; C – lower part of the cone; D – position of sections within structure of the cone; 1 – fine tuff; 2 – coarse lapilli tuff; 3 – agglomerate: a) fine to medium, b) coarse to blocky with basaltic bombs; 4 – impact structure caused by fall of basaltic bomb; 5 – agglutinate and agglutinated bombs.

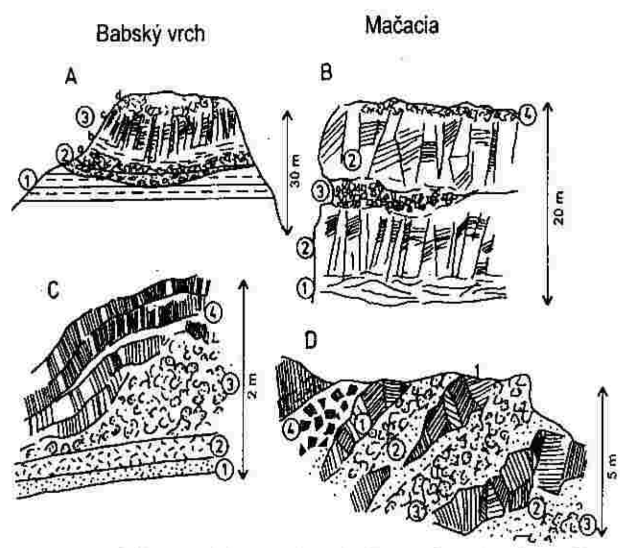


Fig. 9. Lava flows of Cerová basalt Formation. **A** – Lava flow Babský vrch Hill (west of Fiľakovo). 1 – Early Miocene sediments; 2 – fluvial gravels and sands filling a paleovalley (Pliocene); 3 – lava flow: a) basal lava breccia, b) massive basalt with platy jointing, c) – massive basalt with columnar jointing, d) – upper lava breccia ("aa type"); **B** – Complex of lava flows of Mačacia: 1 – massive basalt with platy jointing; 2 – massive basalt with columnar jointing; 3 – basal lava breccia; 4 – upper lava breccia ("aa type"); **C** – Detail of lower part of the lava flow of Mačacia. 1 – fine ash tuff; 2 – coarse lapilli tuff; 3 – lava breccia; 4 – massive lava; **D** – Detail of margins of the lava complex of Mačacia. 1 – massive lava with blocky jointing; 2 – vesiculated lava; 3 – lava breccia; 4 – agglomerate.

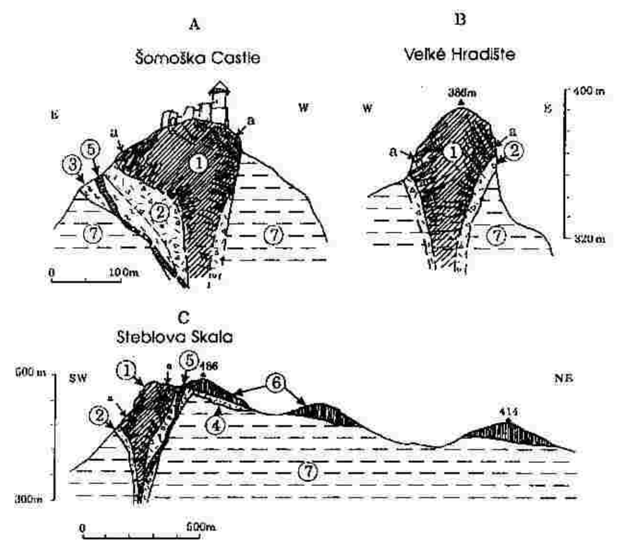


Fig. 10. Necks with related dykes and lava flows. A – lava neck with small lava lake; B – typical lava neck; C – lava neck with related dyke and lava flows. 1 – lava neck; 2 – tuff breccia; 3 – scoria cone; 4 – lapilli tuff; 5 – lava dyke; 6 – lava flow; 7 – Early Miocene sediments.

