Mineralia Slovaca, 47 (2015), 113 – 176
Web ISSN 1338-3523, ISSN 0369-2086

Paleovolcanic reconstruction of the Neogene Vepor stratovolcano (Central Slovakia), part II

VLASTIMIL KONEČNÝ[1], PATRIK KONEČNÝ[1], PETER KUBEŠ[1] and ZOLTÁN PÉCSKAY[2]

[1]State Geological Institute of Dionýz Štúr, Mlynská dolina 1, Bratislava, Slovak Republic
[2]Institute of Nuclear Research of the Hungarian Academy of Sciences (ATOMKI), Debrecen, Hungary

(Received 5. 10. 2015, accepted for publishing 24. 11. 2015)

Abstract

The western part of the Hercynian crystalline massif of the Veporic unit (east of the Middle Slovakian Neogene Volcanic Field) during Neogene represented a volcanic areal with andesite and rhyodacite volcanism. Because the original structure of andesite stratovolcano was removed by denudation, numerous relics of intrusive and intrusive-extrusive bodies of diorites, diorite porphyry, andesite porphyry and rhyodacites are now exposed on the surface, as well as sporadic relics of paleovalleys fillings of distal volcanic zone (they were discussed in Part I in the preceding paper in Mineralia Slovaca 47/1/2015). This paper (Part II) presents and discusses the relics of the volcaniclastic rocks in the paleovalleys fillings on the southern slopes of the Slovenské rudohorie Mts. The volcaniclastic rocks preserved in apical parts of the ridges, dominantly oriented to south, represent relics of the filling of original paleovalleys, which served as transport ways of volcaniclastic material to south into the delta-type sedimentary basin. More extended relics of volcanosedimentary filling of the sedimentary basin (at the southern foot of the andesite stratovolcano) are now preserved as uplifted isolated plateaus (Pokoradz and Blh plateaus) at the northern part of the Rimavská kotlina Basin. The structure and lithology of volcanic and volcanosedimentary sequences, filling the sedimentary basin and exposed on steep slopes of the Pokoradz and Blh plateaus, are documented by the geological-lithofacial map at a scale 1 : 20 000 and a set of profiles. Filling of the southern sedimentary basin – the Vyšná Pokoradz Formation (former Pokoradza Formation in Part I), thick 150–200 m consists dominantly of epiclastic volcanic rocks (epiclastic volcanic sandstones with thin interbeds of siltstones, medium to coarse and blocky conglomerates, epiclastic volcanic breccias and deposits of mass flows as debris flows, hyperconcentrated flows, hot and cold lahars). Volcanic facies represent dominantly the bodies of chaotic breccias of pyroclastic flows of several types: ash-pumice pyroclastic flows, block and ash pyroclastic flows with dominancy of pyroclastic material, and the block and ash flows with dominancy of blocky material coming from explosive destruction and collapses of the extrusive dome – the Merapi type.

Based on analytical data, obtained during mapping and geomagnetic survey of the relics of intrusive-extrusive bodies and remnants of volcaniclastic rocks, the paleovolcanic reconstruction of the andesite stratovolcano (removed by denudation) was done. Construction of probable profile through the stratovolcanic slope is based on the present position of the pyroxene andesite lava flow, preserved on the top of the paleovalley filling (Klenovský Vepor ridge e.p. 1338.4) with inclination 8° to west representing transitional zone from the stratovolcanic slope to distant profluvial plain. The position of the lava flow reflects ca 11 km distance from the central volcanic zone and its base corresponds to the level of the paleorelief ca 1150 m a.s.l. on which the Vepor stratovolcano was built-up. Respecting the position of the intrusive and intrusive-extrusive bodies of central, proximal and distal volcanic zones, the model of the stratovolcanic structure is presented in five profiles from the central to distal zone. The K/Ar radiometric dating provided the 12.28–11.56 Ma age of volcanic and intrusive activity. At the end the paper there follows a discussion about the multistadial evolution of the stratovolcano and its relation to development of the southern sedimentary basin.

Key words: Vepor stratovolcano, andesite lava flow, intrusive complex, volcanosedimentary formations, pyroclastic flow, lahar, epiclastic rocks, pyroclastic rocks, paleovolcanic reconstruction.

Introduction

Scattered intrusive bodies and volcaniclastic rocks of Neogene age in area of the Veporicum crystalline massif and volcanosedimentary complexes at the northern margins of the Lučenská and Rimavská kotlina basins confirm the eastward continuation of the Central Slovakian Neogene volcanic Field (Fig. 1). Intrusive bodies exposed on the surface, as well as volcaniclastic rocks, are supposed in this work to be remnants of the Vepor andesite stratovolcano (Part I – Fig. 3). In contrast to relativelly better preserved andesite stratovolcanoes of the Central Slovakian Neogene volcanic Field, in the area of the Veporic unit due to enormous uplift of extended crustal block the superficial volcanic structure was removed by denudation and the subvolcanic intrusive complex (diorite pluton, dyke swarms, necks and laccoliths) of the central volcanic zone were exposed on the surfice. In the area of proximal volcanic zone numerous shallow intrusive bodies, like laccoliths and dome-like extrusive bodies, are also uncovered (Part I – Fig. 6). Several relics of the paleovalleys filling are preserved in the western distal volcanic zone. In previous Part I of this contribution we have dealt in more details with intrusive bodies of the central and proximal volcanic zones and with remnants of volcaniclastic rocks in the filling of the paleovalleys in the western distal volcanic zone of the Vepor stratovolcano.

In this second part (Part II) we focused dominantly on the relics of the paleovalleys fillings on the southern slopes of the stratovolcano (southern slopes of the Slovenské rudohorie Mts.) and also on the volcanosedimentary complexes of the southern sedimentary delta-lake basin, recently preserved as solitary high plateaus, the Pokoradzská tabuľa Plateau (Pokoradz Plateau) and the Blžská tabuľa Plateau (Blh Plateau) at the northern edge of the Rimavská kotlina Basin (Pokoradza Formation in Part I, the Pokoradz Formation as more appropriate term in Part II). In the following text the results of K/Ar radiometric dating of the rocks, and questions related to volcanic activity and types of eruptions are discussed, as well as the problems of the primary volcanic structure reconstruction, its extent and evolution with relation to the development of sedimentary basin at the southern part of the stratovolcano.

Geographical and geomorphological characteristics of the area on the southern slopes of the Slovenské rudohorie Mts. (Revúcka vrchovina Highland) and at the northern part of the Rimavská kotlina and Lučenská kotlina basins

South of the central volcanic zone in a distance of about 12 km the relics of volcaniclastic rocks in fillings of the original paleovalleys continue to the area of southern slopes of the Slovenské rudohorie Mts., area of the Revúcka vrchovina Highland and volcaniclastic rocks form also the volcanosedimentary complexes of the Pokoradz and Blh plateaus at the northern part of the Lučenská kotlina and Rimavská kotlina basins (Figs. 2 and 3). Following text briefly characterizes the main geomorphologic units: 1 – Revúcka vrchovina Highland, 2 – Rimavská kotlina Basin (northern part), 3 – Lučenská kotlina Basin (northeastern part), 4 – Pokoradz Plateau, and 5 – Blh Plateau (Fig. 2 and Part I – Fig. 4).

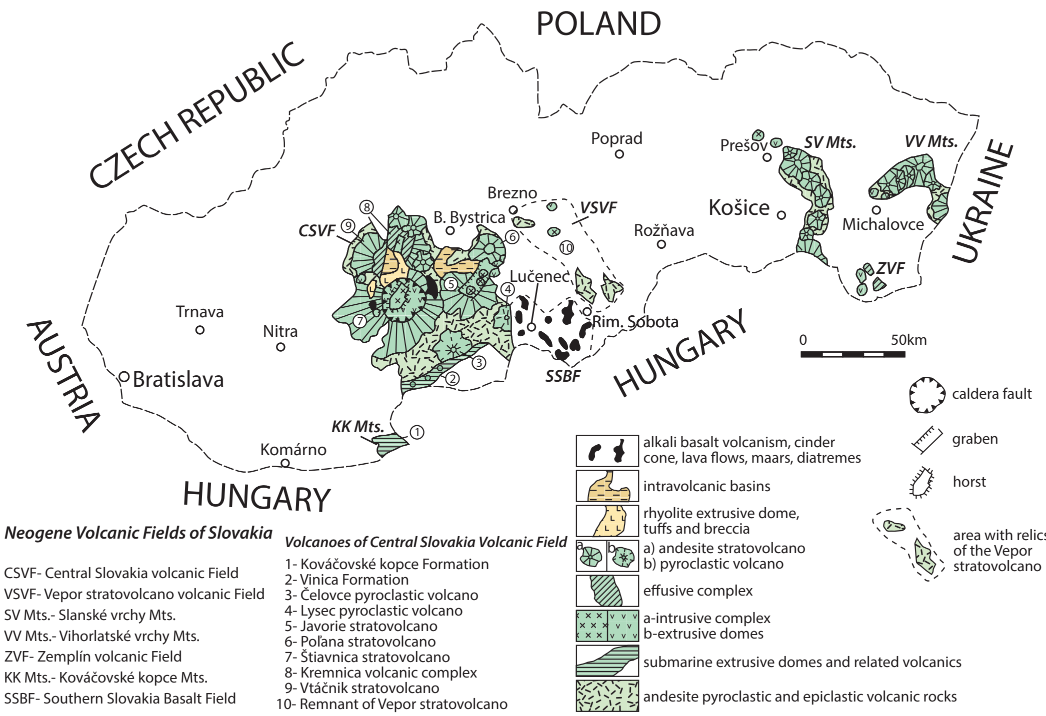


Fig. 1. Distribution of Neogene volcanic rocks in Slovakia.

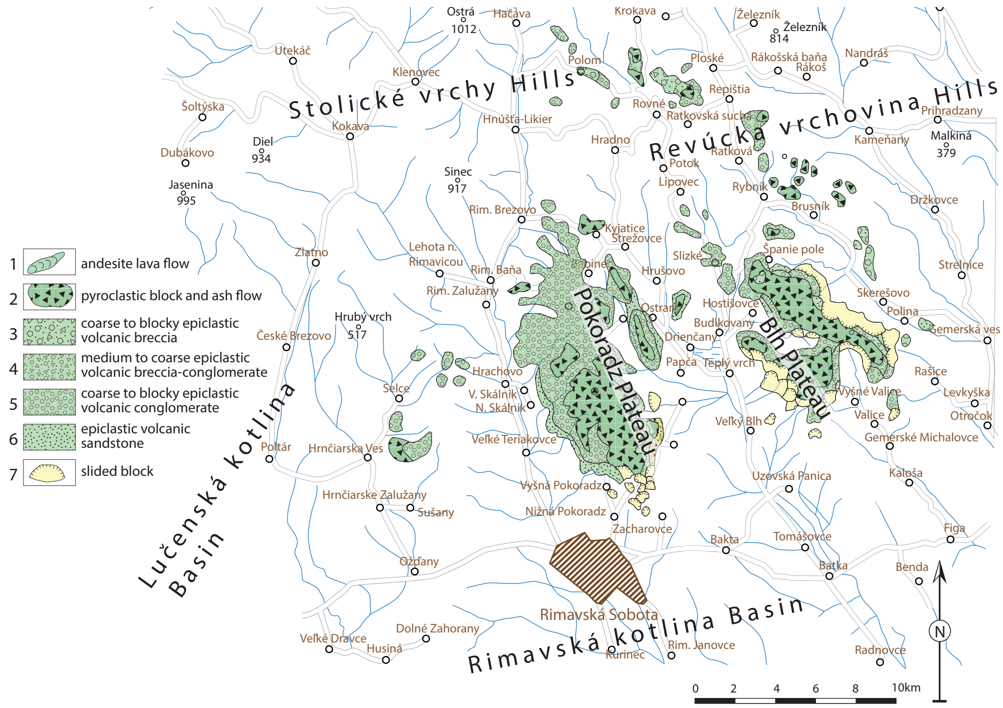


Fig. 2. Scheme of the area with relics of volcaniclastic rocks of the Vepor stratovolcano on the southern slopes of the Slovenské rudohorie Mts. (Revúcka vrchovina Highland) and the northern part of the Rimavská kotlina Basin.

1 – The Revúcka vrchovina Highland

The area of the Revúcka vrchovina Highland with scattered relics of volcaniclastic rocks represents a geomorphological subunit of the Slovenské rudohorie Mts. This area is characterized with mountains of medium hights of about 800 m a.s.l. (highest is the Železník elevation point, reaching 814 m a.s.l.). The mountain relief declines gradually to the south and is divided by deep valleys into several ridges dominantly trending NW–SE and to S. The valleys system is drained with rivers and brooks flowing generally to south (Rimava river, several main brooks like Blh, Slaná, Západný Turiec, a.o.). The northern part the area is built of the crystalline rocks of the Veporic unit (granitoids and crystalline schists). The Gemeric unit with low metamorphosed Upper Paleozoic rocks is overthrusted above the Veporic unit from the south to north. In the southern part of the Revúcka vrchovina Highland the nappe of the Silicic unit is dominant, consisting of the Mesozoic carbonates and argillite schists (Fig. 3). Lithology of the rocks and tectonic structures plays an important role in modelling of the highland type of the relief by erosive processes. Volcaniclastic rocks representing the relics of the paleovalleys fillings are preserved on the top of ridges oriented generally to the south and to the southeast. The paleovalleys were used for transport of volcaniclastic material to the southern area where it was deposited in the basin as the Vyšná Pokoradz Formation. Top parts of the mountains and their steep slopes are forested. Southern part of the area with low and flat hills are agriculturally cultivated, eventually they are used as a pasture for cattle and sheeps. Settlement in the northern part of the Revúcka vrchovina Highland is concentrated namely in valleys with rivers and brooks. Along brook of Západný Turiec there are situated the main villages as Ratková, Ratkovská Lehota, Sása, Rybník and Skerešovo village.

At the northern margin of the Rimavská kotlina Basin the more extent volcanosedimentary complexes of the Pokoradz and Blh plateaus represent relics of primary filling of the Neogene sedimentary basin of the Vyšná Pokoradz Formation. Volcanosedimentary complex developed on the surface of the Oligo-Miocene sediments was later divided by denudation into two isolated larger blocks as individual geomorphological units of the Pokoradz Plateau and Blh Plateau.

2 – The Pokoradzská tabuľa Plateau (Pokoradz Plateau)

The area of the Pokoradz Plateau north of villages Vyšná Pokoradz and Nižná Pokoradz is characteristic with flat relief of the high plateau with maximum elevation about 500 m above surrounding relief of the Lučenská kotlina Basin with Oligocene-Miocene sediments. Medium altitude of the Lučenská kotlina Basin is about 350–370 m a.s.l. The Pokoradz Plateau is limited by steep slopes on the western side with valley of the Rimava River and also by steep slopes on the eastern side with valley of the river Blh, as well as with valley of the Papča brook in the southern part. At the southern edge, the high plateau ends with steep slopes with ca 100–150 m elevation above relief of the Rimavská kotlina Basin. At the northern margins of the plateau there is gradual transition from slopes of the Revúcka vrchovina Highland into the flat relief of the Pokoradz Plateau. The eastern part of the Pokoradz Plateau is dissected by the valleys of NW–SE orientation into several ridges and isolated segments built-up with volcaniclastic rocks. The valleys are followed by the brooks of Papča, Lemešík and others flowing to southwest. Outher steep marginal slopes of the Pokoradz Plateau and isolated segments are modified by huge landslides and landslide fields of volcaniclastic rocks due their instability above Miocene clay sediments (Hrašna et al., 1995; Frnčo et al., 1990). Landslides at the southern slopes obtain typical hummocky relief (northward of the Nižná Pokoradz and Vyšná Pokoradz villages). System of brooks springing in higher levels of the valleys like brooks Papča, Lemešík, Vyvieračka, Šinkov potok, Veľký potok and Hajský potok is drainaged generally to south. Slopes limiting the Pokoradz Plateau are often forested; uppermost part of the flat plateau without forest is cultivated for agriculture purpposes and/or used as pastures. The main villages in the area of the Pokoradz Plateau from north to south are Kyjatice, Babinec, Kraskovo, Lukovištia and Horné Záhorany villages and along the western part of the plateau there are villages Hrachovo, Vyšný Skálnik and Nižný Skálnik. At the southern edge of the plateau the Vyšná Pokoradz and Nižná Pokoradz villages are located.

3 – The Blžská tabuľa Plateau (Blh Plateau)

The Blh Plateau situated east of the Pokoradz Plateau is not as homogeneous as the Pokoradz Plateau. It is separated into two segments by the valley with NW–SE orientation. 1 – The northern segment about 4 km wide in its northern part with maximum altitude 487.5 m a.s.l. on elevation point of Turecký vrch Hill, southward it becomes gradually narrower. From the western and eastern sides, the Blh Plateau is limited by the steep slopes with the altitude difference more than 100 m. Steep slopes are modified by huge landslides of volcaniclastic rocks due their instability above the Miocene sediments. 2 – Southern segment is roughly of triangle shape with narrow ridge directed to NW with the hills Hradište (457.3 m a.s.l.), e.p. 450 and Dlhý vrch elevation point (481.5 m a.s.l.). The high plateau is divided by deep valleys on southern part into three ridges. From the west to east they are: (a) western ridge Dlhý vrch (e.p. 499.2) – Veľká skala, (b) middle ridge Deravá skala (e.p. 495), and (c) eastern ridge with e.p. 471. Steep slopes on the southwestern, southern and eastern sides are modified by extended landslides of volcaniclastic rocks.

The Viničný vrch ridge (e.p. 467) with W–E orientation, located north of the Blh Plateau and the Holý vrch ridge trending N–S between the Pokoradz and Blh plateaus represent segments of the original sedimentary basin of the Vyšná Pokoradz Formation, later separated by the denudation to isolated ridges.

Northern and southern segments of the Blh Plateau are strongly forested. The main villages along the northern side of the plateau are the Španie pole village, and more to west the Slizké village. Along western side of the plateau the Teplý vrch and Veľký Blh villages follow along the Blh brook. Vyšné Valice and Nižné Valice villages are at the southern side of the plateau.

4 – The Rimavská kotlina Basin

The Rimavská kotlina Basin at the southern slope of the Slovenské rudohorie Mts. represents a lowland basin with the transition to the low highland relief in the southern part. The Rimavská kotlina Basin connects at the western side with the Lučenská kotlina Basin along fault and/or fault zone of NNW–SSE direction, which conditioned the origin of the Rimava river valley. Continuing to south, the Rimavská kotlina Basin is from the western side in contact with the Cerová vrchovina Highland with numerous relics of the Neogene-Quaternary alkali basalt volcanism. The Lučenská kotlina Basin gradually passes to east into the Bodvianska pahorkatina Highland. Filling of the Lučenská kotlina Basin is formed by sediments of the Oligocene-Miocene age (Kiscelian–Egerian), representing the basement of the volcanosedimentary Vyšná Pokoradz Formation preserved after its denudation as the Pokoradz and Blh plateaus at the northern side of the Rimavská kotlina Basin. The youngest postvolcanic sediments in the Lučenská kotlina Basin are lake and fluvial sediments of the Pontian age of the Poltár Formation and Quaternary sediments. On the surface of the lowland relief there occur the relics of the primary Pliocene relief dissected by many terraces and valleys. Among the numerous brooks and rivers, heading to south, there are important namely the Rimava river, and brooks Blh, Slaná, Západný Turiec and their tributaries. The lowest part of the Rimavská kotlina Basin has an altitude of ca 150 m a.s.l. Predominant part of the Rimavská kotlina Basin is agriculturally cultivated. It is densely populated with numerous villages and the main town of Rimavská Sobota.

5 – The Lučenská kotlina Basin

The Lučenská kotlina Basin is separated from the east located Rimavská kotlina Basin by the fault zone trending NNW–SSE along the valley of the Rimava River. In the NE part of the Lučenská kotlina Basin, several remnants of volcaniclastic rocks of the Vyšná Pokoradz Formation occur on the surface of the Upper Paleozoic rocks of the Gemeric unit and more to the south on the surface of the Oligo-Miocene sediments. Northern part of the Lučenec Basin represents lowland area with transition to highland relief. This area is not forested and is agriculturally cultivated. Among more important villages there belong the Hrachovo, Veľké Teriakovce, Sušany and Hrnčiarske Zalužany villages.

Rock complexes underlying volcanic rocks on the Slovenské rudohorie Mts. and the northern part of the Rimavská kotlina and Lučenská kotlina basins

Scattered relics of the Neogene volcaniclastic rocks are discordantly deposited on the surface of the Paleozoic and Mesozoic roks of several tectonic units – the Veporic, Gemeric, Meliatic, Turnaic and Silicic units. In the Rimavská kotlina and Lučenská kotlina basins the volcaniclastic rocks are overlying the Oligo-Miocene sediments (Fig. 3).

Veporic unit

The Veporic unit is the lowermost tectonic unit cropping out on the surface north of the Rimavská kotlina Basin (north of the Lubeník-Margecany overthrust line west of Kraskovo village). Rocks of the Veporic unit continue to south beneath the overthrust Gemeric unit. The Veporic unit in this zone is built of the Upper Paleozoic rocks of the *Slatvina and Rimava formations* of Revúca Group (Vozárová and Vozár, 1982).

The Slatvina Formation (Stephanian C-D) contains metamorphosed sandstones, sericite-chlorite- and graphite phyllites.

The Rimava Formation (Permian) represents strongly dynamometamorphosed sandstones, arkoses, multicoloured schists, meta-greywackes with gravels and beds of acid volcanites (Vozárová in Vass et al., 1985). Sporomorphs of the Permian age are sporadically preserved (Planderová in Vass et al., 1985).

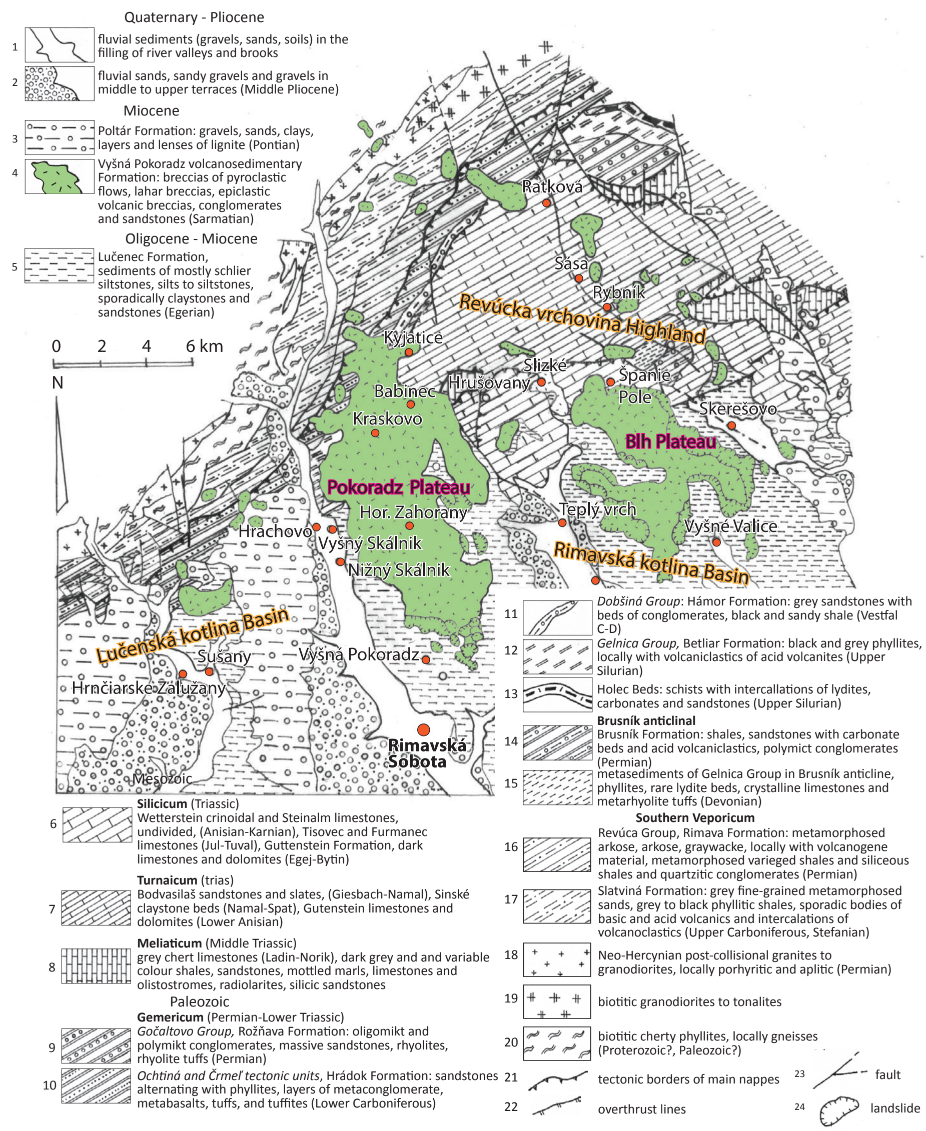


Fig. 3. Structure of the pre-volcanic basement in southern slopes of the Slovenské rudohorie Mts. and in the Lučenská kotlina and Rimavská kotlina basins.

The Lower Triassic age of the grey metamorphosed sandstones, overlying rocks of the Rimava Formation, is supposed, being correlated with the Foederata Group (cf. Part I).

North of the area under discussion there are exposed Meso-Hercynian granitoids (hybridic granitoids to tonalites and biotite granodiorites to tonalites) of Upper Devonian? – Carboniferous age and also Neo-Hercynian postcollision granitoids of Permian age (leucocrate granites to granodiorite). The granitic bodies are hosted by biotite phyllites and gneisses of unknown age (their Proterozoic? age is also supposed).

Gemeric unit

The Gemeric unit is thrust over on the Veporic unit from the south. It forms the footwall of the Tertiary sediments of the Rimavská kotlina Basin. It is presented with following subunits:

The Gelnica Group as the oldest lithostratigraphic subunit consists of tuffitic sediments, graphitic phyllites with intercalations of lydites and carbonates (Vozárová in Vass et al., 1985). Sporomorphs in low metamorphosed sediments manifest their Silurian-Devonian ages (Planderová in Vass et al., 1985). Sediments of the *Betliar Formation* of Upper Silurian age (subunit of the Gelnica Group) represented by the dark to grey phyllites with clastic material of acid volcanics and with intercalations of lydites are cropping out west of the Kraskovo village. Dark schists with lydites and sandstones – the *Holec Beds* of assumed Silurian age occur in the norhern part of the area.

The Ochtiná and Črmeľ tectonic subunits (Lower Carboniferous) are built of the metaconglomerates, metasandstones, locally metabasalts, metadolerites and serpentinites, included into the *Hrádok Formation*.

The Dobšiná Group (Upper Carboniferous – Westphalian C-D) grey sandstones with layers of conglomerates and dark sandy schists crop out north of the Kyjatice village (*Hámor Formation*). They are confirmed by boreholes in the area of the Kociha and Hrachovo villages.

The Gočaltovo Group (Permian), built of polymict conglomerates, sandstones, rhyolites, rhyolite tuffs of the *Rožňava Formation,* crops out NE of the Ratková village.

Meliatic unit

The rocks of the Meliatic unit of Triassic age – grey massive crystalline limestones, siliceous limestones (Ladinian–Norian), dark-grey and multicolour schists, sandstones, mottled marls, limestones and olistostromes (Liassic-Lower Malm) crop out east of the Babinec village and to NW of the Hrušov village. The Meliatic unit is supposed to be covered by the Oligo-Miocene sediments in the Rimavská kotlina Basin.