1st volcanic phase (8.0–6.4 Ma) of Pannonian–Pontian age includes basaltic relics in Central Slovakia (necks near Banská Štiavnica, lava complex of Ostrá Lúka and lava flow of Devičie). Volcanic bodies of the Podrečany Formation developed in the limnic environment of the Poltár Formation in the NW part of the Lučenec Basin. The following activity concentrated in the

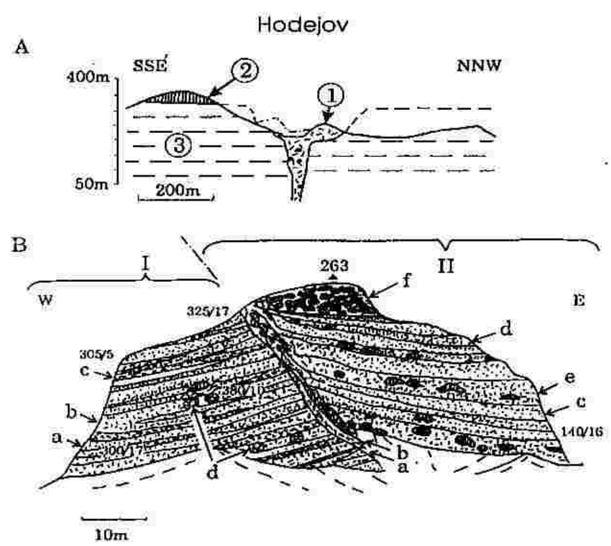


Fig. 12. Hodejov maar – remnants of tuff cone with two evolutionary stages. A – cross-section. 1 – tuff ring with diatreme; 2 – older lava flow; 3 – Early Miocene sediments. B – quarry at Hodejov village; I. older part of tuff cone structure: a) fine tuffs, b) coarse lapilli tuffs, c) scoria, d) "baked" Early Miocene sediments with limonitic rim; II. younger part: a) pumiceous phreatic tuffs, b) agglutinate (secondary lava flow), c) fine palagonite tuffs, d) coarse palagonite tuffs, e) coarse palagonite tuffs with basalt bombs, f) agglutinates.

area of the Cerová vrchovina Highland during the 2nd through 6th volcanic phases.

Volcanic activity of the **2nd** volcanic phase (5.43–3.74 Ma) during the Pliocene (Dacian) occurred mostly in the updomed area and less frequently at its margins in southern part of the Cerová vrchovina Highland. Lava necks of Šomoška, Veľké Hradište, Steblova skala, relics of cinder cones and lava complexes of Pohanský vrch Hill and lava flow of Belinský vrch Hill were formed. Volcanic forms show an advanced degree of destruction.

During the **3rd** volcanic phase (2.92–2.60 Ma – Pliocene, Early Romanian), volcanic activity following a significant break shifted to the margins of the updomed area (lava flows of Mačacia–Tri chotáre, complex of Ostrá Skala and diatremes of Šurice and Hajnačka).

4th volcanic phase (2.25–1.6 Ma) – Pliocene (Late Roma-

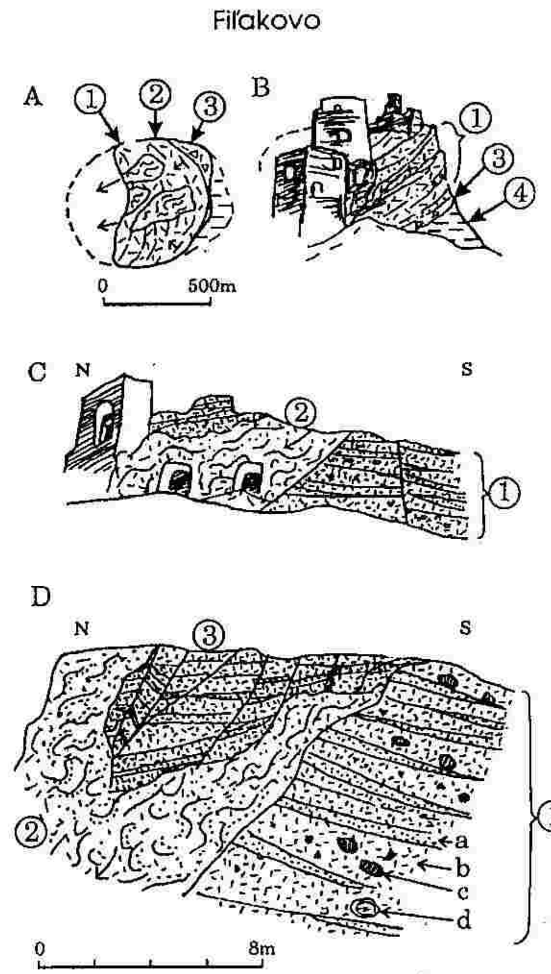


Fig. 11. Castle hill at Fiľakovo – remnants of eroded maar – tuff cone. **A, B** – planar scheme and section, respectively. 1 – inner slope of tuff cone (palagonitized lapilli tuffs); 2 – slump structures; 3 – tuff breccia; 4 – Early Miocene sediments. **C** – upper part of tuff cone; 1 – palagonitized tuffs with scoria and bombs; 2 – slump structure. **D** – detail of slump structure in the lower part of tuff cone. 1 – palagonitized tuffs with scoria and bombs; a) fine tuff, b) coarse lapilli tuff, c) basaltic bomb, d) blocks of Early Miocene sediments with "baked" limonitic shells; 2 – slump structure with deformed beds; 3 – slide block of bedded tuffs.

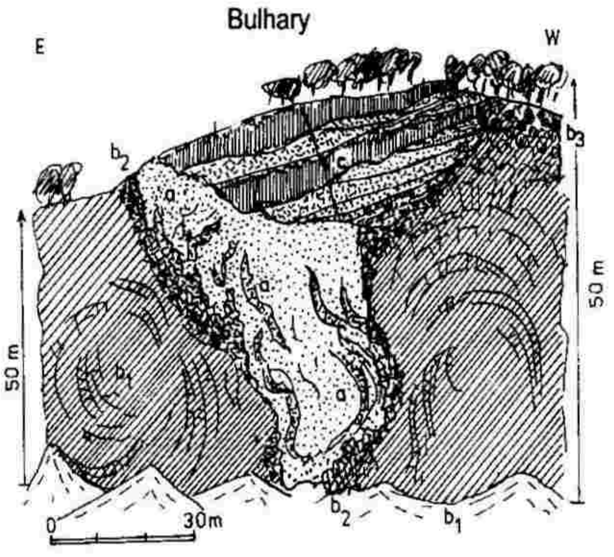


Fig. 13. Bulhary maar intruded by a laccolith-like basalt body; a) deformed maar sediments (palagonite tuffs), b_1) massive basalt body with onion-like jointing, b_2) marginal brecciated zone with peperite and hyaloclastite breccia, b_3) hyaloclastite breccia, c) younger overlying complex of lava flows and palagonite tuffs.

nian) – following a short break in volcanic activity expanded over margins of the updomed area (lava flows of Ratka Fil'akovské Kováče, Buda–Hodejov, and intrusive body of Bulhary). Lava plateau of the Medvedia výšina unit with a cinder cone were formed in the updomed area . Skeletal remains of mammalian fauna were described by Fejfar (1964) from the sediment fill of the maar south of the Hajnačka village. Their age corresponds to Zone MN-16 (Nairn et al. 1975), representing the age of about 1.8–2.0 Ma.

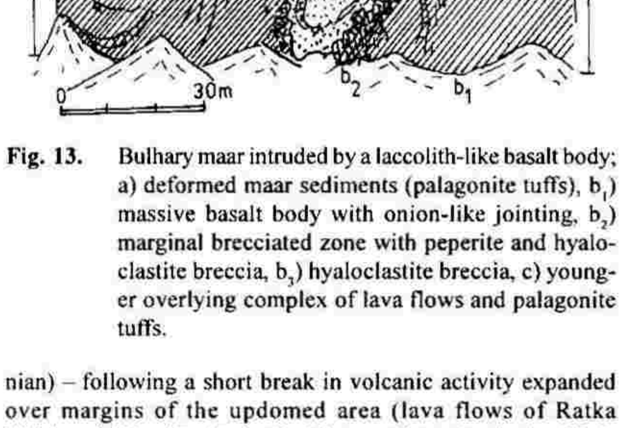


Fig. 15. Diatremes. A – Šurice diatreme. 1 – palagonitized tuff breccia with blocks of Early Miocene sediments; 2 – subsided block of maar fill, a) ash tuffs, b) fine tuffs, c) coarse tuff, d) palagonitized tuff breccia, e) lapilli tuff with scoria fragments, f) agglutinated bombs with scoria matrix; 3 – dykes and short sills; 4 – Early Miocene sediments; 5 – scree. B – Hajnačka diatreme. 1 – palagonitized tuff breccia; 2 – breccia with scoria fragments; 3 – dyke; 4 – Early Miocene sediments; 5 – scree.