Turnaic unit

The Turnaic tectonic unit (Upper Paleozoic-Triassic) is displaced on Gemeric unit. In higher position above Turnaic unit there occurs the nappe of Silicic unit. The Upper

Paleozoic and Triassic sediments of Turnaic unit are exposed on the surface near the Hrachovo village. The Permian rocks, belonging to the *Brusno Formation* (Vozár and Vozárová, 1992), are represented with intensivelly deformed polymict conglomerates with sandstone interbeds. The Lower Triassic sediments encompass the grey, grey-green to violet schists with intercalations of sandstones and sandy limestones, often with distinct schistosity. Lower Triassic sediments are not exposed on the surface; they are buried under the Middle Triassic carbonates, dark and black calcareous phyllites and dark schistosed limestones, which are exposed near the NE margin of the Lučenská kotlina Basin. The Middle Triassic limestones crop out also near the village of Vyšný Skálnik, where the conodont fauna manifests the Anisian age. The Turnaic unit, represented by the *Bódvaszilas sandstones and schists* (Griesbachian–Namalian), *Szin marly beds* (Namalian–Spathian), as well as the *Guttenstein limestones and dolomites* (Lower Anisian) are cropping out NE of the Babinec village (Bezák et al., 2008).

Paleozoic sequences of the Brusník anticline

North-eastward of the Španie pole village (near the northern margin of the Blh Plateau), the anticlinal structure with Paleozoic rocks is developed. In its central part the phyllites, metamorphosed sandstones and conglomerates, reworked rhyolite volcaniclastics and lydites of the Carboniferous *Turiec Formation* are exposed. At the edges of anticlinal structure, schists, polymict conglomerates and sandstones with intercalations of carbonates and acid volcaniclastics of the *Brusník Formation* crop out (Bezák et al., 2008). According to the older interpretation (Elečko et al., 1985), in the central part of anticlinal structure there are present the Devonian rocks of Gelnica Group.

Silicic unit

The Silicic tectonic unit forms the Silicic nappe thrust over the Gemeric, Meliatic and Turnaic units (Elečko et al., 1985). The Silicic nappe, extended in the northern part of the area between villages Hrušovo-Slizké and Budikovany, is built of wetterstein limestones (Ladinian–Cordevolian). In the area east of the Slizké village the Dachstein limestones (Norian), Tisovec and Furmanec limestones (Julian–Tuvalian) are present dominantly.

Tertiary sediments

In the northern part of the Lučenská kotlina and Rimavská kotlina basins, the complex of Oligocene-Miocene sediments overlies the Paleozoic-Mesozoic rocks.

Oligocene

Oligocene sediments (Kiscelian), forming the lower part of the sedimentary fill of the Lučenská kotlina and Rimavská kotlina basins, are not exposed on the surface. The Oligocene basal beds, designated as the *Skálnik Beds* and confirmed by several boreholes, represent continental sediments. Silts and clays with total thickness of about 33 m have variable colours (red-brown, grey-green) and often contain angular fragments of silicites, quartz, quartzites and eventually silicitic breccias. According to the study of sporomorphs the *Skálnik Beds* are correlated with Kiscellian (Planderová in Vass et al., 1982).

Missing basal Skálnik Beds in some areas are replaced with beds of conglomerates, breccias and sandstones with marine litoral fauna, designated as *Číž Beds* (borehole VCH-1). The marine fauna due to its bad preservation is not used for stratigraphic correlations. The main volume of Oligocene sediments forms *Číž Formation,* thick up to 246 m (borehole FV-1 Blhovce), built of claystones and siltstones with microfauna and macrofauna of Oligocene age, corresponding to Kiscellian (Vass and Elečko et al., 1989, 2007).

Oligocene-Miocene

The marine transgression reached climax in the Lučenská kotlina, Rimavská kotlina and Ipeľská kotlina basins and also in the whole area of the Budín Paleogene basin during the Egerian time (Vass, 1981). The sediments of Egerian age (in older terminology Chattian-Aquitanian) are spread in the whole area of the Rimavská kotlina and Lučenská kotlina basins and northward they overlap the primary extent of the Kiscellian sediments. The maximum thickness of Egerian sediments, verified by the borehole, is about 700 m (borehole FV-7 Blhovce). In the southern part of the Rimavská kotlina Basin a thickness of sediments is greater, supposed to be about 1100 m. Northward within the basin, the thickness of sediments rapidly declines.

The sediments of Egerian age in the southern part of the Rimavská kotlina Basin are evolved gradually from underlying Oligocene sediments of the Číž Formation. In the northern part of the Rimavská kotlina Basin there occurs a discordance between Egerian sediments and underlying Oligocene sediments, caused by Egerian marine transgression. In the majority of northern part of the Rimavská kotlina Basin the Egerian sediments lie discordantly on the surface of the Mesozoic carbonate rocks of the Turnaic and Silicic units.

Egerian sedimentary complex underlies the volcanosedimentary complexes of the Pokoradz and Blh plateaus in the northern part of the Rimavská kotlina Basin, encompassing the area from the Španie pole village (eastern side of the basin), to the Lukovištia village (northern side) and Vyšný Skálnik and Hrachovo villages (western side).

The Lučenec Formation of Egerian age is the main lithological unit spreading out from below the volcanosedimentary rocks of the Vyšná Pokoradz Formation. The main lithofacies – *Szecseny schlier* – dominantly consists of silts, siltstones, clayes and claystones. Sandstones are presented only sporadically. The schlier sediments during weathering obtain yellow to grey brown colours, disintegration is schistose, shelly and/or into the irregular fragments. Schlier sediments are rich in marine fauna, nannoplankton and sporomorphs corresponding to Oligocene-Miocene in age (Vass et al., 1989a, b; Vass et al., 2007).

The Lučenec Formation consists of several subunits, forming basal and marginal lithophacies. The *Panica Beds* represent basal lithostratigraphic unit, in the uppermost part laterally passing into schlier sediments. The basal sediments of the *Panica Beds* (according boreholes in the Gemerská Panica area) consist of breccias with material of limestones, crystalline schists, sandstones, polymict conglomerates and sandstones. The *Budikovany Beds* (in the area of the Budikovany village) lie above *Panica Beds* and/or above the Paleozoic and Mesozoic rocks. Beside marls, the main volume of sediments forms the organodetritic sandy limestones with marine fauna. The *Bretka Beds* exposed on the surface near the Bretka village represent marginal facies of the *Lučenec Formation*. They vertically and laterally pass into the upper part of silts and siltstones of the *Lučenec Formation*. They are represented with detritic and organodetritic limestones and limestone breccias.

Miocene

During Sarmatian, the volcaniclastic material from the southern slopes of the andesite stratovolcano was transported and deposited in the Rimavská kotlina Basin and northern part of the Lučenská kotlina Basin, forming the Vyšná Pokoradz volcanosedimentary Formation.

In the younger stage during Pontian time, the fluvial--limnic sedimentation continued in the Lučenská kotlina and Rimavská kotlina basins, resulting in the development of the Poltár Formation of gravels, sands, marls and silts. Associations of palinomorphs indicate Pontian age (Planderová in Vass et al., 1982). The youngest Quaternary sediments represent loamy and rocky deluvial deposits on top of hills and their slopes, in the lowland areas there occur fluvial sediments of numerous rivers and brooks.

I – Filling of the paleovalleys on the southern slopes of the Vepor andesite stratovolcano

During geological mapping and field research numerous relics of volcaniclastic rocks were examinated dominantly in the uppermost part of hills and ridges on the southern slopes of the Slovenské rudohorie Mts. These relics of volcaniclastic rocks were identified as remnants of the primary filling of paleovalleys, directed southward from the southern slopes of the Vepor andesite stratovolcano into the sedimentary basin (Konečný, V. and Konečný, P., 2010). The preceding research and mapping stages in connection with the compilation of geological map at a scale 1 : 50 000 (Lexa and Konečný in Elečko et al., 1985) have recorded these relics, but their relation to andesite stratovolcano was not solved that time.

Paleovalleys were used as pathways for transport of fine to coarse clastic volcanic material during volcanic activity of the andesite stratovolcano to southern sedimentary basin where the volcaniclastic material was deposited in a delta-lake environment. During synchronous subsidence of sedimentary basin there was gradually evolved a thick complex of volcanosedimentary rocks named as the Vyšná Pokoradz Formation. After uplifting and denudation this complex forms recent isolated relics of the Pokoradz and Blh plateaus and several hills at northern edge of the Lučenec Basin. Volcanosedimentary complex is in detail characterized in geological lithofacial map (Konečný, V. and Konečný, P., 2012; Appendix 1/A, B, C and D).

The position of paleovalleys and their fillings is demonstrated on series of profiles oriented from NW to SE Appendix 2A.

Fillings of the paleovalleys reflect different stages of denudation. In many cases only the lower parts of the original thickness are preserved. This article presents the lithology of the paleovalleys fillings from the north to south. In the northern part of the area, the relics of three paleovalleys are preserved in the uppermost levels of the ridges with dominant orientation from NW to SE, respectivelly from NNW to SSE.

1 – The Hrb paleovalley

Relics of volcaniclastic rock in filling of the Hrb paleovalley (southeast of the Polom village) form the uppermost part of the ridge trending NW–SE in length of about 1 700 m (Appendix 2A). At the northern edge, the base of volcaniclastic complex is at altitude 705 m a.s.l., at the southern edge it is lower, about 625 m a.s.l. In the southern part on the base of paleovalley filling, the fluvial sediments represent *tuffitic sands with gravels of volcanic and non-volcanic rocks* (quartz, crystalline schists, granitoids and andesites). Basal bed of variable thickness is incoherent and often is missing. Higher above the basal fluvial sediments, the bed of *fine- to medium-grained andesite conglomerates* is developed at an altitude from 640 m up to 660 m a.s.l. At altitude 660 m a.s.l., the transition to bed, consisting of the *medium to coarse epiclastic volcanic conglomerate* with increasing amount of andesite rounded fragments with dimension up to 20–30 cm occurs in the upper part of basal bed. At a higher altitude of 675–685 m a.s.l., the *coarse to blocky epiclastic volcanic conglomerate* follows with 40–60 cm wide rounded blocks. At an altitude of 685–700 m, the bed of *medium to coarse epiclastic volcanic conglomerate* (rounded andesite blocks wide to 30 cm) occurs again. From 700 m up to 710 m a.s.l. in the bed of *epiclastic volcanic breccia-conglomerate,* besides rounded blocks, also angular and semirounded blocks are present with the dimension from 60 cm up to 1 m. In the uppermost part of the paleovalley filling on the top of the Hrb ridge (elevation points 720.4 and 710), the *coarse to blocky lahar breccia* is exposed with agular to subangular andesite blocks with dimensions up to 60 cm and rare up to 2 m. Matrix is tuffaceous grey, grey brown and locally reddish with frequent pumice fragments and fine angular andesite fragments of dimensions 2–3 cm. The deposition of material is chaotic. Lahar breccia shows signs of partly hot material during transport, so they correspond to category of hot lahars.

2 – The Vrchduby paleovalley

Volcaniclastic rocks, representing the relics of the paleovalley, form an expressive ridge with length of about 1 850 m and orientation from NNW to SSE, located east of the Ratkovská Zdychava village between valleys of Blh and Krokava brooks (Appendix 2A). At its northern segment, the base of the paleovalley is situated at altitude app. 650 m a.s.l., southward it gradually descends to altitude app. 470 m a.s.l. at its southern segment. On the western side, the base of the paleovalley is in lower altitude comparing with its eastern side, so we can conclude that the axis of the paleovalley (the deepest part of the paleovalley) was situted more to the west from actual western side of the paleovalley fill. At the southern edge of the ridge on the base of paleovalley filling a basal bed of *tuffitic sands with pebbles of volcanic and non-volcanic rocks* crops out at an altitude of 470 m a.s.l. Above basal bed there occurs the *chaotic breccia of pyroclastic flow,* which follows at altitude 512 m a.s.l. (Fig. 4).

Chaotic breccia in several rocky cliffs continues to higher altitude on the slopes up to 530 m a.s.l. In the outcrop at this altitude, the separation of material by its granularity was observed. Blocks of greater dimensions are accumulated in the lower part of rocky wall, which correponds to normal gradation (Fig. 4c).

Chaotic breccia in rocky cliffs continued to the level of 583 m a.s.l. The blocks with greater dimension (from 60 cm up to 100 cm) are accumulated in a higher level of pyroclastic flow (reverse gradation). Total thickness of the chaotic pyroclastic breccia is about 70 m. There is not possible to exlude that total thickness represents a several pyroclastic flows with rapid succession and due to intensive welding the lithological margins between individual flows are obscured. Lithological character of breccia corresponds to block and pyroclastic flow ash originated during collapses of eruptive column of the vulcanian type.

Above chaotic breccia of pyroclastic flow, the bed of *coarse to blocky epiclastic volcanic conglomerates* with rounded andesite blocks more than 50–60 cm in diameters follows on the southern

Fig. 4. Chaotic breccia of pyroclastic flow exposed on the southern slope of the cliff at level 500 m a.s.l., consisting dominantly of the vesiculated fragments of subspheric and spheric shape with dimensions 5–25 cm (photo a). Angular fragments are less frequent (ca 10–15 %) and blocks of dimensions 50–150 cm are rare. Matrix is grey-brown, intensively welded to homogenized, containing small vesiculated fragments, which represent ca 65–70 % of the volume. Disintegrated andesite blocks at lower level of the rocky wall (photo b). The chaotic breccia of pyroclastic flow in rocky wall with about 15 m height at level 530 m a.s.l. consists dominantly of vesiculated subspheric fragments up to blocks large to 50 cm (photo c). Comparing with the lower positioned chaotic breccia a higher content of blocks was observed.

slope of the ridge. Thickness of bed is about 7 m. In the higher position above the coarse to blocky conglomerate a bed of *fine epiclastic breccia-conglomerate* follows in thickness of about 15 m with rounded and angular fragments up to 15 cm and sandy tuffitic matrix. In higher part of the paleovalley filling the sequence consists of *coarse to blocky epiclastic volcanic breccia* (with angular to subangular blocks up to 1 m and rare to 2.2 m), thick about 16 m, *fine epiclastic volcanic conglomerates and sandstones*, thick about 14 m, and the *coarse to blocky epiclastic volcanic breccia-conglomerates* with partly rounded and angular blocks with diameters 40–60 cm, as well as the sandy tuffaceous matrix in total thickness of about 7 m. The uppermost part of the sequence on the top of the Vrchduby ridge with elevation points 682 m and 652 m forms *chaotic breccia of pyroclastic flow* with the base at about 624–630 m a.s.l. Breccia consists of vesiculated fragments dominantly from 5 to 35 cm and rare blocks up to 2 m. Tuffaceous matrix is strongly welded together with small vesiculated fragments. Deposition of clastic material is chaotic with distinct concentration of larger blocks near the base of the cliff.

3 – The Kysle – Sušiansky vrch paleovalley

The relics of the paleovalley filling with length of about 3 500 m form northern isolated hill Kysle with e.p. 639.4 and the southern ridge Sušiansky vrch Hill with flat top (elevation points 628, 601 and 582 m), trending NW–SE, and located west of the Ratková village (Appendix 2A).

3/1 – At the base of isolated relic on the slope of Kysle Hill (e.p. 639.4) at altitude app. 600 m a.s.l., a bed of *tuffitic sands is located, containing gravels of volcanic and non-volcanic rocks* (pebbles of quartz, granitoids and crystalline schists) with variable thickness of 5–8 m. Above basal bed, the uppermost part of the hill with flat top is formed of the *coarse to blocky epiclastic volcanic breccia*.

3/2 – The Sušiansky vrch Hill with elevation points 628, 601, and 582 m, forming expressive ridge with flat top, continuing to south, is built-up dominantly by the facies of epiclastic volcanic rocks. Base of the paleovalley filling gradually descends from the level 612 m a.s.l. at the northern edge to south and at the southern edge it occurs at level of about 390 m a.s.l. The most intensive deeping of the paleovalley bottom is roughly in the midle part of the ridge bellow e.p. 601, where the base is located in altitude about 500 m a.s.l. Maximal thickness of the paleovalley filling reaches about 100 m. The basal bed of *tuffitic sand with gravels of volcanic and non-volcanic rocks* is not continuous and in several places, where it is missing on the surface of the pre-volcanic basement, there occur epiclastic volcanic conglomerate and/or epiclastic volcanic breccia. At the southern edge of the paleovalley filing in the upper part of the basal bed at altitude 410 m a.s.l. there is a transition to bed of *fine epiclastic volcanic conglomerate* with thickness app. 20–22 m. Except of the rounded andesite material in fraction 5–15 cm, which dominates, there are also present in small amount the pebbles of non-volcanic rocks from the pre-volcanic basement. Higher on the southern slope of the ridge at altitude 432 m a.s.l., the bed of *coarse to blocky epiclastic volcanic conglomerate* follows in thickness app. 37 m. Rounded andesite blocks are present with dimensions up to 30 cm and rare blocks up to 1–1.6 m. Coarse to blocky conglomerate at the altitude 490 m a.s.l. alternates with the *fine to medium epiclastic volcanic breccia* with thickness app. 5 m. From the altitude 504 m a.s.l. there follows again the *coarse to blocky epiclastic volcanic conglomerate* in thickness about 10 m with rounded blocks up to 30–60 cm. In the higher position of the paleovalley filling (from 514 m a.s.l.), the *fine to medium reworked pyroclastic breccia* follows in a thickness about 13 m, consisting of small vesiculated fragments and smaller amount of angular fragments. Above this breccia from 527 m a.s.l., the *coarse to blocky epiclastic volcanic conglomerate* follows in thickness app. 29 m with rounded blocks of dimension 60–80 cm and rarely up to 1 m. The second app. 20 m thick bed of *fine to medium reworked pyroclastic breccia* is indicated by small vesiculated fragments in the debris at altitude app. 556 m a.s.l. In a higher position above reworked pyroclastic breccia from the level 576 m a.s.l., the bed of *coarse to blocky epiclastic volcanic breccia* is present with rounded andesite blocks large up to 60 cm. On the top of the ridge of Sušiansky vrch Hill the subangular and angular blocks in debris indicate the presence of *coarse to blocky epiclastic volcanic breccia* (blocks with subangular and angular shape ranging from 50 cm to 1.5 m). In the area of the summit with e.p. 601, the presence of rounded and angular blocks indicates facies of *epiclastic volcanic breccia-conglomerate*. Along the summit with e.p. 582 the andesite blocks with dimension 2.5 x 2.6 m occur. The found parallel lamination indicates their origin by the destruction of massive andesite bodies of extrusive type (extrusive domes) and/or blocks originating by the destruction of lava flow transported by pyroclastic flow. Several blocks of migmatitized gneissess in the debris around summit with e.p. Vrch 592.8 were probably transported by rivers during the early stage of evolution of the original flat relief built-up by volcaniclastic rocks.

4 – The Nad Kráľovkou – Brevenovo – Trňová hora paleovalley

The ridge Nad Kráľovkou (e.p. 556.4) – Brevenovo north of the Sása village is oriented in the beginning to SW, but later it is turned to south and finally to SE (Appendix 2A). After interruption of the paleovalley filling by denudation it continues to the south in a small isolated hill Trňová hora with e.p. 461.9. The total length of the paleovalley filling including Trňová hora is about 2750 m. At the northern margin of the paleovalley fill, its base is in the altitude 540 m a.s.l., to south it desdends to altitude 435 m a.s.l. At the southern side of the Trňová hora, the base of the paleovalley fill is in altitude 425 m a.s.l. The paleovalley fill consists predominantly of epiclastic volcanic rocks.

4/1 – The paleovalley Nad Kráľovkou – Brevenovo is characteristic with the rapid bottom deepening in its northern part. Southward only moderate deepening of the paleovalley bottom was observed. The volcanosedimentary complex is relatively thicker in the western side of the paleovalley filling than in its eastern side, which indicates that the paleovalley axis of the trend N–S was situated more to the west. Actual preserved relics of the paleovalley represent its eastern part.

A discontinuous basal bed of fluvial *tuffitic sands with gravels of volcanic and non-volcanic rocks* (granitoids, quartz, crystalline schists and carbonates) of variable thickness of 2–5 m occurs at the base of paleovalley. Above the basal bed, the *medium to coarse epiclastic volcanic conglomerate* occurs on the southern slopes of the Brevenovo ridge at altitude 445 m a.s.l., containing 10–30 cm large rounded fragments. In the upper part of the bed in altitude 461 m a.s.l., the *coarse to blocky epiclastic volcanic conglomerate* contains rounded andesite blocks large app. 50 – 60 cm and sporadically up to 1.8–2 m in diameter. In altitude 485 m a.s.l., the bed of fine to medium epiclastic volcanic conglomerate follows (with rounded fragments and pebbles large 10–20 cm, sporadically up to 30 cm), being alternated with interbeds of *epiclastic volcanic sandstones*. Higher, a bed of *coarse to blocky epiclastic volcanic conglomerate* (with rounded blocks large 40–60 cm, rarely about 100 cm), thick app. 13 m, is placed in altitude 514 m a.s.l. From 527 m a.s.l. there are frequent angular to subangular blocks with diameters 30–60 cm, derived from the bed of *coarse to blocky epiclastic volcanic breccia* with thickness about 8 m. *Medium to coarse epiclastic volcanic conglomerate* with rounded fragments and blocks with dimensions 15–30 cm (sporadically up to 40 cm) in thickness about 7 m follows at the level 535 m a.s.l. Apical parts of Brevenovo ridge with e.p. 553.7 and 551, 553 m according to rounded andesite blocks in rock debris with diameters 20–40 cm up to 1.5 m and 2 m is supposed to be a facies of *coarse to blocky epiclastic volcanic conglomerate*.

In the northern part of the ridge near e.p. 553 a greater block of *autoclastic lava breccias* consists of vesiculated fragments of irregular to angular shape. Block of lava breccia, derived probably from the crater area, was transported by pyroclastic flow (Fig. 5).

Chaotic breccia of block and ash pyroclastic flow with the base, located app. 498 m a.s.l., is exposed in a short segment on the summit with e.p. 556.4 Nad Kráľovkou. Fragments with dominant dimensions 10–15 cm are vesiculated with subspheric shape, representing about 40 %, less frequent are angular, non-vesiculated fragments. Tuffaceous matrix is strongly welded with vesiculated and angular fragments, deposition of material is chaotic (Fig. 6).

Fig. 5. Block of autoclastic lava breccia with dimension 6 x 8 cm. The dark fragments of irregular shape are cemented with the vesiculated lava matrix of the brown-red colour, being strongly vesiculated and oxidized.

Fig. 6. Detail of tuffaceous matrix strongly welded with darker fragments of irreguar and angular shapes.

Transport and deposition of pyroclastic flow exposed on the top of the Nad Královkou ridge have occurred evidently in more advanced stage of evolution of andesite stratovolcano.

4/2 – Isolated hill Trňová hora e.p. 461.9 represents the southern continuation of the paleovalley filling Nad Královkou – Brevenovo. The basal bed of *tuffitic sands with gravels of volcanic and non-volcanic rocks* at the northern side of the hill is at level 435 m a.s.l. and at the southern side in level 425 m a.s.l. Above basal bed, the bed of *coarse to blocky epiclastic volcanic conglomerate* (rounded blocks with diameter up to 30–40 cm) follows. Higher part of paleovalley filling was removed by erosion.

Group of the volcaniclastic rocks relics to NE and E of the Rybník village

Relics of volcaniclastic rocks on the top of small hills to NE and E of the Rybník village indicate continuation of paleovalleys further to SE. Dominantly these relics represent *chaotic breccias of pyroclastic flows*. Bases of pyroclastic flows are located in different levels, varying from 330 m a.s.l. (Hlinisko locality) up to 527 m a.s.l. (Tri Chotáre locality). According to these different levels they can be divided in three groups: a) localites of the southern belt – Hlinisko – Držkov vrch with the base at 330–406 m a.s.l., b) localites of the middle belt – Hrlá hora – Ostrá hora with the base level 450–470 m a.s.l. and c) localites of the northern belt – Tri Chotáre – Androva lúka with the base level 485–500 m a.s.l.

The lateral distribution of the chaotic breccia relics and different levels of their bases indicate that after leaving narrow paleovalleys the space with transition into the proluvial plain and sedimentary basin was suddenly widened and a succesion of pyroclastic flows has deposited.

I – Southern belt

5 – The Hlinisko – Brusníček – Fižliška paleovalley

The southern belt encompasses following relics (Appendix 2A): ridge above the Trňový potok brook valley, Hlinisko and Brusníček (hills without e.p.), as well as Fižliška (hill with e.p. 451). After an interruption, about 1 700 m relic of chaotic breccia continues to SE (ridge with e.p. 441 and Držkov vrch ridge with e.p. 493.3). Southern belt represents the lowest position of relics of chaotic pyroclastic breccias in the filling of the original paleovalley.

5/1 – Ridge above the Trňový potok brook valley. The base of volcanic relics is represented with a bed of medium to coarse epiclastic volcanic conglomerate with rounded andesite blocks with diameter 10–30 cm. *Chaotic pyroclastic breccia of pyroclastic* flow, following above the conglomerate bed with the base at 325 m a.s.l. consists dominantly of vesiculated fragments of subspheric shape and dimension 5–10 cm. Tuffaceous matrix is welded with vesiculated fragments.

5/2 – Hlinisko. On the southern and western slope of the ridge to N of the Rybník village, there is basal bed of *tuffitic sands with pebbles of volcanic and non-volcanic rocks* (pebbles of quartz, crystalline rocks and Mesozoic rocks) at the level 300 m a.s.l. In the upper part of the basal bed, there is at the level 305 m a.s.l. a transition into the facies of *medium to coarse epiclastic volcanic conglomerate* with rounded andesite blocks of dimensions 15–25 cm, rare up to 30 cm. Above conglomerate bed at level 330 m a.s.l., the *chaotic breccia of pyroclastic flow* follows with vesiculated fragments of subspheric shape of dimensions 5–30 cm. Matrix is tuffaceous, strongly welded with small vesiculated fragments. Deposition of clastic material is chaotic.

5/3 – Brusníček (a small hill without e.p. located NE of the Rybník village). Above the basal bed of *tuffitic sands with gravels of volcanic and non-volcanic rocks* with deposition in the level 315–320 m a.s.l., the *medium to coarse epiclastic volcanic conglomerate* follows with rounded blocks up to 30 cm large. *Chaotic breccia of pyroclastic flow* with the base at 342 m a.s.l. is overlain with a conglomerate bed. Breccia contains dominantly the vesiculated fragments of subspheric shape with dimensions 5–25 cm. Tuffaceous matrix is strongly welded with vesiculated fragments. The maximum thickness of breccia is 37 m. Above chaotic breccia from the level of 379 m a.s.l. up to summit with the level 445 m a.s.l., the *coarse to blocky epiclastic volcanic conglomerate* follows with rounded andesite blocks large to 30–40 cm, rarely up to 50 cm. Chaotic pyroclastic breccia in localites Hlinisko and Brusníček represents probably one pyroclastic flow. Thickness of volcaniclastic rocks including chaotic pyroclastic breccia in locality Brusníček is increasing to S and SW – in direction which represents the deeper part of original paleovalley.