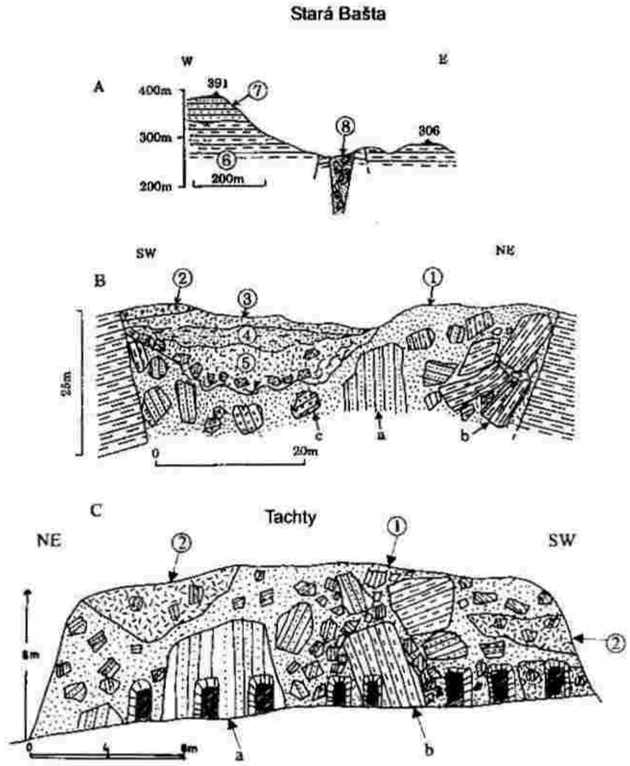


Fig. 14. Stará Bašta diatreme, A – section, B – outcrop. 1 – megabreccia with sandy matrix and blocks of Early Miocene sediments: a) sandstones with glauconite (Jalovce Member), b) sandstones and sands (Tachty Member), c) rhyodacite tuffites (Bukovina Member); 2 – lapilli tuff with fragments of basalt; 3 lapilli tuffs; 4 – fine tuffite and tuffitic siltstone; 5 – mixture of lapilli tuffs and sands with blocks of lapilli tuffs, slumping structures; 6 – Early Miocene sediments (Tachty Member); 7 – Early Miocene sediments with glauconite (JalovceMember); 8 – diatreme fill. C – Tachty diatreme. 1– megabreccia with sandy matrix and blocks of Early Miocene sediments: a) sandstones with glauconite (Jalovce Member), b) sansdtones and sands (Tachty Member); 2 – block of lapilli tuff mixed with fragments of Early Miocene sediments.

5th volcanic phase (1.51–1.16 Ma) is dominantly concentrated in the Lučenec Basin NE of Fil'akovo (group of cinder cones Veľký Bučeň with a lava plateau at their foot). Lava flows directed to the north reached the lowest levels of paleovalleys (about 200 m above sea level) which is in good agreement with their radiometric age. Volcanic activity in the updomed area continued to a limited extent (spatter cone of Duniva hora with a lava flow and lava flow of Borkút with the scoria cone of Roháč).

During the **6th** volcanic phase (probably near the Günz–Mindel boundary, or in Early Mindel) the maars of Hodejov and two maars at Fil'akovo (castle hill and Červený kopec Hill) were formed as inferred from their relations to river terraces.

The **7th** volcanic phase taking place in Central Slovakia in Quaternary times is represented by the scoria cone of Pútikov vršok Hill (near Nová Baňa) and related lava flows, dated to 0.53 ± 0.16 Ma. As the lava flows cover terrac accumulations of the Hron River estimated to be of Riss age, the age of the lava flows probably corresponds to the interval of 0.13–0.22 Ma.

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