5/4 – Fižliška (hill with e.p. 450.1 east of the Rybník village.) Relics of volcaniclastic rocks in the summit area of small hill represent a continuation of the paleovalley to SE. Basal bed of *tuffitic sands with gravels of volcanic and non-volcanic rocks* (pebbles of crystalline rocks, guartz, carbonate rocks) is situated at the level 385 m a.s.l. Bottom of paleovalley inclines to S and SW, because the thickness of basal bed is increasing in this direction. Above the basal bed a *fine to medium epiclastic volcanic conglomerate* is deposited with well rounded andesite fragments large 10–15 cm. *Chaotic breccia of pyroclastic flow* follows in the level 406 m a.s.l. above conglomerate bed. Vesiculated fragments of sheroidal shape and blocks with dimensions up 30–60 cm (rare up to 1.5 m) are dominant. In lesser amount the angular fragments and blocks with diameter up to 30–40 cm are present. Matrix is tuffaceous welded together with smaler vesiculated fragments, distribution of fragments and blocks is chaotic. Thickness of chaotic breccia is about 24 m. In the summit area of Fižliška Hill from the level 430 m a.s.l. up to e.p. 450.1, the *coarse to blocky epiclastic volcanic conglomerate* is present with rounded andesite blocks with dimensions 20–40 m, rare up to 1.2 m.

The localities 5/1–5/4 manifest an increase of the individual facies thicknesses in the direction to S and SW towards the deeper part of the original paleovalley. This indicates that they represent deposits of the northern slopes of original paleovalley with axis directed to SE. In continuation of the original paleovalley to SE there are relics of volcaniclastic rocks on the summit with e.p. 439 to NE of the Brusník village.

6 – The Držkov vrch paleovalley

6/1 – On the slopes of the hill with e.p. 441, the basal bed of *tuffitic sands with gravels of volcanic and non-volcanic rocks* is exposed at the altitude 425 m a.s.l. (Appendix 2A). Southward the base of basal bed moderatelly descends to lower level. Sporadic relics and blocks of *chaotic pyroclastic breccia* follow above basal bed from the level 430 m a.s.l. up to e.p. 441.

6/2 – On the Držkov vrch Hill e.p. 439.3, the basal bed of *tuffitic volcanic sands with gravels of volcanic and non-volcanic rocks* in thickness about 5 m is exposed in the altitude of 415–420 m a.s.l. Higher, the *medium to coarse epiclastic volcanic conglomerate* follows with rounded andesite material with dimensions 5–8 cm, rare up to 20–30 cm. *Chaotic breccia of pyroclastic flow* with the base at level 435 m a.s.l. build the uppermost part of the Držkov vrch Hill. Chaotic breccia consists of small vesiculated fragments of subspheric shape and larger angular fragments and blocks of dimensions 20 to 30 cm and more. Matrix is tuffaceous, strongly welded with smaller vesiculated fragments. Locally, the angular fragments and blocks predominate above tuffaceous matrix and the breccia corresponds to Merapi type. Relics of pyroclastic breccia of localities 5/1–5/6 belong to pyroclastic flow deposited on the paleovalley bottom in the lowest level.

II – Middle belt

Into the Middle belt two groups of relics of volcaniclastic rock belong. Group 7 – ridge above valley of Brusníček brook (without e.p.) – Hrlá hora Hill (e.p. 474). Group 8 – Hrdzákova Hill (e.p. 465) – Ostrá hora Hill (e.p. 450).

7 – The ridge above Brusníček brook – Hrlá hora Hill paleovalley

7/1 – Ridge above the Brusníček brook (NE of the Rybník village) is built of the relics of chaotic breccia of pyroclastic flow, deposited on the surface of Mesozoic carbonates in altitude app. 450 m a.s.l. (Appendix 2A). Breccia exposed in the outcrop consists dominantly of vesiculated fragments of variable dimensions 5–10 cm up to 30 cm, angular fragments are less abundant. Tuffaceous matrix is welded with smaller vesiculated fragments. Chaotic breccia is overlain by *coarse to blocky epiclastic volcanic conglomerate* with rounded andesite blocks up to 40–60 cm large.

7/2 – The Hrlá hora Hill with e.p. 475. Basal bed of *tuffitic sands with gravels of volcanic and non-volcanic rocks* is deposited at the level 470 m a.s.l. on the surface of Mesozoic carbonates. *Chaotic breccia of pyroclastic flow* is emplaced on the western slope of the Hrlá hora Hill above basal bed and partly above Mesozoic rocks. Chaotic breccia consists dominantly of vesiculated fragments of subspheric shape with variable dimensions from 5 to 25 cm. Angular fragments and blocks large up to 50 cm are less frequent. Tuffaceous matrix is strongly welded with small vesiculated fragments. Andesite fragments dominate above matrix, which forms about 35 % of the breccia volume. Distribution of clastic material is chaotic. Relics of pyroclastic breccia of 6/1 and 6/2 belong probably to the same pyroclastic flow.

The continuation of pyroclastic flow after some interruptions due to erosion after the distance about 1.5 km is represented by the relics of chaotic breccia on the summits of Hrdzákova and Ostrá hora hills (north of the Držkov vrch Hill).

8 – The Hrdzákova – Ostrá hora hills paleovalley

8/1 – The Hrdzákova Hill (e.p. 465) has developed the *basal bed* of *tuffitic sands with gravels of volcanic and non-volcanic rocks* (quartz, crystalline schists, granitoids and carbonate rocks) in the level of 450 m a.s.l. (Appendix 2A). The base of *chaotic breccia of pyroclastic flow* is indicated by frequent vesiculated andesite fragments in the debris at level app. 460 m a.s.l. Except of subspheric vesiculated andesite fragments and blocks, there are present also angular fragments and blocks of variable dimensions from 5 to 10 cm, up to blocks 20–30 cm.

8/2 – In the Ostrá hora Hill (e.p. 450.2), *the basal bed of tuffitic sands with gravels of volcanic and non-volcanic rocks* (with pebbles of quartz, granitoids, crystalline schists and migmatized gneissess) is indicated in the altitude 445 m a.s.l. on the NW part of flat summit of the hill. This area is bearing also several blocks of chaotic breccia of pyroclastic flow at disintegrated outcrop. Majority of breccia is formed of angular to subangular fragments with the dimensions 5–25 cm, sporadiacally up to 35 cm. Distribution of fragments is chaotic. Vesiculated fragments with subspheric shape are less abundant. Matrix is tuffaceous of the red brown colour and strongly welded. Fragmental material forms app. 80 % of the volume. Lithologically the breccia corresponds to Merapi type of pyroclastic flow.

III – Northern belt

9 – The Tri chotáre – Androva lúka paleovalley

The group Tri chotáre – Androva lúka encompasses 4 isolated relics of chaotic breccia, occurring north of locality Hrlá hora Hill with the base located about 485–517 m a.s.l.: 1 – summit of Tri Chotáre Hill (e.p. 538.2), 2 – summit with e.p. 527.3, 3 – summit with e.p. 513, 4 – summit and ridge Androva lúka with e.p. 490.7 (Appendix 2A). The basal bed of tuffitic sands with volcanic and non-volcanic rocks is not present and relics of chaotic breccia were deposited immediatelly on the surface of the Mesozoic carbonate rocks.

9/1 – On the summit of the Tri chotáre Hill (e.p. 538.2) the blocks and fragments of chaotic breccia in the altitude 517 m a.s.l. are located on the surface of Mesozoic carbonates. Thickness of chaotic breccia is estimated to 20 m. Fragments dominantly of subspheric shape are vesiculatad with dimensions 5–25 cm, sporadically to 30 cm. Angular fragments with dimensions 10–30 cm are less frequent. Tuffaceous matrix of red brown colour is welded.

9/2 – Summit with e.p. 527.3 (SW of Tri chotáre Hill). Chaotic breccia thick app. 10 m at level 517 m a.s.l. consists dominantly of 10–30 cm vesiculated fragments. Angular fragments are less abundant. Tuffaceous matrix is strongly welded.

9/3 – Summit with e.p. 513 in the area of the Priehybina ridge is bearing relics of chaotic breccia at level 500 m a.s.l., consisting dominantly of vesiculated fragments of subspheric shape with dimension up to 20 cm. Angular fragments are less abundant. Tuffaceous matrix is strongly welded.

9/4 – Summit of the Androva lúka ridge (e.p. 490.7) of the trend NNE–SSW is bearing chaotic breccia with the base about 485 m a.s.l., consisting dominantly of smaller vesiculated fragments of subspheric shape with dimensions 5–15 cm and rare up to 40 cm large blocks. Tuffaceous matrix is strongly welded with small vesiculated fragments.

10 – The Junkovka paleovalley

Locality Junkovka in Northern belt – III. (north of the Androva lúka ridge) includes two relics of volcaniclastic rocks on summits of hills with elevation points 516 m and 488 m (Appendix 2A). Relics of chaotic breccia of pyroclastic flow consist dominantly of vesiculated fragments of subspheric shape with dimensions 5–20 cm, up to 40 cm. Rare angular blocks up to 1.2 m are present, too. Tuffaceous matrix is strongly welded with small vesiculated fragments. Thickness of chaotic breccia is estimated to 13–16 m.

The relics of chaotic breccia of the northern belt, according to similar altitude position of their base, can be supposed to be a product of the same pyroclastic flow. In continuation of pyroclastic flow from NW to SE, the gradual descending of the base from the level 517 m a.s.l. to 485 m a.s.l. can be observed.

11 – The Viničný vrch Hill paleovalley

Isolated ridge of the Viničný vrch Hill, trending W–E, located north of the Španie pole village (Appendix 2A) represents transition from the paleovalley to the sedimentary basin, which is reflected in lithology of volcanosedimentary rocks. Bed of fluvial *tuffitic sands with gravels of volcanic and non-volcanic rocks* (pebbles of quartz, granitoids and gneissess) is situated at the level 375 to 380 m a.s.l. on the base of the paleovalley filling at the southeastern slope of the ridge. In the upper part the basal tuffitic sands pass gradually into the bed of *epiclastic volcanic sandstones with intercalations of siltstones and pumice tuffs* in the altitude 380 m a.s.l. Epiclastic volcanic sandstone is exposed in abandoned small quarry on SE foot of the slope bellow the Viničný vrch Hill at level 388 m a.s.l. In the quarry wall the non-bedded tuff-sandstones represent deposits of hyperconcentrated flows (Fig. 7).

On the SE slope of the Viničný vrch Hill ridge above the bed of epiclastic volcanic sandstone and tuff-sandstones, several conglomerate beds follow: *fine epiclastic volcanic conglomerate* (with rounded 5–15 cm andesite fragments) with base at 405 m a.s.l., *medium to coarse epiclastic volcanic conglomerate* (rounded 15–30 cm blocks) with base at 415 m a.s.l. and *coarse to blocky epiclastic volcanic conglomerate* from the level 420 m a.s.l. with rounded andesite blocks large up to 60 cm and sporadically to 1 m. In the summit area with e.p. 437 there are blocks of *chaotic breccia* of pyroclastic flow with vesiculated fragments of subspheric shape and dimension up to 20–30 cm. Tuffaceous matrix is welded with small vesiculated fragments.

More extended relics of *chaotic breccia of pyroclastic flow, thick* app. 30 m, form the western part of the ridge of Viničný vrch Hill with e.p. 487.3. The base of chaotic breccia is at level about 437 m a.s.l. (Fig. 8).

Fig. 7. General view on wall of abandoned quarry in scheme d and photo a. Massive non-bedded light grey to greenisch tuff-sandstone (scheme d/1; photo a) is incoherent up to slightly consolidated. The massive beds (without layering) with dispersed fragments and blocks of siltstones (scheme d/2; photo b) and with scattered andesite fragments and pumice (photo c) represent deposits of hyperconcentrated flows.

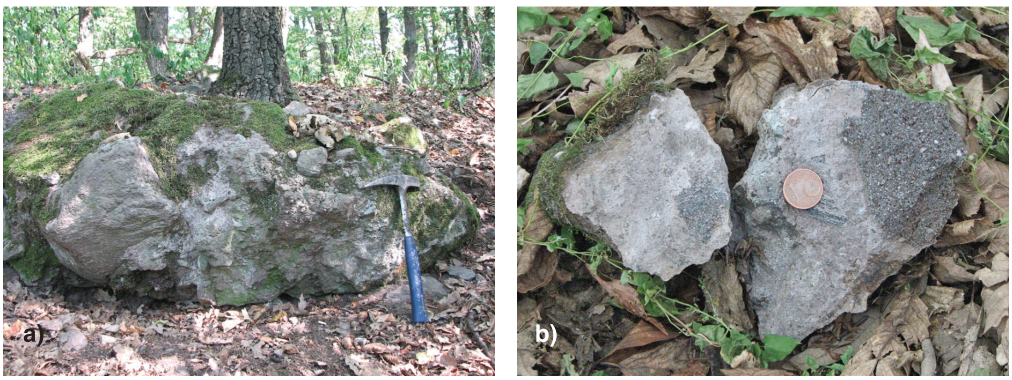


Fig. 8. Chaotic breccia on the top of the ridge 487.3 Viničný vrch consists of vesiculated fragments of spheroidal shape with dimensions 5–15 cm, sporadically up to 35 cm (photo a). Left side of the photo a shows the rounded andesite block derived from the conglomerate bed and transported together with the material of pyroclastic flow. Tuffaceous matrix is strongly welded with small vesiculated fragments and homogenized (photo b).

The base of pyroclastic flow is in similar altitude as the base of pyroclastic flow in locality Hlinisko. The paleovalley in locality Viničný vrch Hill after widening continues southward by a flat relief of proluvial plain and bottom of the sedimentary basin of Vyšná Pokoradz Formation, where the pyroclastic flow has deposited.

Several relics of the paleovaleys filling, passing to south into the delta-type sedimentary basin are preserved west of the Viničný vrch Hill.

12 – The Bukovina paleovalley

The Bukovina ridge represents relic of the paleovalley fill, trending NW–SE in a length about 1.6 km (Appendix 2A). At northwestern edge, the base of paleovalley fill is at level 500 m a.s.l. Towards the SE, the paleovalley bottom gradually descendes to level 445 m a.s.l. Fluvial *tuffitic sands with pebbles of volcanic and non-volcanic rocks* form discontinuous bed at the base of the paleovalley filling. Above basal bed, the *fine to medium epiclastic volcanic conglomerate* beds alternate with *medium to coarse epiclastic volcanic conglomerate* with 20–30 cm pebbles of the rounded andesite material. In upper part of the fill the *coarse to blocky epiclastic volcanic conglomerate* follows with rounded blocks large up to 40 cm, sporadically 1.2-2 m, building the summit area of the ridge with elevation points 518.8 m and 487 m.

Further north of the Bukovina ridge, two relics of coarse to blocky epiclastic volcanic conglomerates crop out south of the Lipové village.

13 – The ridge to NE of Slizké village – Višňaná – Vrchhora paleovalley

Conspicuous ridge to NE of Slizké village in the length about 1 400 m with elevation points 454, 438 and 436 m represents filling of the paleovalley with the course from NW to N–S and finaly to SE into the sedimentary basin (Appendix 2A).The base of the paleovalley fill at the northern end is at level 522 m a.s.l., at the southern edge the base is at level 440 m a.s.l. *Basal bed of tuffitic sand with gravels of volcanic and non-volcanic rocks* is discontinuous. In the southern part of the paleovalley fill the bed of *fine to medium epiclastic volcanic conglomerate* continues above basal bed (rounded andesite material varies from several cm up to 15–20 cm). The *coarse to blocky epiclastic volcanic conglomerate* (30 to 40 cm rounded blocks, rarely up to 60–80 cm) in higher level builds the upper part of the ridge. On the summit of the ridge with elevation points 454 and 436, the relics of *coarse to blocky epiclastic volcanic breccia-conglomerate* are present. Except of the rounded 40–60 cm blocks, there are also present blocks up to 50–60 cm large, having subangular and angular shapes. In the area of summit with e.p. 435 the blocks with dimension 2.2 x 2 m are present.

The Višňaná Hill with flat top (south of Slizké village) represents the continuation of the paleovalley filling of the ridge to NE of the Slizké village with e.p. 454, which passes to SE into the sedimentary delta-basin. Basal bed of *tuffitic sands with gravels of volcanic and non-volcanic rocks* crop out on the southern and eastern slopes of the hill at level 365 m a.s.l. In the higher level the basal bed gradually passes into the bed of *epiclastic volcanic sandstones* often with intercalations of fine epiclastic volcanic conglomerates. From the level 374 m a.s.l. the *bed of coarse to blocky epiclastic volcanic conglomerates* follows with rounded andesite blocks with diameter 20–40 cm, rare blocks up to 60 cm are also present. The uppermost level of the hill with flat top is covered by the *coarse to blocky epiclastic volcanic breccia-conglomerate* according angular and rounded blocks with dimensios up to 40–60 cm. Coarse to blocky epiclastic volcanic facies represent deposits of littoral zone of the delta-lake type.

The Vrchhora Hill with e.p. 461 represents an isolated relic of the paleovalley filling located west of the Slizké village. It is an integral part of the paleovalley filling forming the ridge to NE of Slizké village with e.p. 454. Basal bed of *tuffitic sands with gravels of volcanic and non-volcanic rocks* is indicated by the presence of pebbles of quartz and crystalline rocks on the eastern slope of Vrchhora Hill at level 425–430 m a.s.l. Basal bed is overlied by the *coarse to blocky epiclastic volcanic conglomerate* with rounded blocks of dimensions 20 cm up to 50 cm. *Coarse to blocky epiclastic volcanic breccia – conglomerate* follows from the level 440 m a.s.l. with 25–40 cm large angular, subangular and rounded andesite blocks. The top of Vrchhora Hill is built of conglomerate with rounded blocks large 25–45 cm and rare up to 1.5 m.

14 – The Holý vrch Hill paleovalley

The isolated Holý vrch Hill (e.p. 415), located SW of the Slizké village, has a shape of the ridge long 1 350 m and trending NNE–SSW (Appendix 2A). The basal bed of *tuffitic sands with gravels of volcanic and non-volcanic rocks* is deposited on Mesozoic rocks at level 370 m a.s.l. at the northwestern edge, southward it discordantly overlies the Lower Miocene sediments. The basal bed in upper part gradually passes at the level 375 m a.s.l. into the bed of *epiclastic volcanic sandstones* with thickness about 13 m. Intercalations of fine andesite conglomerates are frequent. Above bed of epiclastic volcanic sandstone, the *coarse to blocky epiclastic conglomerate* follows from the level 388 m up to level 395 m a.s.l. The rounded andesite blocks with dimensions 30–60 cm are deposited in subhorizontal beds and they often alternate with thinner interbeds of epiclastic volcanic sandstones. The uppermost part of the ridge is formed by *chaotic breccia of pyroclastic flow* with the base at about 400 m a.s.l. Breccia consists of vesiculated fragments of subspheric shape with dimensions 5–15 cm, rare up to 20 cm, angular fragments are also present with dimensions from 10 cm up to 30–40 cm. Tuffaceous matrix is welded.

15 – The Stránička – Hajmás paleovalley

The Stránička ridge east of the Viničný vrch Hill represents the easternmost situated relic of the paleovalley filling. Ridge trending NNW–SSE, long 1 700 m, is divided into two parts by erosion: a) northern part with e.p. 380 Stránička, b) southern part with e.p. 384 Hájna (Appendix 2A). The Lower Miocene sediments are underlying the volcanosedimentary complex. Basal bed of *tuffitic sands with gravels of volcanic and non-volcanic rocks* is preserved on the southern edge of the Hájna ridge at level about 325 m a.s.l. In the higher level, the basal bed passes into the bed of *epiclastic volcanic sandstones* (often with thin interbeds and intercalations of the fine andesite conglomerates). Above, the bed of *fine to medium epiclastic volcanic conglomerate* occurs with rounded andesite material with dimensions 5–25 cm. Facies of the *coarse to blocky epiclastic volcanic breccia-conglomerates* overlays the facies of fine to medium epiclastic volcanic conglomerate. In the uppermost part of the ridge, the scattered blocks with subangular to angular shape and dimensions 50–60 cm indicate the presence of *coarse to blocky epiclastic volcanic breccia* and/or *lahar breccia*.

Relics of the paleovalleys fillings in the Lučenská kotlina Basin

In the northeastern part of the Lučenská kotlina Basin, several relics of volcaniclastic rocks represent remnants of original paleovalley fill. Volcaniclastic rocks are deposited directly on the surface of the Paleozoic rocks and in the southern part on the surface of the Lower Miocene sediments.

16 – The Zvonov hrbok I paleovalley

Locality Zvonov hrbok I includes two relics of volcaniclastic rocks NE of the Selce village (Appendix 2A). On the top of flat hill with e.p. 322 a bed of *coarse to blocky epiclastic volcanic conglomerate* is present. The conglomerate bed is overlain by the *coarse to blocky epiclastic volcanic breccia-conglomerate,* which is manifested by the stony debris with rounded and subangular andesite blocks. Top of the southern hill Zvonov hrbok I is covered with *coarse to blocky epiclastic volcanic conglomerate*.

17 – The Zvonov hrbok II paleovalley

Relics of volcaniclastic rocks cover top of three hills from the north to south (Appendix 2A). On the top of the northern hill with e.p. 420, the *epiclastic volcanic sandstones with intercalations of fine epiclastic volcanic conglomerates* crop out. *Coarse to blocky epiclastic volcanic breccia-conglomerate* cover the southern top of the Zvonov hrbok hill II and the *fine to medium epiclastic volcanic breccia-conglomerate* covers a top of the southernmost hill with e.p. 342.

18 – The Opálenica paleovalley

In locality Opálenica three relics of volcaniclastic rocks are present (Appendix 2A). Top of the northern hill with e.p. 420 is formed of the *epiclastic volcanic sandstones with intercalations of fine to medium epiclastic volcanic conglomerate*. This facies covers also top of the hill situated to SE. On the top of the southern hill Opálenica with e.p. 368 a *coarse to blocky epiclastic volcanic conglomerate* occurs according rounded andesite blocks, present in the debris.

19 – The Patočiny – Vyšný Koplalov paleovalley

Locality Patočiny – Koplalov represents the southernmost relics of volcaniclastic rock in the Lučenská kotlina Basin in the lowest position concerning the altitude (Appendix 2A). At the base of the northern volcanic relic of the Patočiny Hill with e.p. 302, the fluvial sediments of *tuffitic sands and gravels with volcanic and non-volcanic material* occur at the level 275 m a.s.l. Higher above the basal bed, the *coarse to blocky epiclastic volcanic conglomerates* follow. In the southern larger relic of volcaniclastic rocks of Koplalov Hill, there is a bed of *coarse to blocky epiclastic volcanic conglomerate,* deposited at level 275–280 m a.s.l. at the western side of the paleovalley on its bottom. Above conglomerate bed a *chaotic breccia of pyroclastic flow* with a base at level 290–295 m a.s.l. is exposed. Breccia consists dominantly of vesiculated fragments of pyroclastic type with dimension 5–25 cm and rare larger blocks up to 40 cm. Tuffaceous matrix is welded with small vesiculated fragments. In the eastern and southern parts of large relic of volcaniclastic rocks, the basal sediments represent *epiclastic volcanic sandstones with fine to medium-grained conglomerates* deposited on the surface of the Lower Miocene sediments. Relics of volcaniclastic rocks are partly covered by fluvial-limnic silts and polymict conglomerates of the Poltár Formation of Pontian age.

Summary about structures and lithology of the paleovalleys fillings on the southern slopes of the Slovenské rudohorie Mts.

Relics of volcaniclastic rocks preserved on tops of the ridges and isolated hills were identified as remnants of the filling of original paleovalleys. During volcanic activity the paleovalleys represent a ways used for transport of volcaniclastic material from the southern slopes of the Vepor stratovolcano into the sedimentary basin. Lithological content of individual paleovalleys is different what is evident namely in the northern area. In the filling of the Hrb paleovalley only epiclastic volcanic facies are present, while in the paleovalley Vrchduby located eastward, except epiclastic volcanic rocks also chaotic breccias of pyroclastic flows are present. The near paleovalley Sušanský vrch, located east of the Vrchduby paleovalley, shows also the different filling lithology. It manifests that paleovalleys in the northern area were used for transport of volcaniclastic material into the southern sedimentary basin in the different time of evolution of andesite stratovolcano. There are also great differences in the depth of erosive cut of paleovalleys, proving that erosive processes forming paleovalleys were not contemporaneous. Tuffaceous and fine to coarse clastic material was transported by rivers, brooks and ephemeral streams, dilute water flows and also episodically by hyperconcentrated mass flows and lahars, resp. debris flows.

Specific type of mass flows represents pyroclastic block and ash flows, corresponding to actual volcanic activity. Some block and ash pyroclastic flows were deposited and welded in different levels of paleovalleys fillings. This fact is important for paleovolcanic reconstruction of individual phases of volcanic activity. In the southeastern part of the area (east of Rybník village), the relics of chaotic pyroclastic breccia occur from the level 340 m a.s.l. up to level 538 m a.s.l. It documents the total 198 m thickness of chaotic breccia, being deposited by several block and ash pyroclastic flows.

In the northern part of the area the base of paleovalleys filling is at level 700 m a.s.l., while in its southern part (east of Rybník village) it is at level 375–380 m a.s.l. That difference points on high energy of ephemeral fluvial streams and rivers, as well as lahars which is documented by deposits of coarse to blocky epiclastic volcanic conglomerate and lahars, sometimes transporting blocks up to 1.5–2 m and more. The southern part of the paleovalleys area was enlarged with transition into the sedimentary basin of the Vyšná Pokoradz Formation with deposition of volcaniclastic material in the delta environment, passing to south into the lake sedimentation.

II – Volcanosedimentary complexes of the Vyšná Pokoradz Formation

Evolution of the sedimentary basin at the southern foot of andesite stratovolcano was very dynamic and has close relations to evolution and space enlargement of the andesite stratovolcano as it reflects in lithology of volcaniclastic rocks, filling the basin. Deposition of volcaniclastic material occurred synchronously with the subsidence of the sedimentary basin with progradation of littoral zone to south. In vertical lithological succession it is possible to decipher processes of deposition in the delta-lake environment with alternating calm lake sedimentation of fine silty material and longer deposition of conglomerate facies in the littoral zone, as well as the phase of sudden and episodic deposition of mass flows like hyperconcentated flows, lahars and block and ash pyroclastic flows. During deposition the sedimentary basin area gradually subsided and accumulation reached thickness about 140 m up to maximum 200 m.

After the Upper Sarmatian and Pliocene termination of volcanic activity during regional uplift of the area, the intensive denudation has resulted in the transformation of sedimentary basin into two separated morphological units as the Pokoradz and Blh plateaus. Because there are some differences in structures and lithology between these two units, they will be discussed separately.

A – Structure and lithology of the volcanosedimentary complex of the Pokoradz Plateau

The Pokoradz Plateau represents western part of the original volcanosedimentary complex of the Vyšná Pokoradz Formation, later separated by erosion from the eastern complex of the Blh Plateau. Sedimentary basin was gradually deeping from the north to south. The base of volcanosedimentary complex at the northern edge is about 450 m a.s.l. and at southern edge it descends to 380 m a.s.l. Thickness of the volcanosedimentary complex is gradually increasing from the north southward, at the northern edge it is only several m and/or several tens of meters, while at southern edge it reaches about 140 m up to maximum 200 m.

Details of geological structure are demonstrated in geological-lithofacial map of the Pokoradz Plateau (Appendix 3A, B, C) and the position of paleovalleys and their filling is presented on series of profiles oriented W–E, ***PF-1*** to ***PF-15*** (Appendix 4A, B).

In following interpretation of structure and lithology of the sedimentary filling of the original basin we come out from the geological-lithological map at a scale 1 : 10 000 (Konečný et al., 2011; Caban, 2009) documented by geological-lithological sections (profiles) trending W–E. Structure and lithology of volcanosedimentary complex of the Pokoradz Plateau is in more details discussed from the north to south in three parts.

1 – Northern part of the Pokoradz Plateau, area between Kyjatice and Lukovištia villages (profiles PF-1 to PF-8)

In the northern part of the area in littoral zone and shallow water environment, the facies of the coarse to blocky epiclastic volcanic conglomerate deposited in a wide belt. Relief of the pre-volcanic basement rocks was generally flat with uplifting at eastern edge (Vršok e.p. 565.5, profile ***PF-1***), which represents the eastern edge of paleovalley, passing from the north southward into sedimentary basin. Bottom of sedimentary basin gradually descended to south.

Pre-volcanic basement in the western part of the basin is formed of Paleozoic rocks of the Veporic unit (Rimava Formation, Permian) and rocks of the Gemeric unit thrust over Veporic unit (Zlatník Formation, Carboniferous), as well as phyllites of Gelnica Group (Devonian?). In the eastern part of Pokoradz Plateau the pre-volcanic basement is formed of Mesozoic rocks (variably coloured schists, Guttenstein limestones and dolomites of Turnaic unit, Triassic). In the southeastern part of the sedimentary basin (the area around the Lukovištia village), the pre-volcanic basement is formed of the Oligo-Miocene sediments, filling of the Rimava Basin. During deposition of volcaniclastic rocks of the Vyšná Pokoradz Formation, the southern part of the sedimentary basin represents the subsidence area with accumulation of relativelly thicker volcanosedimentary complex.

The northern part of the volcanosedimentary complex in the Pokoradz Plateau is formed of the following facies of volcaniclastic rocks: Dominant facies in the northern part of sedimentary basin is represent with the *coarse to blocky epiclastic volcanic conglomerates* deposited immediately on the surface of the pre-volcanic basement rocks (profile ***PF-1,*** Appendix 4A). Conglomerate bed consists of rounded andesite blocks with maximum dimensions about 40–80 cm, rarely are present 1–2 m large blocks. Matrix is sandy, coarse-grained, containing small rounded andesite fragments and gravels, often also with the non-volcanic rocks. Intercalations and thin irregular interbeds of epiclastic volcanic sandstones are often present within the conglomerate bed. Thickness of conglomerate bed is variable, maximally up to 60–70 m.

In the northern part of the Pokoradz Plateau, the basal fluvial *tuffitic sands with gravels of volcanic and non-volcanic rocks* (pebbles of quartz, granitoids and crystalline schists) of variable thicknes (2–5 m) are locally present below the conglomerate bed at the NW and NE edges of the plateau (profile ***PF-3***). Immediatelly on the pre-volcanic basement rocks, also several scattered *relics of chaotic breccia of pyroclastic flow* are situated at the NW and NE edges of the Pokoradz Plateau (Geological-lithofacial map, profiles ***PF-2*** and ***PF-3***).

Chaotic breccia of pyroclastic flows – layer-1a and 1b

Chaotic breccia of pyroclastic flow near the Kyjatice village at NE edge of the Pokoradz Plateau lies on the surface of Mesozoic rocks at the level of 444 m a.s.l. Chaotic breccia contains fragments of variable dimensions and shape. Except of vesiculated subspheric fragments there are present also angular to subangular fragments with dimensions 5 cm to 30 cm, which are locally dominant. Tuffaceous matrix with higher content of pumice is welded with small vesiculated fragments. Fragments and blocks belong to the amphibole-pyroxene andesite (amphibole 3–4 mm, rarely to 1 cm). Chaotic breccia of pyroclastic flow according its position directly on the surface of pre-volcanic basement rocks is marked as a ***layer-1a***. Southward continuation of chaotic breccia of pyroclastic flow was removed by erosion during the development of coarse to blocky epiclastic volcanic conglomerate in the littoral zone.

Several scattered relics of *chaotic pyroclastic breccia* deposited directly on the pre-volcanic basement rocks with the base at 425–440 m a.s.l. can be found at western edge of the Pokoradz Plateau (N and W of locality Rudno e.p. 491.2, NW of Kraskovo village profile ***PF-3***). Other relics of chaotic pyroclastic breccia in similar position occur on western slope of the Rimavická hora at level 400 m a.s.l. (profile ***PF-4***). Relics of chaotic pyroclastic breccias at the western edge of the Pokoradz Plateau are marked as a ***layer-1b***.

Chaotic pyroclastic breccia located W of Rudno e.p. 491.2 consists dominantly of vesiculated fragments with subspheric shape in dimensions from 5 cm up to 15 cm, rare blocks up to 30 cm. The angular non-vesiculated fragments are less frequent. The tuffaceous matrix with the pumice content is strongly welded with small vesiculated fragments (margins of fragments are obscured). Fragments and blocks represent the coarse porphyric amphibole-pyroxene andesite (plagioclase 2–3 mm, pyroxene 1–2 mm, amphibole 4–6 mm) with the brown glassy groundmass (signs of the contact of hot pyroclastic material with the water environment).

Relics of chaotic breccias of layers-1a and 1b, deposited immediatelly on the surface of pre-volcanic basement rocks, represent *early phase of eruption of pyroclastic flows*, reaching the northern part of sedimentary basin before deposition of thick bed of littoral coarse to blocky conglomerates. The continuation of 1b pyroclastic flow to SW probably corresponds to relic of chaotic pyroclastic breccia in the Kamenná hora e.p. 358 in the NE part of the Lučenec Basin. Relic of chaotic pyroclastic breccia with base at level about 300 m a.s.l. is underlain and overlain by beds of coarse to blocky epiclastic volcanic conglomerates (similarly as in the case of Rimavská hora, profile PF-4). The altitude difference of their bases can be explained by the 100 m subsidence of the northern part of the Lučenec Basin along the NNW–SSE trending fault zone. Tectonic movement according this fault system occurred in the post-volcanic phase during Pliocene.

Areal distribution of chaotic pyroclastic breccias (layer-1a and 1b) of this early phase indicate that pyroclastic flows in their way to south followed individual separated lines divided by uplifted basement rocks in the northern part of sedimentary basin. This area to NW of Kraskovo village with relativelly higher position of the pre-volcanic basement (ridge) is indicated in profiles ***PF-3*** and ***PF-4***. Gradual deepening of sedimentary basin southward in the eastern part of volcanosedimentary complex of the Pokoradz Plateau is documented by position of the basal bed, descending from the level 400 m a.s.l. to 375 m a.s.l. (***PF-3*** and ***PF-4***). Above basal bed, the bed of *epiclastic volcanic sandstones* alternates with the *coarse to blocky epiclastic volcanic conglomerate* (***PF-3***) and more southward above basal bed there were identified several beds of *medium to coarse and coarse to blocky epiclastic conglomerates,* alternating with interbeds of *epiclastic volcanic sandstones* with total thickness about 75 m (***PF-4***). Deepening of sedimentary basin southward in the eastern part of the Pokoradz Plateau documents also the profile ***PF-5*** (basal bed descends to level 375 m a.s.l.) and ***PF-6*** (basal bed is in level 360 m a.s.l.), as well as the profiles ***PF-7*** and ***PF-8,*** where the basal bed descends to level about 300 m a.s.l. and total thickness of epiclastic volcanic rocks reaches about 120 m. Pre-volcanic basement in the eastern part sedimentary basin is formed of the Lower Miocene sedimentary complex (profile ***PF-6***). Gradual deepening of the sedimentary basin southward in the eastern part is documented also by the profile ***PF-5***.

Morphological elevation of the pre-volcanic basement, evident in profiles ***PF-3*** (the Rudno area) and ***PF-4*** (the Kraskovo area), is eliminated southward in profile ***PF-5***. In relativelly shallower western part of the sedimentary basin, the deposition of the coarse to blocky epiclastic volcanic conglomerate is dominant (***PF-3***, ***PF-4***, ***PF-5***). Continuing southward to a deeper part of the sedimentary basin, the coarse to blocky epiclastic volcanic conglomerate alternates with layers of epiclastic volcanic sandstones (***PF-6***, ***PF-7***, ***PF-8***). The base of conglomerate bed in direction to S descends to levels 380 m a.s.l. (***PF-7***) and 345 m a.s.l. (***PF-8***).

In discussion about evolution of the sedimentary basin of Vyšná Pokoradz Formation and interpretation of volcanic processes occurring on the stratovolcano slope, it is important to devote more attention to deposits of mass flows like pyroclastic flows and lahars.

Chaotic breccia of pyroclastic flow layer-2

Chaotic breccia with base about 460 m, builds up the Konková ridge (e.p. 468.6) in the eastern part of the Pokoradz Plateau (PF-3, PF-4). Breccia represents the uppermost part of lithological succession above 125 m thick epiclastic volcanic horizon.

Chaotic breccia with the base about 460 m a.s.l. represents the uppermost part of lithological succession above 125 m thick epiclastic volcanic horizon, where epiclastic volcanic conglomerate alternates with interbeds of epiclastic volcanic sandstones. At the southern edge of the ridge the base of chaotic pyroclastic breccia descends to level about 450 m a.s.l.

Chaotic breccia of pyroclastic flow of layer-2 consists dominantly of fragments with angular shape with dimensions 5–30 cm up to blocks with diameters 60–80 cm. Tuffaceous matrix is strongly welded with small vesiculated fragments. Petrographically there was identified material of fine to medium porphyric pyroxene andesite and rare material of medium porphyric amhibole-pyroxene andesite (amphibole up to 3–4 mm). Chaotic breccia of pyroclastic flow of ***layer-2*** southward occupies a broader area. The relics of chaotic breccia cover the flat top of the Kováčova hora Hill (NW of the Lukovištia village) with base at 453 m a.s.l. (***PF-5***, ***PF-6***) and the summit of the Pri skalke Hill (e.p. 474; SW of the Lukovištia village). Chaotic breccia of pyroclastic flow on the flat top of Konková ridge on eastern edge of the Pokoradz Plateau continues to south as a narrow Banková ridge, trending N–S (elevation points 430.1, 443 and 450 m).Total length of pyroclastic flow on the top of both ridges is about 4.6 km and the base of pyroclastic flow descends from the level 460 m a.s.l. (at the northern edge of Konková ridge) to level 415 m a.s.l. (at the southern edge of Banková ridge). According to similar levels of the bases of pyroclastic relics there can be supposed relatively flat bottom of the sedimentary basin with moderate south dip during the deposition of pyroclastic flow.

*Chaotic breccia of pyroclastic flow – lay*er-2 exposed in cliff on the western slope of the Bankov vrch e.p. 450 (SE of Lukovištia village), comparing with chaotic breccia of layer-1, is different in lithology. It consists dominantly of angular fragments with low vesiculation, having dimensions 5–15 cm and blocks to 60–80 cm, sporadically up to 1.5 m. Vesiculated fragments are less frequent. Distribution of fragments and blocks is chaotic. Material of pyroclastic flow belongs to pyroxene and amphibole pyroxene andesite. Lithological characteristic corresponds to pyroclastic block and ash flows of Merapi type originating during destruction and collapses of extrusive domes (Fig. 9).

Fig. 9. Chaotic breccia is exposed in rocky cliff, high about 15 m, on the western slope of the Bankov vrch Hill with e.p. 450, SE of the Lukovištia village (photo a). Breccia is characteristic with the dominancy of angular fragments. The tuffaceous welded matrix is subordinated, representing about 20 % of the rock volume (photo b).

Lahars (debris flows)

Lahars represent next type of the mass flows, episodically transporting clastic and muddy-tuffaceous material from the southern slopes of andesite stratovolcano at its foot.

Several lahar bodies are idenfied on the eastern slope of the Pokoradz Plateau west and south of the Lukovištia village (***PF-6***, ***PF-7*** and ***PF-8***).

Lahar breccia in the northern part of the Pokoradz Plateau is identified on the eastern slope of the ridge with e.p. 497.6 (west of Lukovištia village) at the level 420 m a.s.l., located above the bed of epiclastic volcanic sandstone (***PF-5*** and ***PF-6***). Andesite fragments with dimensions 5–30 cm are angular to subangular. Subspheric and vesiculated fragments are less frequent. Sporadically the rounded blocks with dimensions 30 up to 40 cm are also present with their higher concentration near the base. In tuffaceous-sandy matrix there is higher content of pumice and small angular and spheroidal vesiculated fragments up to 3–4 cm large. Lahar was probably initiated in connection with explosive activity, which is manifested by the higher content of pumice in the matrix. During movement of lahar, the rounded andesite blocks were mobilized from underlying conglomerate beds. Deposition of material is chaotic with a tendency of accumulation of coarser blocks near the base (normal gradation). Lahar bodies are also identified on the western and eastern slopes of the Bankov vrch ridge located southeast of the Lukovištia village (***PF-7*** and ***PF-8***).

Lahar breccia above the bed of coarse to blocky epiclastic volcanic conglomerate is exposed on the northern slope of the Lemešík ridge (e.p. 436) at level 410 m a.s.l. NE of the Horné Zahorany village above the conglomerate bed (profile ***PF-8***, Fig. 10).

Lahar breccia represents type of cold lahars; clastic material was not in a hot state during transport and deposition. But the presence of higher content of pumice material does not exlude that mobilization of lahar has occurred in connection with explosive eruption due to the heavy rains. Lahars at their movement to south, also as pyroclastic flows, preferred deeper eastern part of the sedimentary basin.

2 – Southern part of the Pokoradz Plateau, area from the Kociha village to Vyšná Pokoradz village (profiles PF-9 to PF-14)

Southern part of the Pokoradz Plateau is characteristic with continuing southward deepening of the sedimentary basin (***PF-9,*** Appendix 4A). The base of volcanosedimentary complex at the western edge of the Pokoradz Plateau is at the level about 300 m a.s.l. At the eastern edge it is lower – about 275 m a.s.l. Deepening of sedimentary basin is reflected by increasing thickness of the lower complex of epiclastic volcanic sandstones and greater number of conglomerate beds. The total thickness of the volcanosedimentary complex in this part of the sedimentary basin is ca 150 m.

Lower complex of epiclastic volcanic sandstones is exposed in several outcrops and in abandoned quarries on the western slopes of the Pokoradz Plateau (east of Nižný and Vyšný Skálnik villages). At the entry to valley with the Vyvieračka brook, in a wall of small abandoned quarry the beds of epiclastic volcanic sandstones alternate with thinner layers of siltstones (Fig. 11).

From the siltstone layers in lower complex of epiclastic volcanic sandstone at locality Nižný Skálnik there was described the

Fig. 10. Lahar breccia in rocky cliff consists of andesite fragments dominantly of angular to subangular and also suboval shapes with 5–20 cm dimensions (photo a). Upper part of the cliff shows larger block of brecciated andesite. Matrix is tuffaceous-sandy with a higher content of pumices and smaller angular and rounded andesite fragments (photo b). Distribution of clastic material is chaotic with a certain tendency to accumulate larger 2 blocks in the upper part of lahar body (effect of kinetic sieving). Kinetic sieving is process when during movement of the lahar and/or pyroclastic flow small particles migrate downward and large ones gradually migrate upward. The rounded blocks, coming probably from the underlying bed of coarse epiclastic volcanic conglomerate, were mobilized during movement of the lahar body.

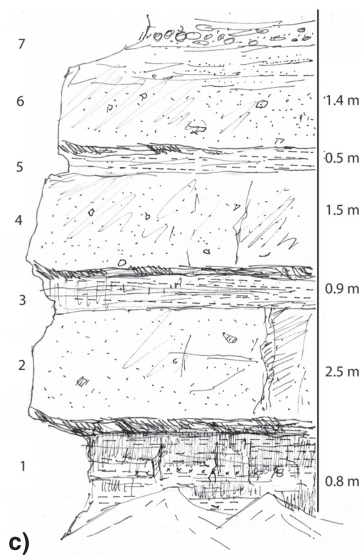


Fig. 11. Sedimentary succession in abandoned quarry is documented in photo a, b and scheme c. The lower part of the outcrop is built of the light grey-green siltstone bed (scheme c/1), thick app. 80 cm, with fine lamination and intercalations of fine-grained tuffs (photo b). On the surface of the platy jointing siltstone, the remnants of flora and imprints of leaves are rarely preserved. Presence of pumice fragments in tuff layers points on explosive activity and deposition of ash-pumice material from the volcanic cloud. Above bed of siltstone, the body of non-bedded coarse epiclastic volcanic sandstone occurs with thickness about 2.5 m (scheme c/2, photo a, b), having dispersed smaller andesite fragments and pumice fragments.This body of epiclastic volcanic sandstone was deposited by the hyperconcentrated flow. In vertical succession next follows again the siltstone bed (scheme c/3), representing a continuation of a calm lake sedimentation. In a higher position in the quarry wall the body of non-bedded epiclastic volcanic sandstone follows as a product of hyperconcentrated flow (scheme c/4) and again it is alternated with thin siltstone bed (scheme c/5). Higher body of epiclastic volcanic sandstone (scheme c/6) exhibits signs of normal bedding in its uppermost part. In vertical lithological succession the thicker complex of volcanic sandstone follows (scheme c/7) with structures of cross-bedding expressed also by the deposition of fine conglomerate interbeds.

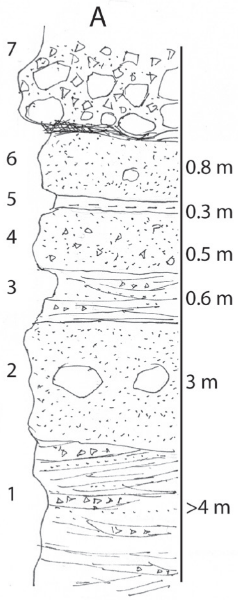
flora of Sarmatian age (Němejc, 1960, 1967). Later in this locality the flora of Sarmatian age was investigated also by Sitár and Dianiška (1979).

Southward to deeper part of sedimentary basin (***PF-10***, ***PF-11***, Appendix 4B), the lower complex of epiclastic volcanic sandstones is exposed in imposant walls of abandoned quarries at the western foot of steep slopes of Pokoradz Plateau. In a quarry bellow e.p. 379 (east of the Vyšný Skálnik village), the upper part of the lower complex of epiclastic volcanic sandstones is exposed (Fig. 12).

Transition from the calm sedimentation in the lake environment to sedimentation with rapid and episodic supply of the tuff-sandy material by hyperconcentrated mass flow can be demonstrated in the locality on the slope of gorge bellow the Magin hrad Hill south of the Nižný Skálnik village (Fig. 13).

Sedimentary sequence documents that after the deposition of fall-tuffs into the lake environment, the area of sedimentary basin was supplied by repeating transport of sandy tuffs by hyperconcentrated flows and debris flows. The differences between the western shallower part and eastern relativelly deeper part of the sedimentary basin, expressed in profile ***PF-9***, are gradually eliminated southward in the deeper part of the sedimentary basin (see profiles ***PF-10*** and ***PF-11***, Appendix 4B).

Coarse to blocky epiclastic volcanic conglomerates are frequent facies in filling of the southern part of the sedimentary basin, forming beds with variabile thickness from 5 to 15 m and rare to 25 m. Andesite blocks up to 30–60 cm in diameter, rare up to 1.5 m, are semirounded to rounded, well sorted and deposited with subhorizontal layering. Individual beds of blocky conglomerates al-



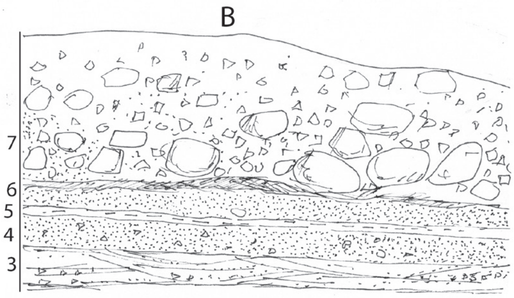


Fig. 12. The lower part of the quarry wall east of the Vyšný Skálnik village exposes the medium to coarse epiclastic volcanic sandstone (scheme A). Bed of epiclastic volcanic sandstone with cross-bedding structure contains small angular to subangular andesite fragments (1). Above it the body of non-bedded epiclastic volcanic sandstone follows with the scattered rounded blocks, deposited by hyperconcentrated flow (2). Higher in vertical succession the medium to coarse epiclastic volcanic sandstone occurs with the cross-bedding (3). Above, two bodies of non-bedded epiclastic volcanic sandstones follow (4, 6), being deposited by hyperconcentrated flow. They are separated by thin siltstone interbed (5). In the uppermost part of the quarry wall the body of lahar breccia occurs (7) with sharp contact of the base on the surface of underlying epiclastic volcanic sandstone (scheme B). Lahar breccia consists of 5 to 15 cm andesite fragments with angular to subangular shape. Andesite blocks large up to 30–40 cm and rarely up to 1.5 m are subangular to suboval. Deposition of material is chaotic with the tendency of the larger blocks accumulation in the lower part of the lahar body. Fragments large 15-30 cm are less frequent. Tuffaceous-sandy matrix with silty component represents about 60–70 % of the volume.

Fig. 13. In the lower part of the outcrop, the fine-grained tuffaceous lake sediments alternate with lighter thin layers of silts (scheme e/1, photo a). Horizontal bedding of thin silty layers and fine-grained tuffs is often disturbed by deformation structures and small vertical shifts. Fine tuffs and silty sediments represent fall-tuff from the plinian type volcanic cloud of eruption, deposited in calm lake environment. Higher in vertical succession, the body of massive, non-bedded sandy tuff with pumices and small andesite fragments is deposited with sharp base on underlying lake sediments (scheme e/2, photo a, b). Body of non-bedded sandy tuff was deposited by hyperconcentrated flow. At the base the deformation and erosion of underlying lake sediments were locally observed (photo c). Higher above body of non-bedded sandy tuff the sequence of layered epiclastic volcanic sandstones follows with cross bedding structures and alternating of fine and coarser fractions with intercalations and layers of fine conglomerates (scheme c/3 and 4, photo d). In the uppermost part of the sequence there follows the epiclastic volcanic breccias, transported and deposited by debris flows and/or lahars follows.

ternate with layers of epiclastic volcanic sandstones. Matrix among rounded andesite blocks – the coarse-grained epiclastic volcanic sandstone, represents about 20–30 %. In beds of coarse to blocky epiclastic volcanic conglomerate, the separation of blocky material according their dimensions was observed, with dominant fraction having about 30–40 cm in diameter. In deposition of individual blocks there can be often seen the preference of horizontal and/or subhorizontal direction. Conglomerate beds form flat tabular bodies which can continue over greater distances (see geological map and profiles). In the area documented by profiles ***PF-10*** and ***PF-11*** on the western and eastern slopes of the Pokoradz Plateau, during geological mapping there were identified 5 beds of coarse to blocky epiclastic conglomerates. Continuing southward in sedimentary basin, their number raises to 7 (profile ***PF-12***), which corresponds to deepening of sedimentary basin. In vertical profiles the coarse to blocky epiclastic volcanic conglomerates alternate with beds of epiclastic volcanic sandstones.

Facies of coarse to blocky epiclastic volcanic breccia-conglomerate occurs in different levels of the volcanosedimentary complex. Except the partly and well rounded blocks with dimensions up to 30–60 cm and rare to 1.5 m, there are also present angular and subangular blocks (locality on the western slope of the Pokoradz Plateau bellow e.p. 378 at level about 285 m a.s.l. east of the Vyšný Skálnik village). Blocky andesite material of rounded and angular shape comes probably from the destruction of chaotic breccias of pyroclastic flows, lahars and blocky conglomerates with short transport and redeposition.

The facies of medium to coarse epiclastic volcanic conglomerates with rounded andesite material of dominant dimensions 15–30 cm also principally contributed to building of volcanosedimentary complex in the southern part of the Pokoradz Plateau (profiles ***PF-11***, ***PF-12***, ***PF-13***. Appendix 4B). Facies occurs in several levels and forms discontinuous beds of smaller thickness.

Epiclastic volcanic sandstones with variable thickness (from several m up to 10–15 m) are frequent in different levels of volcanosedimentary complex, dividing individual beds of coarse to blocky epiclastic volcanic conglomerates and epiclastic volcanic breccias. In their lithology, the medium to coarse epiclastic volcanic sandstones dominate often with cross-bedding. Fine conglomerates form irregular lenses and interbeds of small thickness and often strained cross bedded structures. Epiclastic volcanic sandstones are often disturbed by erosive channels, filled by conglomerates (Fig. 14).

Fine to medium epiclastic volcanic breccias are often present in the southern part of the volcanosedimentary complex, forming discontinuing beds of small thickness. Facies of this type is exposed on the eastern slope of the Pokoradz Plateau south of the Horné Zahorany village (Fig. 15).

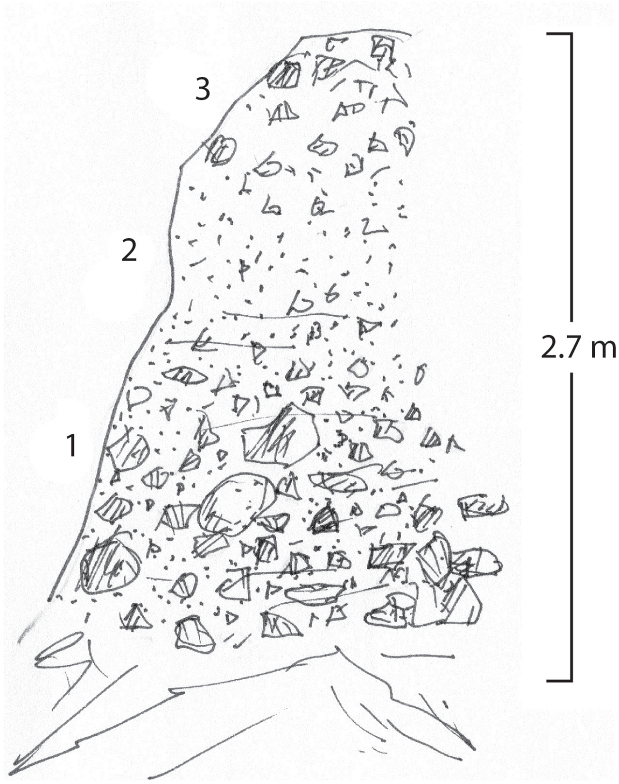


Fig. 15. In the cliff bellow e.p. 498 Prídel in the Veľký potok valley south of the Zahorany village a fine to medium epiclastic volcanic breccia is exposed. In the lower part of the cliff the epiclastic volcanic breccia with angular to subangular fragments large 5 to 25 cm and normal gradation crops out (1). Scarce rounded blocks come from underlying bed of the coarse to blocky conglomerate of northern littoral zone. In the upper part of outcrop a gradual transition into the coarse epiclastic volcanic sandstone is observable (2). The fine to medium epiclastic volcanic breccia with reverse gradation follows in the upper part of outcrop (3).

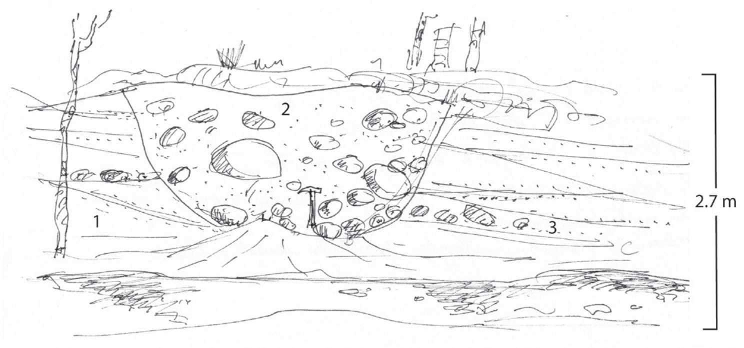


Fig. 14. Bed of epiclastic volcanic sandstone exposed in the forest cut (at the eastern edge of the Pokoradz Plateau bellow e.p. 491 west of Dražice village. Medium to coarse epiclastic volcanic sandstone is distinct with cross bedding structures (1) and frequent lenses of fine andesite conglomerate (3). Erosive channel (2) cut in epiclastic volcanic sandstone is filled with the coarse to blocky epiclastic volcanic conglomerate.

Outcrop of fine to medium epiclastic volcanic breccia above epiclastic volcanic sandstone is exposed on southeastern slopes of the Pokoradz Plateau (Fig. 16).

The reworked tuffs and pumice tuffs. Ash and ash-pumice tuffs after falling down from volcanic cloud were transported from the slopes of stratovolcano and adjacent areas into the sedimentary basin by ephemeral streams, dilute streams and hyperconcentrated flows. Ash-pumice tuff forms thin interbeds within beds of fine epiclastic volcanic sandstones and siltstones, eventually the fragments of pumices are dispersed in bodies of epiclastic volcanic sandstones, deposited by hyperconcentrated flows and/or lahars. Thin interbeds of ash-pumice tuffs were identified in lower part of the lower complex of epiclastic volcanic sandstones in abandoned quarry at the entrance to the Vyvieračka valley NE of the Vyšný Skálnik village. Intercalations and interbeds of small thickness of ash-pumice tuffs

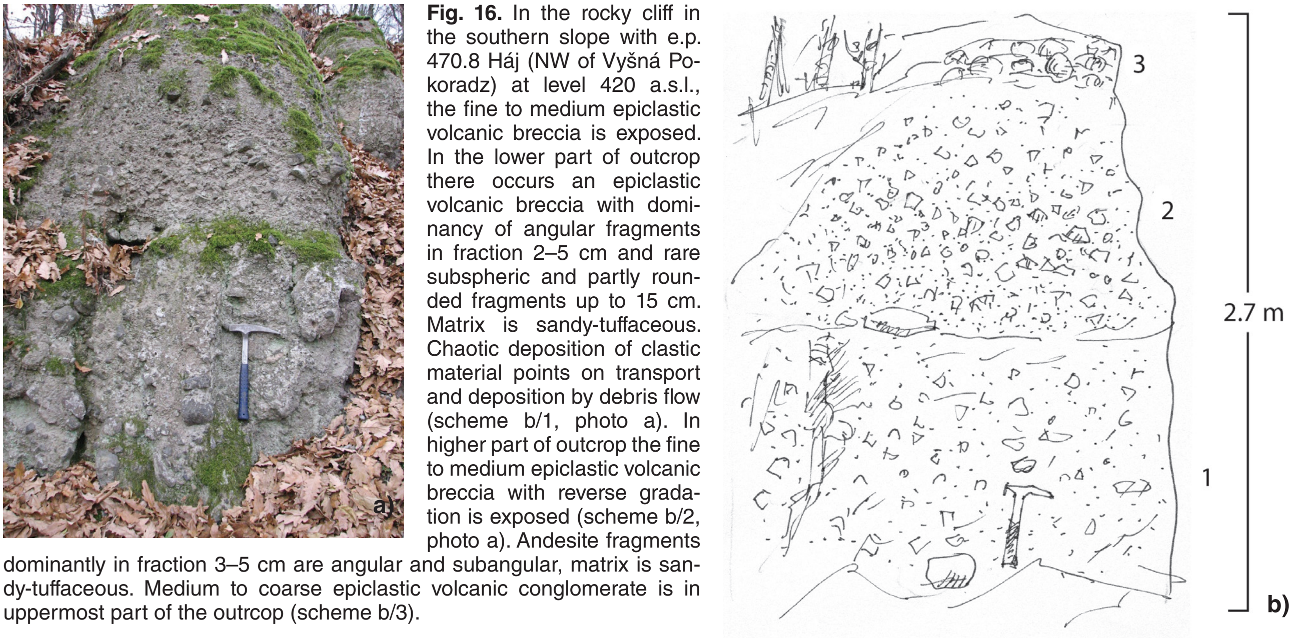


Fig. 16. In the rocky cliff in the southern slope with e.p. 470.8 Háj (NW of Vyšná Pokoradz) at level 420 a.s.l., the fine to medium epiclastic volcanic breccia is exposed. In the lower part of outcrop there occurs an epiclastic volcanic breccia with dominancy of angular fragments in fraction 2–5 cm and rare subspheric and partly rounded fragments up to 15 cm. Matrix is sandy-tuffaceous. Chaotic deposition of clastic material points on transport and deposition by debris flow (scheme b/1, photo a). In higher part of outcrop the fine to medium epiclastic volcanic breccia with reverse gradation is exposed (scheme b/2, photo a). Andesite fragments dominantly in fraction 3–5 cm are angular and subangular, matrix is sandy-tuffaceous. Medium to coarse epiclastic volcanic conglomerate is in uppermost part of the outrcop (scheme b/3).

are also present within the bed of epiclastic volcanic sandstones in higher levels of volcanosedimentary complex. Because of their small thickness, they are not expressed in geological-lithological map and they are marked only by symbols and commented in the legend.

Reworked fine to medium pyroclastic breccia represents dominantly the pyroclastic material transported into the sedimentary basin by streams after heavy rains, hyperconcentrated flows and debris flows (lahars). Beds of reworked fine to medium pyroclastic breccias were identified in several levels of volcanosedimentary complex. Reworked pyroclastic breccia is exposed at the southwestern edge of the Pokoradz Plateau SW of the Horné Zahorany village (Fig. 17).

Fig. 17. Reworked pyroclastic breccia is exposed in lower part of the slope of Šinkov potok brook valley, at level 421 m a.s.l. above bed of coarse to blocky epiclastic volcanic conglomerate. Breccia consists dominantly of vesiculated subspheric fragments in diameters from 3–5 cm up to 10 cm and rare blocks up to 20 cm. Vesiculated fragments are red-brown coloured, angular fragments are less frequent. Tuffaceous matrix is rich on pumice. Pyroclastic material is unsorted to weakly sorted and deposited with graded bedding.

Chaotic breccias of pyroclastic flows in the southern part of the Pokoradz Plateau

Deposits of chaotic breccias of pyroclastic flows contribute essentially to building of volcanosedimentary complex. Study of pyroclastic flows give us important informations for reconstructions of volcanic processes and evolution of sedimentary basin related to stratovolcano.

Chaotic breccia of pyroclastic flow – layer-2

Chaotic breccia of pyroclastic flow – ***layer-2*** in the northern area is limited only on the eastern part of the Pokoradz Plateau (Konkova and Bankov vrch). Chaotic breccia – ***layer-2***, continuing to south on top of the plateau, is gradually spread wider and finaly occupies whole area in the uppermost part of the plateau from the western edge to eastern. Base of chaotic breccia of pyroclastic flow of layer-2 in the northern part is about 460 m a.s.l., southward the base moderatelly descends to levels about 450 m a.s.l. (middle part of the plateau) and 440–430 m a.s.l. (southern part of the plateau, the Horné Zahorany village area, profiles ***PF-10*** and ***PF-11***). Chaotic breccia of pyroclastic flow is deposited on the surface of coarse to blocky epiclastic volcanic conglomerate. The bottom of the sedimentary basin on which the pyroclastic flow has deposited was flat and gradually deepening southward. Epiclastic volcanic complex, underlying chaotic breccia of layer-2, in the northern area has several meters, in southern part its thickness rises up to 150 m. It can be deduced that eruption and deposition of pyroclastic flows has occurred in a more advanced stage of evolution of the stratovolcano and the sedimentary basin, too.

Chaotic pyroclastic breccia – layer-2, spreading in the uppermost part of the Pokoradz Plateau, probably consists of succession of several pyroclastic flows, as it is indicated by differences in lithology of individual localities, which are characterized further.

Chaotic breccia – layer-2 on the eastern slope of Prídel (SE of Zahorany village, profile ***PF-12***) follows to eastern edge of the Pokoradz Plateau. In rocky cliff on the eastern side of ridge to SE of the Ping e.p. 489.6, bellow the e.p. 460, the chaotic pyroclastic breccia above the coarse to blocky epiclastic volcanic conglomerate is exposed with base at about 448–450 m a.s.l. (Fig. 18).

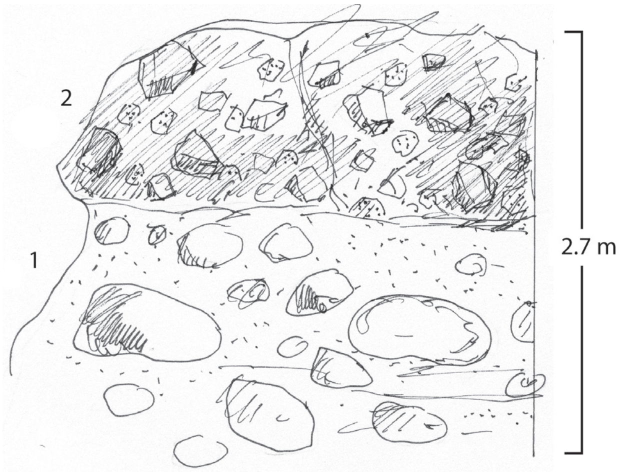


Fig. 18. The coarse to blocky epiclastic volcanic conglomerate (1) is located in the lower part of outcrop. Higher the chaotic breccia follows (2), consisting of 5–20 cm fragments and rare 40–50 cm blocks. Except of dominating fragments and blocks with angular shape, there are also present vesiculated fragments and blocks with subspheric shape.Tuffaceous matrix is strongly welded with small vesiculated fragments, deposition is chaotic without signs of sorting.

Chaotic breccia forms rocky cliffs at the southern part of the plateau south of the Ping e.p. 489.6. Base of chaotic breccia is at the level 448–450 m a.s.l. (Fig. 19).

Higher on the slope at 460 m a.s.l., the chaotic breccia with dominancy of strongly welded tuffaceous matrix (brown-red) is exposed in several outcrops. Breccia represents probably higher flow unit in succesion of pyroclastic flows.

Above chaotic breccia of in the area of summit with the Ping e.p. 489.6, the big rounded blocks with dimensions to 2 x 2 m are present (Fig. 20).

Chaotic breccia is exposed in rocky cliff at the eastern edge of the Cerová flat ridge with e.p. 453 in the eastern side of the Pokoradz Plateau (profile ***PF-13***). Chaotic breccia was deposited on the surface of coarse to blocky conglomerate with the base about 440 m a.s.l. (Fig. 21).

Andesite material belongs to fine porphyric pyroxene andesite. Lithology of breccia is close to breccias of pyroclastic flows generated during collapses of eruptive columns of vulcanian type. Above chaotic breccia in the higher level of Cerová ridge, the bed of coarse to blocky epiclastic volcanic conglomerate is exposed and in the uppermost part of the ridge with elevation points 524.8 and 502 a thick bed of chaotic breccia occurs, corresponding to pyroclastic flows 3 and 4 (***PF-13***) that will be discussed later.

Southern continuation of chaotic breccia was found in an outcrop on the southern slope of the ridge east of e.p. 524.8 Malá Paláska (west of Dražice village). Base of the chaotic breccia is at level 441 m a.s.l. (Fig. 22).

Chaotic breccia in several outcrops follows higher on the southern slope of the ridge of Malá Paláska up to level 450 m a.s.l., where it is exposed in a cliff (Fig. 23).

Chaotic breccia of pyroclastic flow, layer-2, is exposed also in several outcrops at the western edge of the Pokoradz Plateau at the base level at about 445–450 m a.s.l. It is deposited above the bed of coarse to blocky epiclastic volcanic conglomerate.

Fig. 19. Fragments 8–20 cm large and rare blocks up to 0.5 m of the fine porhyric pyroxene andesite form chaotic breccia. They are often extremely vesiculated with subspheric shape. Tuffaceous matrix is intensively welded with smaller vesiculated fragments.

Fig. 20. Textures of paralel lamination in andesite block indicate origin of blocks from the destruction of massive lava bodies (probably lava flow and/or extrusive dome). It is assumed that transport of large blocks over such great distances occurred by the pyroclastic flow and/or lahar.

Fig. 21. Chaotic breccia consists of vesiculated subspheric fragments and blocks large 5–15 cm, rarely up to 30 cm. Fragments with angular shape are less frequent. Tuffaceous matrix is strongly welded, to homogenized, with smaller vesiculated fragments. Dominant matrix forms about 60–65 vol. %.

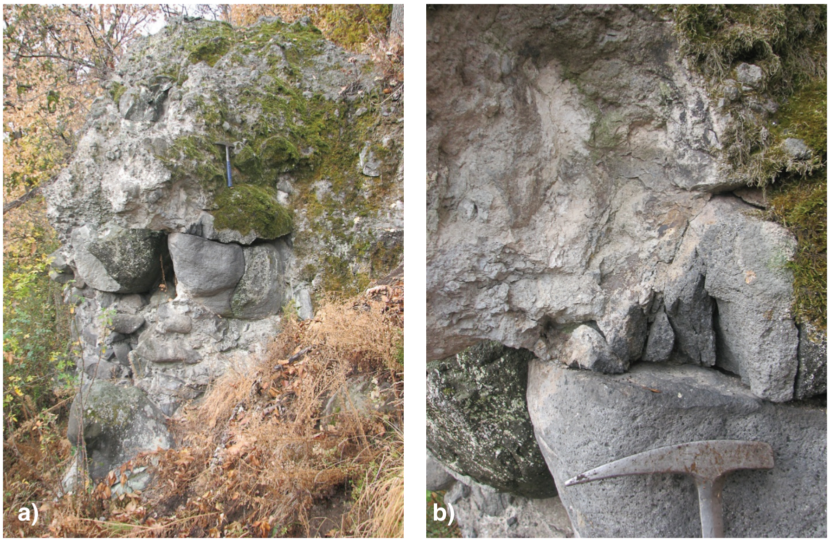


Fig. 22. In rocky cliff the chaotic breccia of pyroclastic flow (scheme c/2) is exposed above coarse to blocky epiclastic volcanic conglomerate (scheme c/1, photo a). Detail of the base of chaotic breccia in contact with underlying conglomerate (photo b). Breccia consists of vesiculated fragments of subspheric shape with dimension 5–25 cm and rarely up to 50 cm. Angular fragments and blocks are less abundant. Several blocks disintegrated along radial and concentric fractures document processes of autoexplosivity and disintegration in hot state during their transport in pyroclastic flow. Tuffaceous matrix is strongly welded.

Fig. 23. Chaotic breccia in rocky cliff (scheme b/2 in photo a) is deposited on bed of the coarse to blocky epiclastic volcanic conglomerate (scheme b/1, photo a). Fragments forming chaotic breccia dominantly with dimensions 5–25 cm, rare blocks up to 50 cm, are subspheric and vesiculated. Angular fragments and blocks are less frequent. Tuffaceous matrix is strongly welded, deposition of material is chaotic. It is not posible to exclude that breccia with the base at level 441 m a.s.l. represents subsided block from the higher level with original base about 450 m a.s.l.

3 – Southern edge of the Pokoradz Plateau, north of Vyšná and Nižná Pokoradz villages (profile PF-15)

Southern border of the Pokoradz Plateau forms an imposant morphogical step in relief, high ca 130–150 m, limiting the southern edge of the plateau against lowland relief of the Rimavská kotlina Basin. In a number of rocky cliffs and walls of abandoned quarries on the southern steep slopes of the plateau, the inner structure and lithology of the sedimentary basin is exposed from the base to top of the volcanosedimentary sequences. Study of these outcrops provided an information about an inner structure of the volcanosedimentary complex and completed the mapping data from the western and eastern slopes, limiting the Pokoradz Plateau. Following description characterizes the inner structure of volcanosedimentary complex on the southern slopes of Pokoradz Plateau in vertical profile from the lower to upper levels:

Lower part of volcanosedimentary complex is formed by a thick lower bed of epiclastic volcanic sandstones between levels 350–440 m a.s.l. (profile ***PF-15***). Epiclastic volcanic sandstones are medium to coarse-grained with frequent intercalations of fine sandstones to siltstones with pumices and thin interbeds of fine to medium conglomerates. Upper part of the lower complex of epiclastic volcanic sandstones is exposed in walls of abandoned quarries at level 438–442 m a.s.l. on southern slopes of Pokoradz Plateau bellow e.p. 526.4 and 524 Stráň (Fig. 24).

In some parts of the quarry wall, in upper part of bodies of non-bedded tuff of hyperconcentrated flow, a gradual transition into a bed of epiclastic volcanic sandstone was observed, manifesting graded bedding, eventually cross-bedding. In deposits of hyperconcentrated flows, the rounded or partly rounded andesite blocks are sporadically present. They were derived from underlying conglomerate bed during the mass flow. Thin interbeds of siltstones, separating bodies of hyperconcentrated flows, represent products of the fine ash-dust material falls from eruptive ash clouds. These siltstone interbeds contain often imprints of leaves and remnants of flora.

Fine to medium epiclastic volcanic conglomerates are often present in the lower complex of epiclastic volcanic sandstones like intercalations, lenses and/or interbeds, as can be seen in walls of abandoned quarries bellow e.p. 526.4 and e.p. Stráň 524 on the S slopes of the Pokoradz Plateau (Fig. 25).

a)

b)

c)

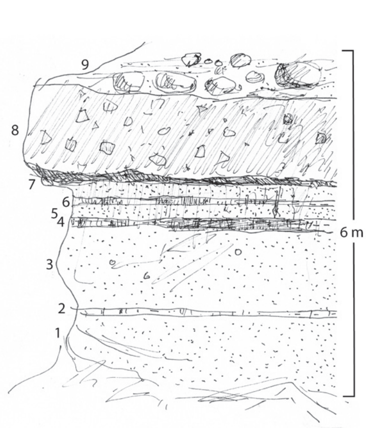


Fig. 24. In a quarry wall at the entrance into artificial cave a following sequence is exposed (scheme c/1–9). In the lower part of the wall a body of non-bedded, medium to coarse epiclastic volcanic sandstone was deposited by hyperconcentrated flow (1). Higher is transition to the fine tuff sandstones and siltstone. Above it, a thicker body of non-bedded sandstone follows again (3), being deposited by hyperconcentrated flows. In the upper part of the body there is gradual transition from the coarse epiclastic volcanic sandstone into thin layer of the fine tuff-sandstone and higher into light grey to yellow siltstone (4). Two layers of non-bedded tuffs of hyperconcentrated flows follow above (5 and 7), being separated by thin layer of siltstone (scheme c/6, photo a). Lower sequence of epiclastic volcanic sandstone is interrupted by the deposition of lahar breccia (scheme c/8, photo b), higher followed by the deposition of coarse to blocky epiclastic volcanic conglomerate (scheme c/9).

a)

b)

c)

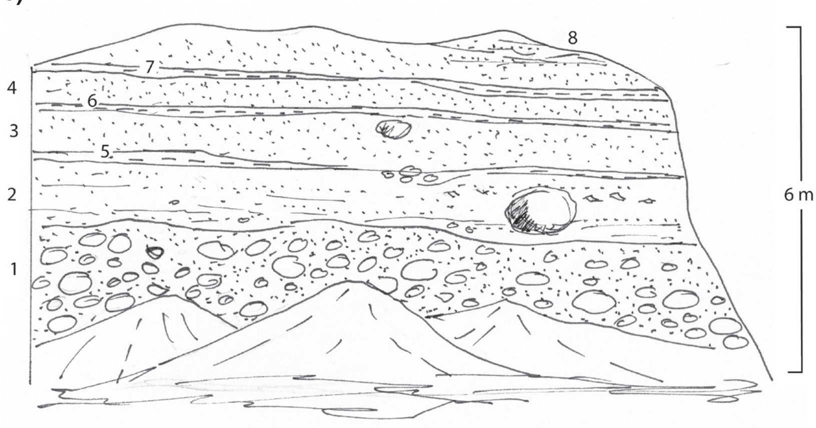
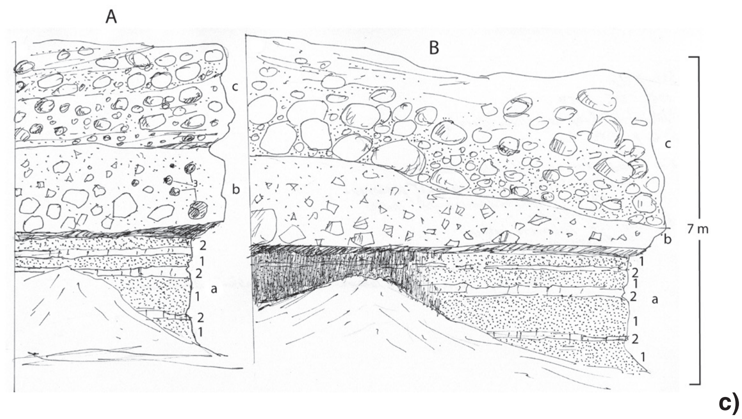


Fig. 25. Into lower part of the quarry wall fine to medium epiclastic volcanic conglomerates often alternate with the bodies deposited by hyperconcentrated flows (scheme c/1–8). Fine to medium epiclastic volcanic conglomerate with pebbles 5–15 cm and rare pebbles of quartz and crystalline rocks is exposed in lower part of outcrop (scheme c/1). Higher the bed of epiclastic volcanic sandstone with graded bedding follows with fragments of pumices and fine conglomerate (scheme c/2, photo a). Isolated rounded andesite block with dimensions about 60 cm derived from conglomerate bed of littoral zone is present too (photo b). In the higher level of the quarry wall three beds of non-bedded epiclastic volcanic sandstone were deposited by the hyperconcentrated flows (scheme c/3, 4 and 8). They are separated by thin layers of epiclastic volcanic siltstones (scheme c/5, 6 and 7). Intercalations and dispersed pumice material in bodies of hyperconcentrated flows document the explosive activity during deposition of lower complex of epiclastic volcanic sandstones.

Above the lower complex of epiclastic volcanic sandstones a *lahar breccia* is exposed in walls of abandoned quarry bellow e.p. 526.4 m at level 440 m a.s.l. Lahar breccia was deposited discordantly with sharp contact of its base on the surface of epiclastic volcanic sandstone. Local erosive structures on the surface of sandstone bed were observed. Deposition of lahar breccia upon epiclastic volcanic sandstones indicates finishing of the lower sequence of epiclastic volcanic sandstones and siltstones (Fig. 26).

Fig. 26. Position of lahar breccia on the surface of the lower epiclastic volcanic sandstones is documented in schemes A and B. Explanations to schemes: a – lower complex of epiclastic volcanic sandstones form bodies of non-bedded epiclastic volcanic sandstone deposited by hyperconcentrated flow (1) alternated with thin layers of siltstones (2). Higher the lahar breccia follows (b), as well as the bed of medium to coarse epiclastic volcanic conglomerate (c). In the lahar breccia the hollows after trees and their branches occur (scheme A/3). Lahar breccia consists of vesiculated fragments of subspheric shape with dimensions 5–25 cm and rare blocks up to 40–60 cm of suboval to subangular shape (photo a and b). Several rounded to subrounded andesite blocks up to 40 cm in diameter come from littoral conglomerate bed crossed by lahars. Sandy-tuffaceous matrix of lahar contains pumice and small angular and subspheric vesiculated andesite fragments in fraction 1–3 cm. Deposition of material is chaotic with tendency of concentration of bigger andesite blocks near the base of lahar body (photo b). Base of the lahar body above sequence of epiclastic volcanic sandstones is sharp and discordant.



Immediatelly below the base of lahar breccia on the contact with underlying epiclastic volcanic sandstone is a thin bed, containing smaller and greater pumice fragments, which indicates that mobilization of lahar and its deposition was preceded by explosive eruption of plinian type, resp. that eruption initiated the lahar movement (Fig. 27).

In the lower part of lahar breccia and its base there occur numerous cavities after trees (Fig. 28). Imprints of trees and their parts are preserved on the ceiling of artificial caves (Fig. 28c). It proves that lahar in its way from stratovolcano slope was moving across a forested area.

Fig. 27. Detail of dispersed partly rounded pumice fragments in epiclastic volcanic sandstones (photo).

Thickness of lahar breccia is variable, reaching max. about 4–5 m. Locally it is strongly reduced by erosion to 1.0–0.5 m. On profile ***PF-15*** the lahar breccia is shifted down along fault to lower position at level 430 m a.s.l. (bellow e.p. 512.7 Kozinec) and further to west to level 420 m a.s.l. (bellow e.p. 470.8 Háj).

Bed of coarse to blocky epiclastic volcanic conglomerate follows above lahar breccia at level 445–448 m a.s.l. Base of conglomerate bed is uneven, conglomerate material often fills erosive channels on the surface of underlying lahar breccia (Fig. 29).

Total thickness of the conglomerate bed is about 20–25 m. Vertically, the conglomerate bed is not uniform. On the southern slope bellow e.p. 524 in rocky cliff the bed of coarse to blocky epiclastic volcanic conglomerate is exposed above the lahar breccia. In upper part of cliff the transition to fine and medium epiclastic volcanic conglomerate occurs (Fig. 30).

Chaotic breccias of pyroclastic flows on the southern edge of the Pokoradz Plateau

Chaotic breccia of pyroclastic flow – layer-2 on the southern slopes of Pokoradz Plateau in supposed level about 440–450 m a.s.l. was not confirmed. Chaotic breccia of pyroclastic flow – layer-2 probably underwent destruction in the southern part of sedimentary basin and became a source of material for conglomerate bed. As we mentioned above, in corresponding level on

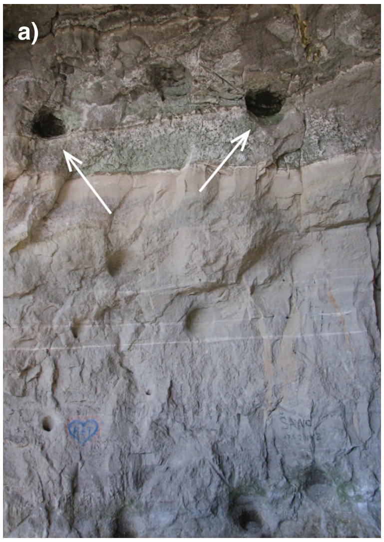


Fig. 28. Hollows after trees (photo a, b) in the lower part of lahar breccia, indicating that lahar in its way has crossed forested area at the southern foot of the stratovolcano. The ceiling of artificial caves contains preserved hollows after imprints of vegetations, leaves and branches of trees (photo c), as well as parts of silicified trees (photo d).

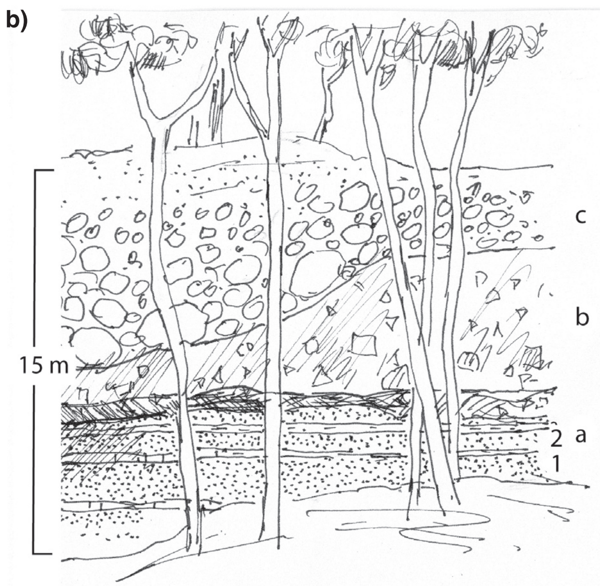


Fig. 29. In the quarry walls on southern slope of the Pokoradz Plateau bellow e.p. 526.6 Stráň the bed of medium to coarse and blocky epiclastic volcanic conglomerate is deposited above lahar breccia. Explanation to scheme b: a – beds of epiclastic volcanic sandstones deposited by hyperconcentrated flows (1, 2) alternating with thin layers of siltstones; b – lahar breccia reduced by erosion; c – bed of epiclastic volcanic conglomerate. Andesite blocks forming conglomerate bed are dominantly of dimensions 10–30 cm, partly rounded to well rounded, rare blocks reach 60–80 cm in diameter (photo a). Matrix is coarse-grained, sandy with fine rounded and subangular fragments. Conglomerate material is sorted with concentration of larger blocks near the base (photo a). Conglomerate material filled the erosive channel on the surface of lahar breccia body (scheme b).

the southern slopes of the Pokoradz Plateau the lahar breccia and thicker bed of coarse to blocky epiclastic volcanic conglomerate are deposited.

Chaotic breccia of pyroclastic flows – layer-3

On the southern slopes of the Pokoradz Plateau the *chaotic breccia of pyroclastic flow* – layer-3 is deposited above the coarse to blocky epiclastic volcanic conglomerate at level 475 m a.s.l. below e.p. 526 Stráň and e.p. 524 (Fig. 31). According to this higher position, the chaotic breccia is named as a ***layer-3***.

Westward the chaotic breccia of pyroclastic flow – layer-3 has deposited above the bed of coarse to blocky epiclastic volcanic conglomerate at level 446 a.s.l. It was found on southern slopes of the Pokoradz Plateau west of e.p. 512.7 Kozinec in partly subsided block (profile ***PF-15***).

Fig. 30. In the rocky cliff on slope below e.p. 524 north of the Vyšná Pokoradz village the conglomerate bed above lahar breccia follows. Explanations to scheme b: lahar breccia (b) is deposited on eroded surface of non-bedded epiclastic volcanic sandstone (a). Sporadic hollows after trees (2) and fragments of silstones (1) are present. Coarse to blocky epiclastic volcanic conglomerate (c) with concentration of greater blocks in lower part forms the upper part of the cliff. Photo a documents situation on scheme b. In following rocky cliff below e.p. 515 (scheme c) the beds of coarse to blocky epiclastic volcanic conglomerate with interbeds of medium to coarse and fine conglomerate alternate with epiclastic volcanic sandstones.

b)

c)

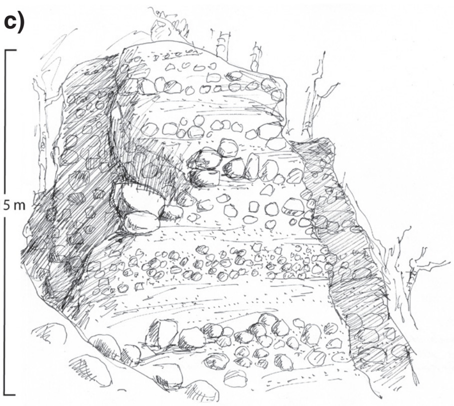
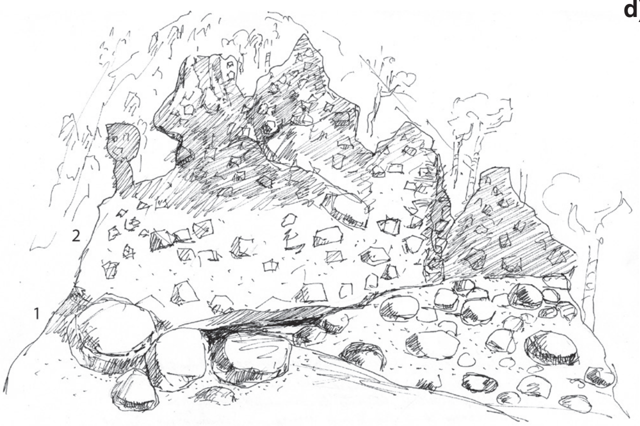


Fig. 31. Chaotic breccia of pyroclastic flow is exposed in rocky cliff bellow e.p. 524 north of the Vyšná Pokoradz village. Chaotic breccia (scheme d/2) is deposited on bed of coarse to blocky epiclastic volcanic conglomerate with rounded blocks of dimensions 20–40 cm up to 60 cm (scheme d/1, photo a). In its lower part the breccia of pyroclastic flow consists dominantly of fragments with angular shape and dimensions 15–30 cm (photo b). Vesiculated fragments with dimensions 10–15 cm of subspheric shape are less frequent. Tuffaceous matrix locally red-brown, strongly welded with small vesiculated fragments represents about 35–40 % of the rock volume. Near the base of the breccia body the tuffaceous matrix dominates above fragments. Larger blocks with dimensions 40 cm up to 1.5 m with angular shape are concentrated in higher level of the chaotic breccia (photo c). Reverse gradation points on efect of kinetic sieving.

d)



At the western edge of Pokoradz Plateau on southern slope of ridge bellow e.p. 470.8 Háj, the outcrop of chaotic breccia of pyroclastic flow is in level 420–430 m a.s.l. Gigantic andesite block with dimensions 4 x 5 x 3 m is exposed bellow the outcrop of chaotic breccia (Fig. 32). Breccia consists dominantly of vesiculated subspheric fragments 5–25 cm large and also of angular fragments up to blocks 40 cm and tuffaceous welded matrix. Chaotic breccia belongs probably to layer-2

Fig. 32. Gigantic andesite block on southern slope of the ridge below e.p. 470.8 Háj. Structure of lamination with parallel jointing observed in large andesite block points to origin of block from extrusive dome and/or lava flow. Large andesite block was transported from stratovolcanic slope probably by the high energy pyroclastic flow.

a)

b)

Fig. 33. Chaotic breccia of pyroclastic flow, exposed in cliff on the western edge of the ridge bellow e.p. 478.9, is formed dominantly of vesiculated fragments of spheroidal shape with dimensions 5–20 cm, angular fragments are subordinate (photo a). Tuffaceous matrix is strongly welded with smaller vesiculated fragments and homogenized (detail in photo b). Lithology of breccia corresponds to pyroclastic flows generated during collapses of eruptive columns of vulcanian type.

Chaotic breccia of pyroclastic flow in higher position on the southern slope of the ridge with e.p. 470.8 at level 460–465 m a.s.l. on the southwestern edge of the Pokoradz Plateau represents a part of extended cover of chaotic breccia of pyroclastic flow (Fig. 33).

Chaotic breccia of pyroclastic flows – layer-4

Chaotic breccia of pyroclastic flows with the base at 494–500 m a.s.l., designated as a layer-4, represents the uppermost unit of the sequence of pyroclastic flows on the southern edge of the Pokoradz Plateau. Chaotic breccia is exposed in a number of outcrops at the southern margin of the plateau with e.p. 512 Kozinec, e.p. 526.4 Stráň, e.p. 524 and cliffs more eastward in the area of e.p. 516 and e.p. 517.4 Veľký vrch.

*Chaotic breccia of pyroclastic flow – **layer-4***, exposed in cliff SE of e.p. Kozinec with the base about 494–495 m a.s.l. lies on bed of coarse to blocky epiclastic volcanic conglomerate (Fig. 34).

Fig. 34. Breccia forming cliff below e.p. 512.7 Kozinec consists dominantly of vesiculated fragments of the fine porphyric pyroxene andesite (±amphibole), subspheric in shape with dimensions 5 to 15 cm, rarely up to 25 cm. Angular fragments are less frequent (10 to 15 %). Tuffaceous matrix, containing pumice, is strongly welded with small vesiculated fragments and homogenized. Matrix related to fragments is dominant and represents about 60 % of volume. Lithological character of the breccia resembles the breccias of pyroclastic flows, generated by collapses of eruptive columns of the vulcanian type.

Next outcrop in cliff to south of e.p. 512.7 Kozinec shows the size differentiation of clastic material (Fig. 35).

Chaotic breccia continues eastward in rocky cliffs at the level 512 m a.s.l. on SE slope bellow e.p. 526.4 Stráň. In outcrops there dominate vesiculated fragments of subspheric shape with dimensions 5–25 cm and rare blocks up to 40 cm. Angular fragments with dimensions 15–30 cm occur in subsidiary amount. Tuffaceous strongly welded matrix predominates above fragments.

In higher positioned outcrop at level 522 m a.s.l. on the southern slope of the Pokoradz Plateau, two beds of chaotic breccia were observed, being separated by thin tuff intercalation (Fig. 36).

Total thickness of chaotic breccia of ***layer-4*** at the southern edge of Pokoradz Plateau in the Stráň summit area of ca 30 m thickness is built-up by several pyroclastic block and ash flows. In the uppermost level of the chaotic breccia of layer-4 there are erosive channels on its surface, being filled by conglomerate material (Fig. 37).

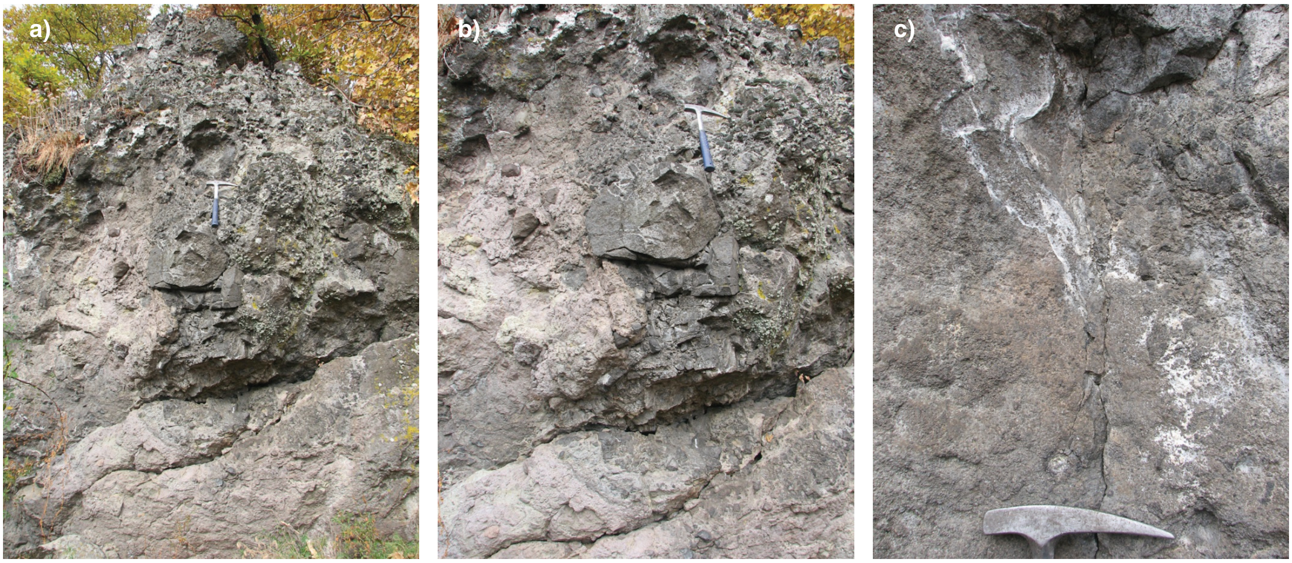


Fig. 35. In the lower part of the cliff below e.p. Kozinec on the southern slope of the Pokoradz Plateau a chaotic breccia of pyroclastic flow is exposed. Strongly welded to homogenized tuffaceous matrix with smaller vesiculated fragments of dimensions 5–8 cm dominates in the lower part of the cliff (photo a). In the upper part of the cliff, the angular fragments and blocks are concentrated, showing reverse gradation (photo a). Several greater blocks show disintegration along radial and concentric fissures into angular fragments dispersed into matrix (photo b). Disintegration of blocks in the hot state has occurred evidently during the transport and deposition of the pyroclastic flow. Andesite fragments belong to fine/medium porphyric pyroxene andesite. The breccia in lower part with more welded and homogenized matrix is penetrated along the net of fissures with subvertical orientation, containing veinlets of secondary minerals (photo c). They represent the pathways of fumarols, ascending after deposition of hot pyroclastic material.

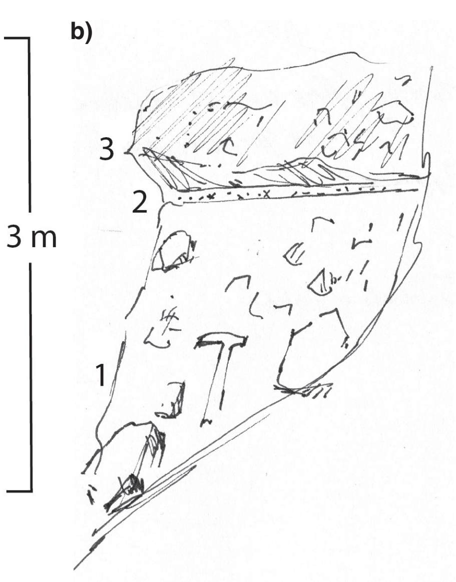


Fig. 36. Chaotic breccia, consisting of vesiculated, subspheric and also angular fragments to blocks up to 35 cm large, is exposed in lower part of outcrop (scheme b/1, photo a). Thin ash-tuff layer (scheme b/2) covers the lower chaotic breccia. Chaotic breccia in the uppermost part of the cliff is formed dominantly of the smaller vesiculated fragments, strongly welded with tuffaceous matrix (scheme b/3). This succession points on fact that chaotic breccia – layer-4 consists of several flow units of pyroclastic flows.

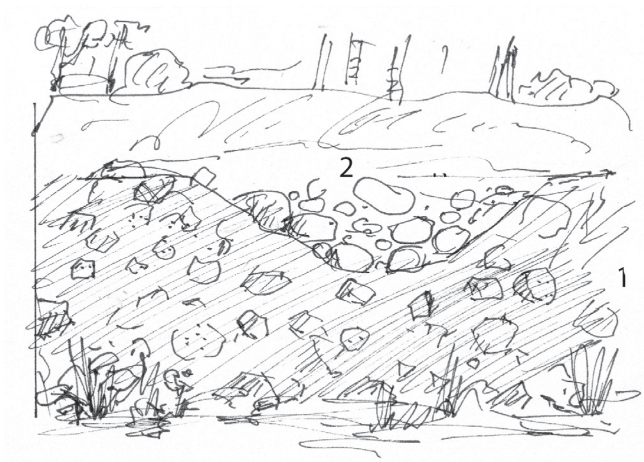
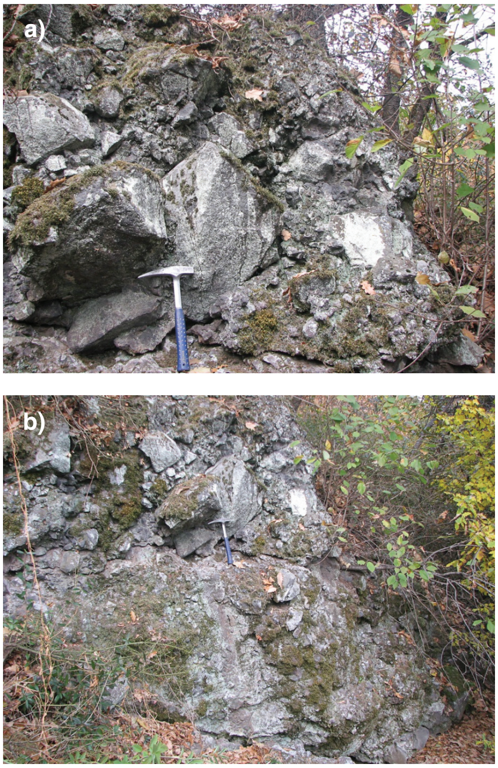


Fig. 37. On the southern slope of the Pokoradz Plateau of the Stráň locality at level 510 m a.s.l., the chaotic breccia of pyroclastic flow is exposed (1 in scheme). Breccia consists dominantly of vesiculated subspheric fragmens large 5–20 cm and rarely by angular blocks of dimensions up to 30 cm. On the surface of chaotic breccia, the erosive channel is filled by the coarse conglomerate material (2 in scheme). The erosive channel on the surface of chaotic breccia of the layer-4 documents continuing processes of erosion and destruction of chaotic breccia in the littoral zone occurring immediately after deposition of pyroclastic flow.

Chaotic breccia of ***layer-4*** above coarse to blocky epiclastic volcanic conglomerate at level 505–508 m a.s.l. is exposed on eastern edge of the Pokoradz Plateau in rocky cliff bellow e.p. 515 (Fig. 38).



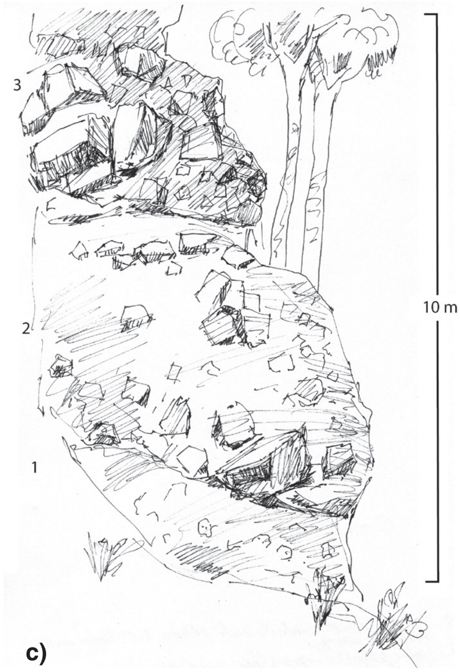


Fig. 38. In the lower part of the cliff, the chaotic breccia consists dominantly of strongly welded tuffaceous matrix with small vesiculated fragments (scheme c/1, photo b below hammer). Besides the vesiculated subspheric fragments, also small angular fragments are present in smaller amount. Higher in the middle part of the cliff, the chaotic breccia contains dominantly angular to subangular fragments large 15–20 cm and rarely up to 30–40 cm (scheme c/2, photo b above hammer). Coarser blocks are concentrated in lower and also upper parts of this bed. Tuffaceous strongly welded matrix with small vesiculated fragments forms about 50–60 vol. %. In the uppermost part of the cliff, the angular fragments up to blocks with dimensions 40–60 cm are dominant with signs of disintegration and splittering (scheme c/3, photo a). Matrix represents small portion – about 10–15 vol. %. In vertical direction the reverse gradation in distribution of fragments and blocks in the cliff can be observed, which indicates process of kinetic sieving during the movement of pyroclastic flow. Lithological character of described type of chaotic breccia corresponds to Merapi type pyroclastic flow, being generated by collapses and explosive destruction of extrusive domes.

Results of study of chaotic breccia – layer-4 can be summarized as a follows:

Chaotic breccia of layer-4, being deposited on coarse to blocky epiclastic volcanic conglomerate at level 495–500 m a.s.l. on the southern edge of Pokoradz Plateau, represents the uppermost member of succession of pyroclastic flows and also the uppermost preserved member of lithofacial complex of the Vyšná Pokoradz Formation. Chaotic breccia with ca 30 m maximum thickness is not uniform. In its structure and total thickness there participate several lithologically and structurally differing pyroclastic flows. During their deposition an extended flat relief in the sedimentary basin has originated, which consequently led to end of sedimentation in the western part of sedimentary basin. Lake sedimentation has shifted probably more southward, which is indicated by the erosive channels on the surface of chaotic breccia of layer-4 at the southern edge of the Pokoradz Plateau. That assumption is supported by findings of relics of epiclastic volcanic sandstones with intercalations of siltstones and fine conglomerate, cropping out near Šafarikovo town at the distance about 13 km to the southeast from present southern denudation edge of the Pokoradz Plateau.

B – Structure and lithology of the eastern volcanosedimentary complex of the Blh Plateau

The Blh Plateau represents isolated relic of volcanosedimentary complex of the Vyšná Pokoradz Formation, located east of the Blh brook valley. Despite the volcaniclastic material was transported and deposited in one sedimentary basin, there are some differences in lithology and facies succession of volcanosedimentary complexes between the Pokoradz Plateau and Blh Plateau. This is the reason, why structures and lithology of volcanic and volcanosedimentary facies of both plateaus are characterized separately.

Thickness of the volcanosedimentary complex at the northern edge of the Blh Plateau is about 60–70 m, locally up to 100 m (summit with e.p. 487.5 Turecký vrch). Southward the thickness of volcanosedimentary complex moderately increases to about 100 to 120 m. The base of volcanosedimentary complex at the northern and southern edges of the Blh Plateau is located nearly in the same altitude – about 385–390 m a.s.l. At its eastern edge, the volcanosedimentary complex is divided on individual blocks by several faults and its base due to their tectonic subsidence is in lower position – app. 350–360 m a.s.l. The basement of volcanosedimentary complex at the northern edge of the Blh Plateau is formed by Mesozoic rocks. Southward in the sedimentary basin, the Mesozoic rocks are alternated by Lower Miocene (Egerian) sediments. Morphologically the Blh Plateau is divided to northern and southern segments.

Details of geological setting are shown in geological-lithofacial map of the Blh Plateau (Appendix 1C, D) and on series of profiles ***B-1*** to ***B-9*** oriented W – E (Appendix 2B).

Northern segment of the Blh Plateau

Northern segment of the Blh Plateau forms distinct morphological unit, trending NW–SE, rising above lowland of the Rimava Basin by 200–250 m. In the northern part of the plateau, the relief reaches maximum level about 487 m a.s.l. At the southern edge of the plateau the relief slightly descends to 460 m a.s.l. Structure and lithology of volcanosedimentary complex, building the Blh Plateau, is documented by geological-lithological map and profiles. Special attention was devoted to characteristics of pyroclastic flows.

1 – Northern part of the area (profiles B-1 to B-3, Appendix 2B)

North of volcanosedimentary complex of the Blh Plateau, a system of paleovalleys on the southern slopes of the Slovenské rudohorie Mts. (described earlier) was used as pathways for the transport of volcaniclastic material into the sedimentary basin located south. Isolated Viničný vrch Hill, e.p. 467.1, located northward of the Blh Plateau, represents transition from the paleovalley into southern sedimentary basin. On the southern slope of the Viničný vrch Hill in wall of abandoned quarry at level 388 m a.s.l. a bed of epiclastic volcanic sandstones contains intercalations and thin interbeds of siltstones and vitrocrystal tuff with signs of deposition in shallow lake environment.

Volcanosedimentary complex at the NW edge of the Blh Plateau is underlied by Mesozoic rocks and in E part by the Lower Miocene sediments (profile ***B-1***).

On the western edge of the Blh Plateau, the *basal bed of tuffitic sands with gravels of volcanic and non-volcanic rocks,* thick about 5 m, is deposited on Mesozoic rocks at level about 385 m a.s.l. In its upper part at level 390 a.s.l., the basal bed gradually passes into the bed of *epiclastic volcanic sandstones,* thick about 10 m. Epiclastic volcanic sandstones often contain pumices and intercalations of fine andesite conglomerates. Except the cross bedded and normal bedded epiclastic volcanic sandstones, the non-bedded bodies of epiclastic volcanic sandstones are identified as deposits of hyperconcentrated flows. Bodies of hyperconcentrated flows often contain dispersed fragments of andesites and siltstones. In the eastern part of the volcanosedimentary complex, the transition from the upper part of epiclastic volcanic sandstones into the bed of *fine to medium epiclastic volcanic conglomerate* with rounded andesite material in fraction 5–20 cm was found west of the Španie Pole village.

On the western slope of the Blh Plateau on the ridge with e.p. 450 Päť chotárov (profile ***B-1***), the bed of *coarse to blocky epiclastic volcanic conglomerate,* thick app. 10 m, follows above epiclastic volcanic sandstone at the level 400 m a.s.l. The *chaotic breccia of pyroclastic flow* in thickness about 20 m is deposited with base at 410 m a.s.l. above coarse to blocky epiclastic volcanic conglomerate. Chaotic breccia according to its position corresponds to *pyroclastic flow* – ***layer-2*.** Higher from the level 430 m a.s.l. up to level 440 m a.s.l., the *coarse to blocky epiclastic volcanic conglomerate* follows. Vertically and laterally the coarse to blocky epiclastic volcanic conglomerate pass into *medium to coarse epiclastic volcanic conglomerate*. The next thick bed of *chaotic breccia of pyroclastic flow* with base at level 440 m a.s.l extends into an area of the summit e.p. 450 Päť chotárov and on the summit with e.p. 469. According to its position, chaotic breccia corresponds to *pyroclastic flow* – ***layer-3*.** Chaotic breccia of pyroclastic flow – layer-3 is exposed in cliff below the e.p. 469 (Fig. 39).

Southward (profile ***B-2***) due to the gradual deepening of sedimentary basin, the *basal bed of tuffitic sands with gravels of volcanic and non-volcanic rocks* descends to the level 355 m a.s.l. on the western slope of the plateau. At the eastern edge of the plateau, the basal bed is lower at level 325 m a.s.l. (profile ***B-2***). On the western slope from the level 366 to level 380 m a.s.l. a thick bed of *epiclastic volcanic sandstone* follows with a higher content of pumice. Higher above the bed of epiclastic volcanic sandstone a *coarse to blocky epiclastic volcanic conglomerate* is deposited between 380–400 m a.s.l.

Chaotic breccia of pyroclastic flow with thickness about 25 m, follows at level 400 m a.s.l. above coarse to blocky epiclastic volcanic conglomerate on the western slope of the Blh Plateau. Chaotic pyroclastic breccia corresponds according to its position at level 400 m a.s.l. to ***layer-2***, exposed in rocky cliff on the western slope below e.p. 487.5 Turecký vrch (Fig. 40).

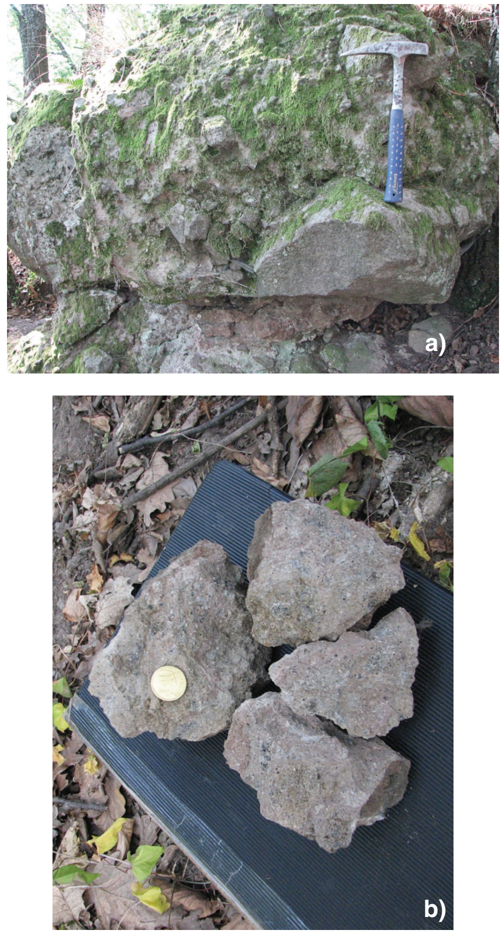


Fig. 39. Chaotic breccia of layer-3 is exposed on the northern slope of the ridge with e.p. 464 west of the Španie pole village. Breccia consists dominantly of vesiculated fragments with subspheric shape large 5–25 cm and rare 30–60 cm angular blocks (photo a). Angular fragments and blocks are less frequent. Tuffaceous matrix strongly welded with small vesiculated fragments (photo b) forms about 60 vol. %.

Continuation of chaotic breccia in that level to south in deeper part of the basin finishes at a short distance. In higher level on the western slope of plateau from 425 m up to 440 m a.s.l., the *coarse to blocky epiclastic volcanic conglomerate* with rounded andesite blocks up to 30–40 cm follows.

On the western slope of e.p. 487.5 Turecký vrch the *chaotic breccia of pyroclastic flow* follows at level 440 a.s.l. Breccia represents continuation of pyroclastic flow from the northern area on summit e.p. 450 Päť chotárov and summit with e.p. 460 (profile ***B-2***). Breccia consists dominantly of vesiculated 2–20 cm fragments and strongly welded matrix. In the uppermost part of the hill with e.p. 487.5 Turecký vrch the angular and rounded andesite blocks in stony debris probably indicate a presence of *coarse to blocky epiclastic volcanic breccia-conglomerate* produced by the destruction of underlying chaotic breccia of pyroclastic flow.

On the eastern slopes of the Blh Plateau similar situation as on the western slope can be observed (profile ***B-2***). Basal bed of *tuffitic sands with gravels of volcanic and non-volcanic* rocks descends to level 350 m a.s.l. (bellow e.p. 436) and further to east to

Fig. 40. In the rocky cliff on the southern slope of the Päť chrbátov hill west of Španie pole village, the chaotic pyroclastic breccia is exposed. In the lower part of the cliff the breccia is formed by dominant vesiculated andesite fragments of subspheric shape large 5–15 cm, blocks up to 30 cm are rare (photo a). In the higher part of the cliff, the angular fragments and blocks large up to 40–60 cm are more frequent with signs of reverse gradation (scheme b). Tuffaceous matrix of red-brown colour is strongly welded with small vesiculated fragments.

the level 325 m a.s.l. Above basal bed of tuffitic sands the bed of *epiclastic volcanic sandstones* follows in thickness about 15 m. Bed of *medium to coarse epiclastic volcanic conglomerate* crops out above epiclastic volcanic sandstone from 340 m up to 375 m a.s.l. Conglomerate beds alternate with thinner layers of epiclastic volcanic sandstones.

On the eastern slopes of the Blh Plateau greater blocks and outcrops of *chaotic breccia* of pyroclastic flows are exposed at level 375–377 m a.s.l. According to the lowest position above sea the breccia represents probably ***layer-1***.

On the eastern slope of the Blh Plateau the outcrops and scattered blocks of *coarse to blocky epiclastic volcanic conglomerate* follow between levels 380–400 m a.s.l. Above conglomerate bed, the chaotic breccia of pyroclastic flow is exposed at the level 400 m a.s.l. on the northern slope below e.p. 432 Konečný vrch in several rocky cliffs (Fig. 41).

On the northern slope below e.p. 436 (east of Turecký vrch Hill and south of the Španie pole village), above thick conglomerate bed, the bed the *upper chaotic breccia of pyroclastic flow is exposed* at level 440 m a.s.l. in several cliffs (Fig. 42).

Further changes in structure and lithology of volcanosedimentary complex southward are document by profile ***B-3***. On the western slope of the Blh Plateau in the structure of volcanosedimentary complex there dominate facies of *coarse to blocky epiclastic volcanic conglomerates* alternating with beds of epiclastic volcanic sandstones. The presence of chaotic breccias of the layer-1 and layer-2 was not identified, except of the chaotic breccia of layer-3 in the uppermost part of the lithological sequence.

Volcanosedimentary succession is characterized in more details on the southern slope of the Veľká Lysá ridge situated north of the Hostišovce village. Basal bed of *tuffitic sands with gravels of volcanic and non-volcanic rocks* thick about 5 m is deposited in 348 m a.s.l. on the surface of the Lower Miocene sediments (profile ***B-3***). Above the basal sediments the beds of *lower epiclastic volcanic sandstones and tuff-sandstones* (often with intercalations of siltstones and fine conglomerates) follow up to level 367 m a.s.l. (Fig. 43).

On the western slope of the Blh Plateau a thick overlying complex of *coarse to blocky epiclastic volcanic conglomerates* follows above lower epiclastic sandstones and tuff-sandstones alternating with layers of epiclastic volcanic sandstones up to level 445 a.s.l. (profile ***B-3***). During geological mapping 4 distinct beds of coarse to blocky epiclastic volcanic conglomerate were identified.

Conglomerate beds with partly rounded to well rounded andesite blocks with dimensions up to 40–60 cm (rare up to 80 cm) form subhorizontal beds thick 5–20 m. They often contain intercalations and thin beds of epiclastic sandstones and/or they alternate with thin interbeds of fine to medium epiclastic volcanic conglomerates (Fig. 44).

Beds of coarse to blocky epiclastic volcanic conglomerates are separated and/or alternate with beds of epiclastic volcanic sandstones of variable thickness from 5 m up to 25 m (Fig. 45 – a).

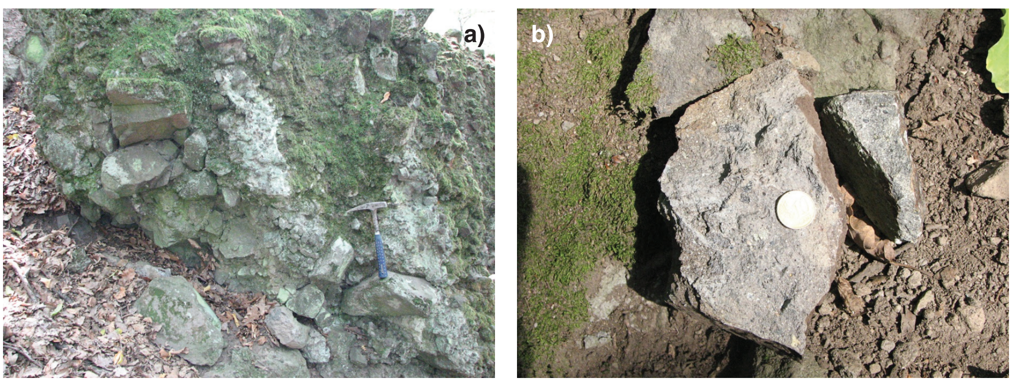


Fig. 41. Chaotic breccia of pyroclastic flow exposed in cliff below e.p. 432 at level 400 m a.s.l. In the lower part of the cliff, the vesiculated fragments large 5–25 cm, rare up to 40 cm with subspheric shape are dominant, the angular fragments and blocks large up to 20–30 cm are less frequent (photo a). Tuffaceous matrix of red-brown colour is strongly welded with vesiculated fragments and homogenized (photo b). In the higher level of the cliff the content of angular fragments and blocks is gradually increasing with the signs of reverse gradation. Breccia corresponds to layer-2. Thickness of chaotic breccia is about 25 m. Above chaotic breccia of pyroclastic flow a bed of coarse to blocky epiclastic volcanic breccia follows in thickness about 15 m up to level 440 m a.s.l.

Fig. 42. In rocky cliff at the northern edge of the ridge with e.p. 436 south of the Španie pole village the chaotic breccia of pyroclastic flow is exposed in ca 15 m height (photo a). Chaotic breccia in the lower part of the cliff consists dominantly of subspheric vesiculated 5–25 cm fragments, smaler angular 5–10 cm fragments are less frequent (scheme d/1, photo b, lower part). Tuffaceous matrix is strongly welded with small vesiculated fragments and locally it is homogenized (photo c). Upper part of the cliff bears a higher concentration of larger fragments and blocks (scheme c/2, photo b, upper part), corresponding to reverse gradation of clastic material during movement of pyroclastic flow immediately before its sudden deposition (effect of negative kinetic sieving). Several blocks show disintegration according to radial and concentric fissures into angular fragments. This indicates processes of autoexplosivity in hot stage during movement in pyroclastic flow. In the lower part of strongly welded breccia, the light veinlets of secondary minerals penetrate along fissures with subvertical orientation and they also cover the inner cavities (photo c). They represent the ways of fumaroles ascending after deposition of hot pyroclastic material.

Epiclastic volcanic sandstones are sorted with normal and reverse gradation and cross-bedding. Often intercalations of fine conglomerates are present, too. In higher levels of volcanosedimentary sequence, the epiclastic volcanic sandstones contain intercalations and thin layers of siltstones and fine tuffs with pumice thick about 1–4 cm (Fig. 45 – b, c). Presence of pumice indicates actual explosive activity of plinian type during their deposition.

Lithological sequence on the western slope of Blh Plateau finishes with deposition of *chaotic breccia of pyroclastic flow* at level 445 m a.s.l. Breccia lying on coarse to blocky epiclastic volcanic conglomerate consists dominantly of vesiculated fragments of subspheric shape with dimensions 5–15 cm and angular 10–30 cm fragments, as well as the rare blocks large up to 1.5 m. Tuffaceous matrix is strongly welded with small vesiculated fragments.

Facial succession on the eastern slopes of the Blh Plateau (eastern part of profile ***B-3***) is very different comparing its western side. In lithological succession on eastern slopes 3 beds of chaotic breccias of pyroclastic flows were identified (profile ***B-3***).

On the eastern slope of the Blh Plateau the following succession in vertical profile was identified. Basal bed of *tuffitic sands with gravels of volcanic and non-volcanic rocks* with base about 330 m a.s.l. passes in upper part into bed of *epiclastic volcanic sandstones* and higher up to *medium to coarse epiclastic volcanic conglomerates* with rounded blocks large up to 25–30 cm.

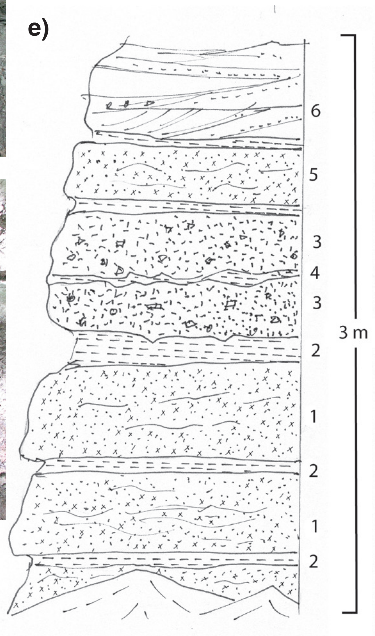
Chaotic breccia of pyroclastic flow lies on conglomerate at the level 355 m a.s.l. Breccia exposed in rocky cliffs follows higher up to level 371 m a.s.l. (thickness of breccia is about 16 m). Breccia consists of vesiculated fragments of subspheric shape with dimensions 5–10 cm, and rare blocks large up to 25 cm. Angular fragments large up to 30 cm and sporadically up to 60–80 cm are present too. Tuffaceous matrix welded with small vesiculated fragments is characteristic with a higher content of small angular fragments. Above chaotic breccia a *medium to coarse epiclastic volcanic conglomerate* with rounded andesite blocks up to 20–30 cm large and in thickness about 29 m follows up to level 400 m a.s.l. This breccia corresponds probably to ***layer-1***.

Chaotic pyroclastic breccia of pyroclastic flow in higher position on the eastern slope of the Blh Plateau at level 400 m a.s.l., probably corresponding to ***layer-2***, has deposited on bed of *medium to coarse epiclastic volcanic conglomerate*. Breccia is exposed in several outcrops and cliffs (Fig. 46a, b, c).

Chaotic breccia in the upper part of cliff is interpreted as upper, light part of pyroclastic flow (richer in tuff-pumice component), which was separated during movement of pyroclastic flow from lower denser and heavier part of flow with content of fragments and blocks of greater dimensions. Lower part of pyroclastic flow is braked by contact with the basement rocks and due to fricton and collisions was laid down sooner than the upper more mobile part of the flow. Higher above the chaotic breccia of pyroclastic flow a *coarse to blocky epiclastic volcanic conglomerate* (with rounded andesite blocks large up to 40–60 cm) follows on the eastern slope of the Blh Plateau up to level 437–440 m a.s.l.

Third layer of *chaotic breccia of pyroclastic flow* overlies a bed of *coarse to blocky epiclastic volcanic* – ***layer-3*** *conglomerate* at level 440 m a.s.l. at the eastern edge of the Blh Plateau. Chaotic breccia represents the uppermost member of the lithological succesion and covers summit area of the Konečný vrch ridge and summit area of e.p. 470.1, and also extends on top of flat relief of the Blh Plateau from the eastern to western edges. We suppose that in total thickness about 30 m of chaotic breccia, several py-

Fig. 43. Lower complex of epiclastic volcanic sandstones is exposed on the southern slope of Veľká Lysá at level 358 m a.s.l. (scheme e). In lower part of outcrop there are three beds of fine ash tuffs and vitrocrystal tuffs with signs of graded



bedding structures (scheme e/1), alternating with thin interbeds of yellow-ochre siltstones (scheme e/2). Ash tuff and vitrocrystal tuff represent partly reworked fallen tuffs from ash volcanic cloud (photo a and b). Thin siltstone beds come from the dust ash fine material, sedimented in lake environment (scheme e/2). Higher in succession, two bodies of non-bedded epiclastic volcanic sandstone follow (scheme e/3) with dispersed fragments of siltstones and andesites, laid down by hyperconcentrated flows (photo c, above hammer). Between two bodies of non-bedded epiclastic volcanic sandstones thin bed of siltstone (scheme e/4) with deformation structure is present. Higher above in succession there follows a bed of fine tuff (scheme e/5). In the uppermost part of outcrop the epiclastic volcanic sandstone with cross-bedded structures, accentuated by beds of fine conglomerate can be seen (photo d, scheme e/6).

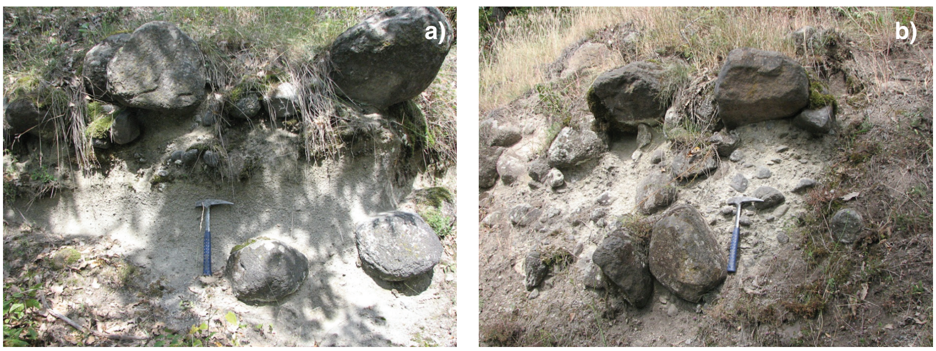


Fig. 44. On the southern slope of Veľká Lysá at level 367 m a.s.l. coarse to blocky conglomerate alternate with thin bed of epiclastic volcanic sandstone (photo a). Higher on the slope of Veľká Lysá at level 377 m a.s.l., the coarse to blocky conglomerates alternate with the fine to medium epiclastic volcanic conglomerate (photo b).

Fig. 45. On southern slope of Veľká Lysá ridge at level 415 m a.s.l. the bed of epiclastic volcanic sandstone with dispersed pumice and intercalations of siltstones is exposed (photo a). Bed of epiclastic volcanic sandstone is partly eroded in the uppermost part during deposition of the overlying conglomerate bed. In photo b there is detail of dispersed pumice fragments, partly rounded in epiclastic volcanic sandstone.

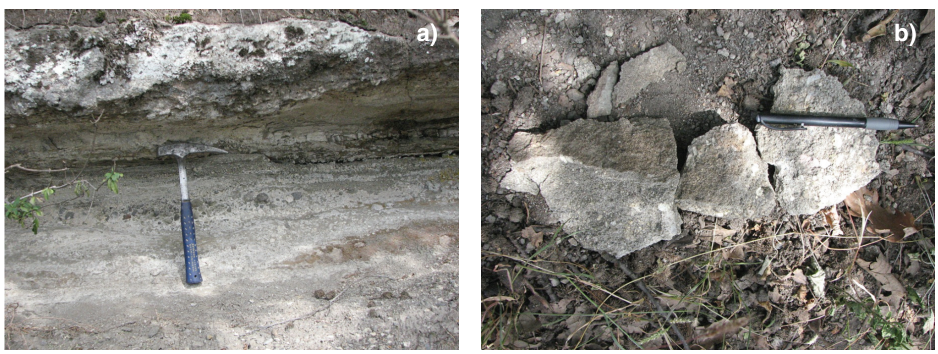


Fig. 46. Chaotic breccia exposed in cliff below the Konečný vrch Hill at level 405 m a.s.l. is formed dominantly of vesiculated subspheric fragments with dimensions 5–20 cm (scheme c/1). Angular fragments up to 30 cm and rare blocks up to 1.5 m are less frequent and they are concentrated dominantly in the lower part of the cliff. Tuffaceous matrix, strongly welded with small vesiculated fragments (photo b), is locally rich on pumice 0.5–1 cm fragments. Matrix forms app. 40–45 vol. %. In the upper part of the cliff the small vesiculated fragments with dimensions 3–5 cm, rare up to 10 cm are dominant (scheme c/2, photo a). Tuffaceous matrix in the upper part of cliff shows low degree of welding and/or is not welded, containing small dark vesiculated andesite fragments and higher content of pumice.

roclastic flows, resp. flow units have contributed. Chaotic breccia of pyroclastic flow – ***layer-3*** consists of vesiculated fragments of subspheric shape with dimensions 3–10 cm, the angular fragments with dimensions 15–30 cm up to 1–1.5 m are less frequent. Tuffaceous matrix is welded with smaller vesiculated fragments, deposition of material is chaotic.

Facial differences between western and eastern slopes of the Blh Plateau along transversal profile ***B-3*** are summarized as follows. While on the western slope only one bed of pyroclastic flow is present (the uppermost ***layer-3*** with base at 445 m a.s.l.), on the eastern slopes of the Blh Plateau there are except of uppermost bed identified two beds of chaotic breccia in the lower level of lithological sequence. On the western slope at corresponding levels the beds of coarse to blocky conglomerate are developed, which material is probably partly comming from the destruction of preceeding chaotic breccias of pyroclastic flows. Western area of sedimentary basin represents relativelly shallower part of basin, more favourable for development of conglomerate facies, while the eastern relativelly deeper part of the basin was preferred during transport of pyroclastic flows.

2 – Southern part of the area (profiles B-4 to B-7, Appendix 2B)

Southern part of the northern segment of the Blh Plateau area becomes gradually narrower, trending to the southern edge with transition to ridge with e.p. 457 Jablonka.

Lithological succesion on the western slopes of the Blh Plateau in the southern part of the area (profile ***B-4***) is similar as in the case of profile ***B-3***. Basal bed of *tuffitic sands with gravels of volcanic and non-volcanic rocks* (with the base at level 345 m a.s.l. and thickness about 3 m) passes gradually in the upper part into lower bed of *epiclastic volcanic sandstones* with thickness about 30 m. Higher from the level 378 m a.s.l. up to level 450 m a.s.l. a thick complex of *coarse to blocky epiclastic volcanic conglomerates* follows (4 beds) with rounded blocks 30–40 cm up to 90 cm, alternating with interbeds of *epiclastic volcanic sandstones*. At the level 433 a.s.l. in the bed of coarse to blocky conglomerate the big blocks with dimensions 2 x 3 m are present.

Chaotic breccia of pyroclastic flow in the uppermost part of vertical lithological succession at level 450 m a.s.l. represents continuation of layer of chaotic breccia from the summit part of the Veľká Lysá Hill (north of Hostišovce village) and shows similar lithological character. Vesiculated fragments with subspheric shape are in dimensions 5–25 cm, angular fragments with greater dimensions up to 30–60 cm are also present. Tuffaceous matrix is welded with small vesiculated fragments. That layer of chaotic breccia, building flat top of the Blh Plateau, continues to its southern edge.

Continuing to south in the southern part of the Blh Plateau a similar succession was identified on the western slope of the plateau (profiles ***B-5*** and ***B-6***). Above basal bed of *tuffitic sands with gravels of volcanic and non-volcanic rocks* and above *bed of epiclastic volcanic sandstones* a thick complex of *coarse to blocky epiclastic volcanic conglomerate* follows (4 beds), alternating with layers of *epiclastic volcanic sandstones*. Southward the facies on western slopes are disturbed by extended slides of rocks masses to such a measure that identification of their original position is almost impossible.

Eastern slopes of the Blh Plateau are similarly modified by huge slides of rock masses. Chaotic breccia of pyroclastic flow with the base at about 350–355 m a.s.l. were revealed northward (profile ***B-3***), its continuation to south was confirmed also in profile ***B-4***. Higher above the bed of chaotic breccia of pyroclastic flow, two beds of *coarse to blocky epiclastic volcanic conglomerate* follow, alternating with layers of *epiclastic volcanic sandstone*. Uppermost member of the succession represents *chaotic breccia of pyroclastic flow* with the base at level about 405 m a.s.l.

Southward the eastern slopes of the Blh Plateau are strongly disturbed by rock slides (see geological-lithological map and profiles ***B-4***, ***B-5***, ***B-6***) and the identification of primary position of facies is in some cases problematic.

Chaotic breccia of pyroclastic flow above conglomerate bed is exposed in cliffs on the eastern slope of the Podpolom ridge with a base located at about 400 m a.s.l. (***B-5***). Chaotic breccia consists of vesiculated smaller fragments and angular fragments to blocks up to 30–60 cm large. Tuffaceous matrix is welded with small vesiculated fragments.

Continuing to south (***B-6***) on the western slope of the Blh Plateau three beds of *coarse to blocky epiclastic volcanic conglomerate* alternate with *epiclastic volcanic sandstones* and within a bed of *epiclastic volcanic breccia* they were also identified. Higher above them the *chaotic breccia of pyroclastic flow* with the base about 430 m a.s.l. is exposed in the summit area of e.p. 482.5 Strmý breh in several cliffs and scattered blocks. Breccia consists of vesiculated fragments of subspheric shape with dimensions 5–15 cm and angular 5–20 cm fragments, which dominate. Tuffaceous matrix is strongly welded with small vesiculated fragments and homogenized. Chaotic breccia follows to eastern edge of the Blh Plateau (e.p. 475.6 Vysoká), where its base occurs above coarse to blocky epiclastic volcanic conglomerate in the level 425 m a.s.l.

Below the base of chaotic breccia on the western slope of the Strmý breh summit in outcrops along the road cut, the specific type of breccia is exposed at level 425 m a.s.l. Breccia consists of small strongly vesiculated pumiceous fragments and ash-pumice matrix. Chaotic breccia represents deposits of ash pumice flow preceding the block and ash pyroclastic flow.

Along the southernmost transversal W–E trending profile ***B-7,*** crossing the e.p. 457 of the Jablonka ridge, the extended rock slides disturbed the facial succession on both western and eastern slopes. At level 400–410 a.s.l. a *bed of epiclastic volcanic sandstones* is exposed. Higher the *coarse to blocky epiclastic volcanic conglomerate is present* with overlying *chaotic breccia of pyroclastic flow,* exposed at the level 425–427 a.s.l. in cliff on southern slope of the ridge with e.p. 458 (Fig. 47).

On the southern slope of the ridge with e.p. 457 Jablonka, the sequence of *epiclastic volcanic sandstone* (with content of pumice) and *coarse to blocky epiclastic volcanic conglomerate* in the upper part is exposed between levels 360-425 m a.s.l. The *lahar breccia* with angular to subangular fragments with dimensions 5–20 cm and rare blocks up to 30–40 cm and sandy matrix follows above the *coarse to blocky epiclastic volcanic conglomerate*.

On the summit area of the ridge at level 442 m a.s.l., the *chaotic breccia of pyroclastic flow* (Fig. 48) is exposed above bed of coarse to blocky epiclastic volcanic conglomerate.

The chaotic breccia, building summit area of the Blh Plateau and southern ridge, consists evidently of a several pyroclastic flows of different lithology and probably also different origin.

Southern segment of the Blh Plateau

1 – Southern area of the Blh Plateau (profiles B-8 to B-10, Appendix 2B)

Southern segment of the Blh Plateau, situated NE of the Teplý vrch village, is roughly of triangle shape. At its NW edge a narrow ridge trending NW–SE with e.p. 457.8 Hradište is present. The southeastern edge of the plateau is divided by deep erosive valleys into several NW–SE trending ridges. From the west to east they are as follows: 1 – ridge with e.p. 499.2 Dlhý vrch, 2 – ridge with e.p. 495 Deravá skala and 3 – ridge with e.p. 741. Steep slopes limiting margins of the Blh Plateau are modified by large to enormous slides of volcanic rocks due their instability above Lower Miocene sediments. Larger part of the plateau represents a reservation of red deer.

Structure and lithology at the northern edge of southern segment documents western part of transversal profile ***B-7***, which begins on western slope of the plateau and eastward it is crossing summit with e.p. 457.3 Hradište, and next summits with elevation points 540, 457.6 and 481.5 Dlhý vrch, continuing to east through the Žiha valley. The eastern final part of the profile, crossing the ridge with e.p. 457 Jablonka, was already commented.

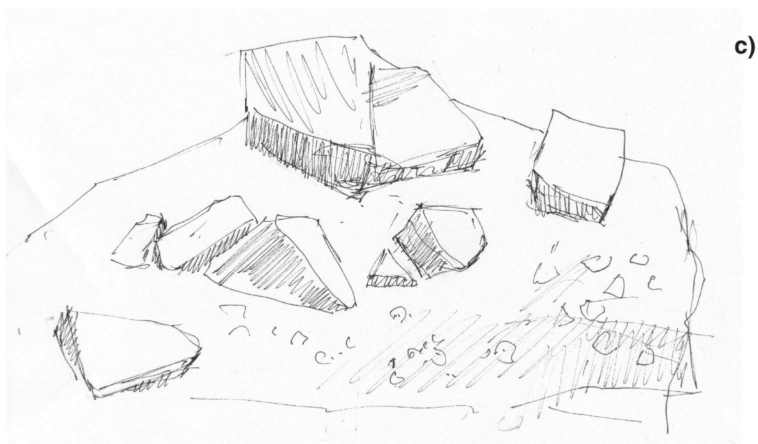


Fig. 47. Chaotic breccia exposed on the southern slope of the ridge with e.p. 458 (photo a). Angular fragments of breccia with dimensions 5–25 cm and blocks up to 40–60 cm (rare to 1 m) are dominant, vesiculated subspheric fragments with dimension 5–8 cm are less frequent. Tuffaceous matrix is welded with smaller vesiculated fragments. In the left part of the photo below the breccia, a large rounded block of underlying conglomerate bed is located (photo a). On the western slope of the ridge with e.p. 458, the chaotic breccia is exposed (photo b, scheme c). In the lower part of outcrop, the tuffaceous matrix welded with small vesiculated fragments is dominant (photo b, near hammer). Angular fragments to blocks originating by the disintegration of a larger block during transport in pyroclastic flow are concentrated in the higher part of outcrop (photo b, above hammer, scheme c). Lithology of chaotic breccia of pyroclastic flow corresponds to Merapi type, related to destruction of extrusive dome.

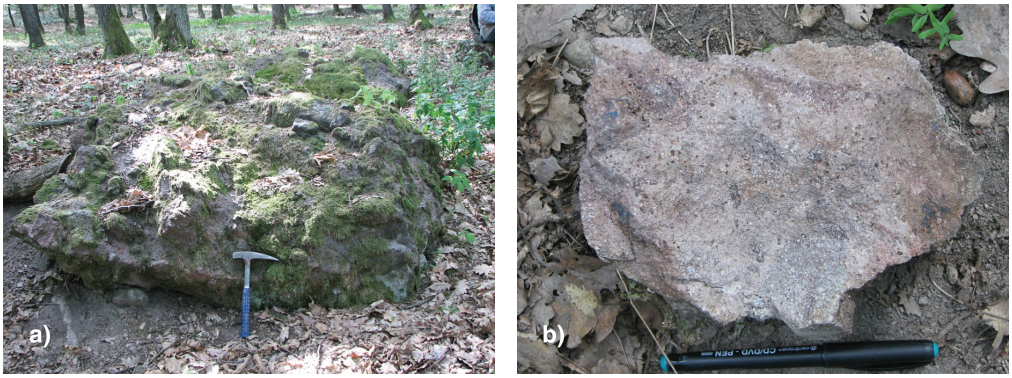


Fig. 48. Chaotic breccia consists of vesiculated fragments with dimensions 5–25 cm to about 30 cm and blocks with subspheric shape (photo a). Tuffaceous matrix of reddish-brown colours is strongly welded and homogenized with small vesiculated fragments (photo b). Chaotic breccia of pyroclastic flow is close to types which originated during collapses of eruptive columns of vulcanian type eruptions.

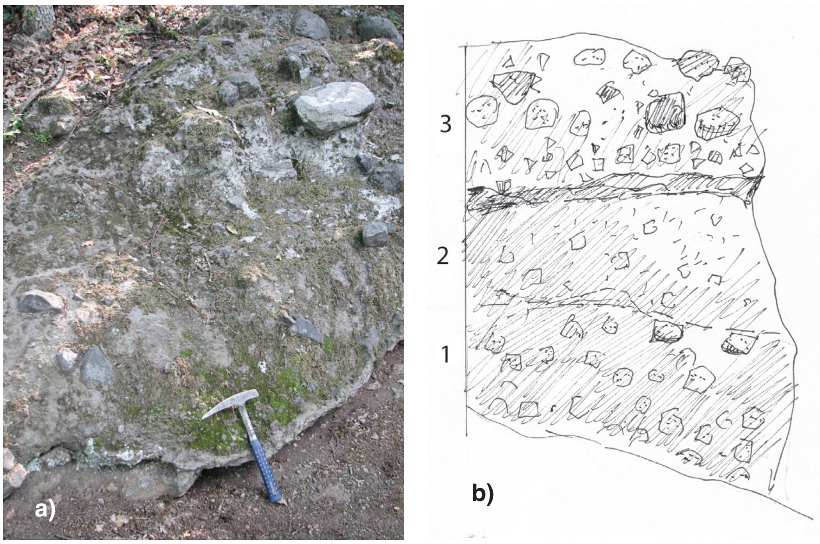


Fig. 49. Chaotic breccia of pyroclastic flow is exposed in rocky cliff on the western slope of the ridge with e.p. 457.3 Hradište in altitude 430 m a.s.l. Breccia in the lower part of the cliff (scheme b/1, photo a) consists dominantly of vesiculated fragments with subspheric shape and dimensions 5–15 cm, angular fragments are in less abundant. Tuffaceous matrix of light grey colour, welded with small vesiculated fragments, forms about 60 %. In the higher level of the cliff (scheme b/2) the matrix welded with small fragments represents about 85 vol. %. The uppermost part of the cliff (scheme b/3) manifests conspicuous concentration of up to 30–40 cm large fragments and blocks of subspheric shape and vesiculated structure. Smaller fragments are concentrated dominantly in the lower part of bed. Matrix represents about 50 % of volume, or the clastic material prevails. It is supposed that three units of pyroclastic flows are present in the cliff. In the lower part of the cliff unit 1 and unit 2 without sharp margins are present and unit 3 occurs in upper part of the cliff.

On the western slope of the Veľké Hradište ridge between levels 350–430 m a.s.l. the complex of *epiclastic volcanic sandstones* alternates with the *fine to medium epiclastic volcanic conglomerate, epiclastic volcanic breccia-conglomerate* and *coarse to blocky epiclastic volcanic conglomerate* (profile ***B-7***). At the level 410 m a.s.l. the scattered blocks of *chaotic breccia of pyroclastic flow* are present on the western slopes of the ridge. Vesiculated fragments of subspheric shape and vesiculated structure of dimensions 5–20 cm and rare up to 30–40 cm are dominant, angular fragments are less frequent. Tuffaceous matrix of red-brown colour is strongly welded with small vesiculated fragments.

Chaotic breccias of pyroclastic flow exposed in numerous outcrops and cliffs in the summit area of the ridges are referred in details in the study of lithology and structures (Fig. 49).

Chaotic breccia of pyroclastic flow is exposed in cliff on the southern slope of the ridge with e.p 457.3 Hradište at level 435 a.s.l. (Fig. 50).

Outcrops of chaotic breccia continue on the summit of the ridge with e.p. 450 east of Hradište ridge (Fig. 51).

Chaotic breccia of Merapi type containing angular fragments and blocks is exposed in several outcrops and cliffs in the summit area of the ridge with e.p. 457.6 Nad horárňou (Fig. 52).

Chaotic breccia of pyroclastic flow of specific type is exposed in abandoned quarry on NW slope of the ridge with e.p. 450 at level 395 m a.s.l. (Fig. 53).

Ash-pumice pyroclastic flows were generated during collapses of the plinian eruptive column. Higher above the ash-pumice pyroclastic flow, the chaotic breccia of Merapi type is exposed on the slope of the ridge with e.p. 457.7 Nad Horárňou (Fig. 52).

The revealed succession indicates that after the plinian eruptions, generating ash-pumice pyroclastic flows, there follow the eruptions of the block-ash pyroclastic flow of Merapi type, related to destruction of extrusive domes.

Chaotic breccia of the ash-pumice-like type is identified also on the western slope of the Dlhý vrch ridge at the level 433 m a.s.l. below the bed of block and ash pyroclastic flow of Merapi type.

More complete succession of pyroclastic flows is exposed in the gorge on the northern slope of the ridge with e.p. 489 Holý vrch at the level 433 m a.s.l. (Fig. 54).

In higher level on the northern slope of Holý vrch Hill at about 448–450 m a.s.l., the chaotic breccia of blocky pyroclastic flow of Merapi type is exposed in several outcrops.

The sequence on the northern slope beneath the e.p. 489 Holý vrch can be interpreted as follows: Volcanic activity had started with huge (enormous) eruptions of ash-pumice tuffs of Plinian type. Fallen pyroclastic material washed down from the slopes of stratovolcano and was deposited in the lake environment. During continuing plinian eruptions the ash-pumice pyroclastic flows were generated with collapses of eruptive columns. Next block and ash pyroclastic flow transported dominantly hot juvenile material, ash tuff, vesiculated fragments and blocks of disintegrated magma and also blocks coming from older volcanic structure. Final series of blocky pyroclastic flows of Merapi type is probably related to ascending and collapses of extrusive domes in the area of central volcanic zone and/or on slope of stratovolcano.

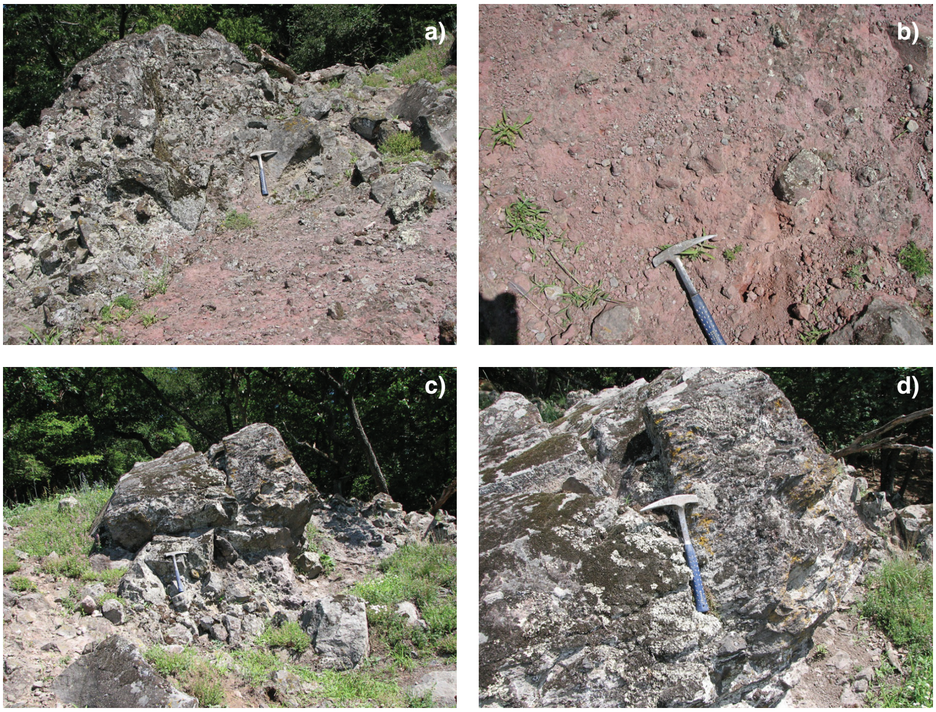


Fig. 50. Chaotic breccia of pyroclastic flow is exposed on the southern slope of e.p. 457.3 Hradište. Chaotic breccia is heterogeneous. Fragments of subspheric shape with dimensions 3–10 cm (rare 15–20 cm) are dominant in the lower part of outcrop. Angular fragments are less frequent. Reddish strongly welded tuffaceous matrix with small vesiculated fragments represents 80–90 vol. % (photo b). In the upper part of outcrop, the fragments and blocks of greater dimensions are accumulated with reverse gradation (photo a, c). Large blocks often show structures of paralel lamination (photo d). These characteristics indicate the origin of pyroclastic flow due to the collapse and destruction of extrusive dome (Merapi type). Larger fragments and blocks, carried in the upper part during movement of pyroclastic flow, emphasize the effect of kinetic sieving.

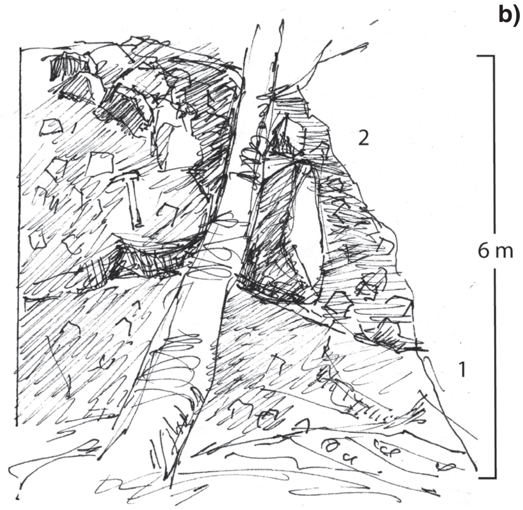


Fig. 51. Chaotic breccia of pyroclastic flow is exposed in the wall of cliff on the summit with e.p. 450. In the lower part of cliff, the strongly welded tuffaceous matrix with small vesiculated fragments dominates (scheme b/1, photo a, below hammer). In the upper part of the cliff, the coarse to blocky material is accumulated with reverse gradation. Noteworthy there is a presence of big rounded blocks in the upper part of chaotic breccia (photo a, above hammer, scheme b/2 at hammer). Rounded block probably come from underlying conglomerate bed of littoral zone, crossed by moving pyroclastic flow.

Fig. 52. Chaotic breccia of pyroclastic flow, forming rocky cliffs on apical parts of the ridge with e.p. 457.6 Nad horárňou, consists dominantly of angular fragments with dimensions 5–25 cm up to 40–60 cm blocks. The vesiculated subspheric fragments are less frequent. Tuffaceous matrix welded with small vesiculated fragments represents about 30–40 vol. %. Schmincke (2004) for pyroclastic flow with higher content of fragments and blocks suggests the term "blocky pyroclastic flow". Chaotic breccia with dominant content of angular fragments and blocks follows to east in outcrops located in apical parts of the ridge with e.p. 481.5 Dlhý vrch.

Profile ***B-8*** documents structure and lithology of volcanosedimentary formation on the southern edge of the Blh Plateau. Profile ***B-8***, trending SW–NE, begins on the SW slope of the Blh Plateau, crossing ridges Veľká skala, Deravá skala with e.p. 495 and ridge with e.p. 475, where it finishes. On the western slope of the Veľká skala ridge, the huge rock landslides have occurred along scarp zone in the complex of *epiclastic volcanic sandstones,* alternating with interbeds of *fine to medium epiclastic volcanic conglomerates*. Basal bed is supposed at level 355 m a.s.l. *Coarse to blocky epiclastic volcanic breccia-conglomerate* with rounded and angular andesite blocks up to 0–50 cm follows from the level 420 m a.s.l. up to 430 m a.s.l.

Chaotic breccia of pyroclastic flow on the southern slope of Veľká skala, deposited with base about 431 m a.s.l. above the bed of the coarse to blocky epiclastic

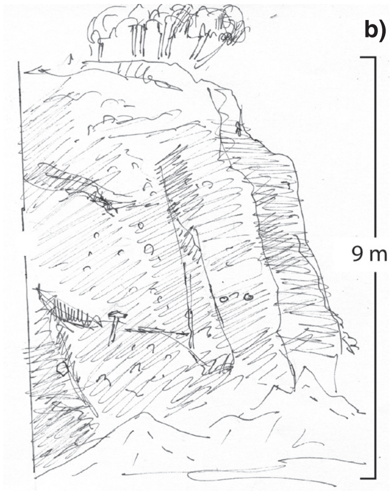


Fig. 53. In the wall of abandoned quarry at the forest road on the NW slope of the southern segment of the Blh Plateau, the specific type of breccia is exposed (scheme b; photo a). Small, strongly vesiculated fragments of pumiceous character of subspheric and irregular shapes with dimensions 5–15 cm represent about 8–10 % of the breccia volume. Angular 3–10 cm fragments are rare, they form only about 2–3 vol. %. Tuffaceous pumice matrix consists of small vesiculated fragments of pumice, being strongly welded with ash tuff material of light grey to yellow-rose colour (photo c). Tuffaceous-pumice matrix represents about 85–90 vol. %. Lithic, dark andesite fragments coming from older volcanic structure, having sharp edges against matrix, are sporadic (photo c). Deposition of pyroclastic material is chaotic. Rare andesite pebbles and rounded blocks were derived probably from underlying conglomerate beds, and eventually from fluvial sediments on the bottom of paleovalley.

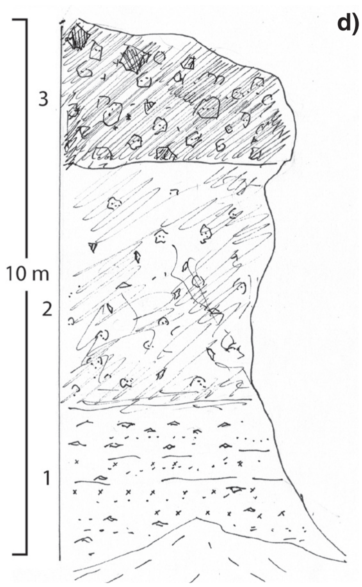


Fig. 54. In the outcrop on the northern slope of e.p. 489 Holý vrch, located in gorge, the following succession is exposed (scheme d): 1 – Bed of reworked pumice tuff in the lower part of outcrop shows weak signs of bedding (scheme d/1). Locally the imprints of leaves and remnants of flora are present with scattered of fine andesite fragments (photo b). The pumice--ash pyroclastic flow follows above reworked pumice tuff (scheme d/2, photo a). Vesiculated subspheric fragments with dimensions 5–10 cm are sporadic, representing about 10–15 vol.%. Angular lithic fragments of non-vesiculated andesite with dimensions from several cm to block about 30 cm are rare. Tuffaceous matrix with high concentration of pumice is welded with small vesiculated fragments. Chaotic breccia in the upper part of outcrop (scheme d/3, photo c) consists of vesiculated andesite fragments of subspheric shape with dimensions 5–15 cm, angular andesite fragments and blocks large up to 30 cm are rare. Tuffaceous matrix with higher concentration of pumice is welded with small vesiculated fragments. In vertical section a higher concentration of blocks in the upper part of breccia is observed with signs of reverse gradation (photo c).

volcanic breccia-conglomerate, consists of angular fragments with dimensions 10–20 cm and rare blocks up to 80 cm. The vesiculated fragments of subspheric shape and dimensions 5–10 cm are less frequent. Tuffaceous matrix locally of brown-red colour is welded with vesiculated fragments. The deposition of material is chaotic. Breccia with dominant content of angular blocks corresponds to Merapi type. Breccia of this type continues in outcrops and cliffs higher on the western slope up to level 452 m a.s.l. (Fig. 55).

Profile ***B-8*** continuing to NE passes the next ridge Deravá skala with e.p. 495. At level 374 m a.s.l. a landslide scarp edge occurs in a complex of *epiclastic volcanic sandstones* with interbeds of reworked tuffs with higher content of pumice tuffs and layers of fine clastic material. Higher on the slope at level 417 m a.s.l. in rocky cliffs the *lahar breccia* is exposed (Fig. 56).

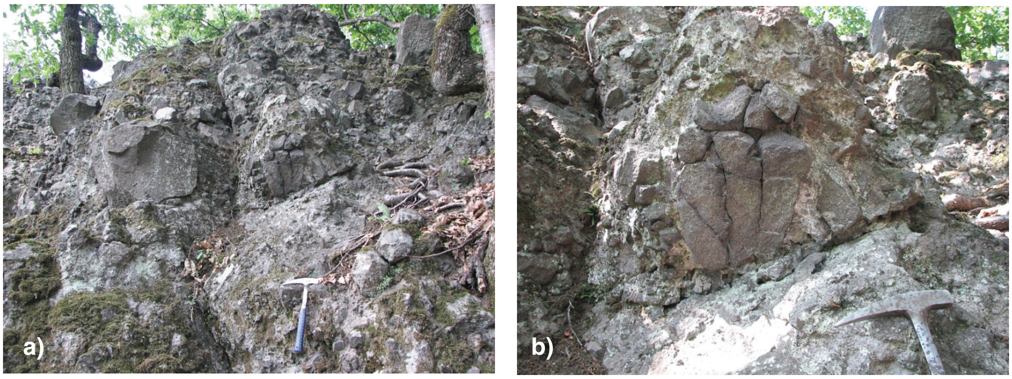


Fig. 55. Chaotic breccia of pyroclastic flow is exposed in higher level of the slope below the Veľká skala Hill in cliff located at level 452 m a.s.l. Chaotic breccia is chacteristic with dominancy of angular fragments with dimensions 5–25 cm and blocks up to 50–80 cm. The vesiculated, subspheric fragments with dimensions 5–15 cm are less frequent (photo a). Tuffaceous matrix light grey, locally reddish is welded with vesiculated fragments. Several blocks with dimension up to 60–80 cm show disintegration along radial and concentric fissures in hot stage during transport in pyroclastic flow (photo b). Angular fragments are dispersed into tuffaceous matrix.

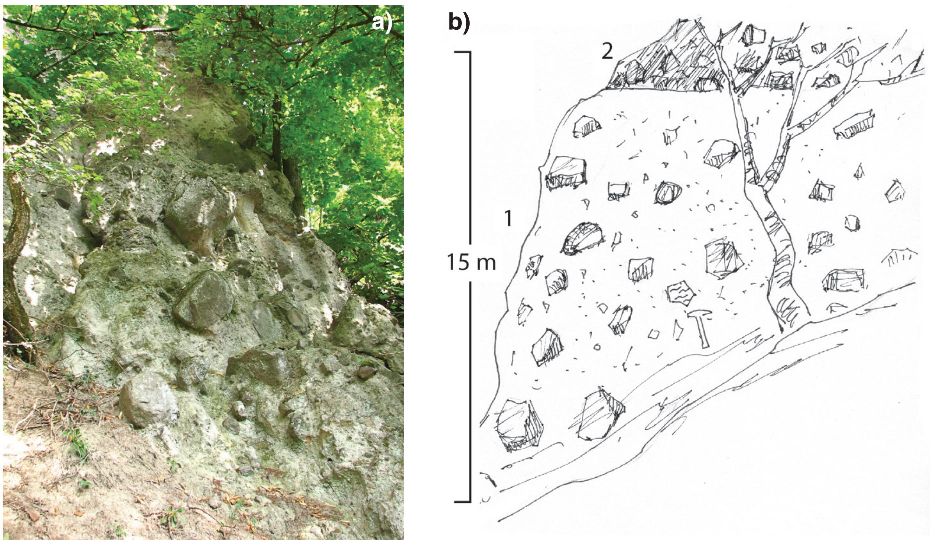


Fig. 56. Lahar breccia, exposed on the southern slope of Deravá skala e.p. 495, consists of polymict clastic material (scheme b). Except angular to rounded andesite fragments with dimensions 5–30 cm (photo a, scheme b), also the fragments and blocks of non-volcanic rocks with dimensions up to 10–20 cm are often present, belonging to crystalline schists, granitoids, migmatitized gneisses (photo c above hammer), fragments of Paleozoic sediments, and small pebbles and gravels of quartz and crystalline rocks. Clay-tuffitic matrix is forming about 85 vol. % (photo d, detail of matrix). Thickness of lahar body is about 15 m. Lithology of lahar breccia corresponds to cold lahar. Higher content of non-volcanic material indicates that lahar, leaving the stratovolcanic slope, has continued in movement on the surface, built-up by Hercynian crystalline rocks and next on bottom of paleovalley with fluvial sediments (pebbles of quartzites and gravels of non-volcanic material).
Chaotic breccia of pyroclastics flow follows above lahar (scheme b/2).

On the western slope of the Deravá skala ridge, the bed of *coarse to blocky epiclastic volcanic conglomerate* in thickness about 2–5 m is deposited on lahar breccia. Above conglomerate bed there follows the chaotic breccia of pyroclastic flow at the level 434 m a.s.l. (Fig. 57).

Lahar breccia in higher position on the western slope of the Deravá skala ridge with thickness about 15 m is exposed at level 447 m a.s.l. Except of andesite fragments and blocks, the fragments of non-volcanic rocks (crystalline schists, granitoids and pebbles of quartz) are present too. Sandy-tuffitic matrix with clay component is strongly dominant above clastic material. The deposition of material is chaotic. Breccia can be classified as a cold lahar. Above lahar breccia at level 462 m a.s.l. a bed of *coarse to blocky epiclastic volcanic conglomerate* follows with rounded blocks large up to 40–50 cm and sporadically up to 1.2 m. Thickness of conglomerate bed is about 3–4 m.

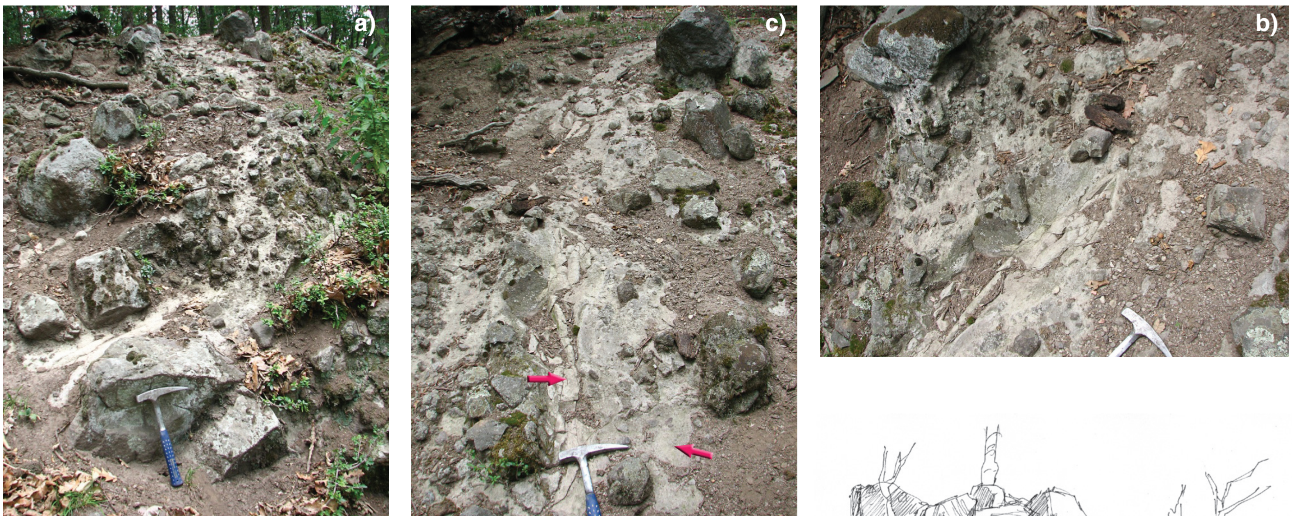
The second body of *chaotic breccia of pyroclastic flow* is deposited on coarse to blocky conglomerate at level 465 m a.s.l. Chaotic breccia continues to higher level in several cliffs and large blocks up to level 474 m a.s.l. (thickness of breccia is about 9 m, Fig. 58).

Higher above chaotic breccia, the *coarse to blocky epiclastic volcanic conglomerate* follows with rounded andesite blocks large up to 30–40 cm at the level 474 m a.s.l. Thickness of conglomerate bed is about 8–9 m.

Fig. 57. Chaotic breccia of pyroclastic flow, exposed on the western slope of the Deravá skala in the level 434 m a.s.l., consists of vesiculated fragments of subspheric shape with dimensions 5–15 cm and angular fragments up to 30 cm and rarely to 1 m. Tuffaceous matrix is strongly welded with small vesiculated fragments. Chaotic breccia in outcrops and cliffs continue higher up on the slope to level 447 m a.s.l. (thickness of breccia is about 13 m). The higher concentration of blocks in the upper part of pyroclastic flow indicates reverse gradation. Lithology of breccia corresponds to Merapi type of pyroclastic flow.

Third body of *lahar breccia* – hot lahar type follows above conglomerate bed in higher level of the slope Deravá skala at level 483 m a.s.l. (Fig. 59).

Fig. 58. Chaotic breccia of pyroclastic flow exposed on the western slope of Deravá skala Hill at level 465 m a.s.l. (photo a) consists dominantly of angular fragments up to 15–20 cm large and rare blocks of dimensions to 80 cm up to 2 m with signs of disintegration into angular fragments (photo b). Vesiculated fragments of subspheric shape with dimensions 5–15 cm are also present. Tuffaceous matrix is strongly welded with vesiculated fragments. Lithological character of breccia is close to Merapi type of block and ash pyroclastic flows.



d)

Fig. 59. Lahar breccia is exposed in cliff bellow the e.p. 495 Deravá skala at level 483 m a.s.l. (scheme d; photo a). Lahar breccia is lithologically heterogeneous, composed of vesiculated 5–15 cm andesite fragments and subangular to angular fragments large up to 20 cm and rarely up to 60 cm. Rounded andesite blocks are less frequent. Sandy tuffaceous matrix is consolidated but nonwelded. In the lahar breccia the fragments and blocks of sediments are enclosed (scheme d/1). Heterogeneous character is emphasized by local concentration of larger blocks and in other place with accumulation of smaller fragments with dimensions 5–15 cm. Irregular bodies of fine sandy material often with steep inclination are present in breccia (photo a, b and c) They probably resulted on further slides and crushing of material due its gravitation instability after its deposition on the bottom of sedimentary basin. Relatively higher content of vesiculated fragments with subspheric shape (pyroclastic fragments) and higher degree of consolidation of matrix indicate a partly hot stage of material during transport.

Concerning of the origin of lahar breccia we suppose that original pyroclastic flow, after invading into water environment, due to absorption of the water, cooling and by mobilization of sedimentary material from underlying rocks, has transformed into the hot lahar, moving further on the bottom of sedimentary basin.

Coarse to blocky epiclastic volcanic conglomerate with rounded blocks large up to 40–60 cm and thickness about 5 m follows above lahar breccia in the summit of e.p. 495 Deravá skala. In the upper part, the conglomerate bed passes gradually into facies of coarse to blocky epiclastic volcanic breccia-conglomerate.

Profile ***B-8*** in its final part is crossing the ridge with e.p. 471. From the foot of the slope up to its top the following sequence was identified:

At the level 381 m a.s.l. in sporadic outcrops a bed of *epiclastic volcanic sandstones and tuff-sandstones* with pumices and fine andesite fragments is exposed. Body of lahar breccia follows above epiclastic volcanic sandstones at the level 383 m a.s.l. (Fig. 60).

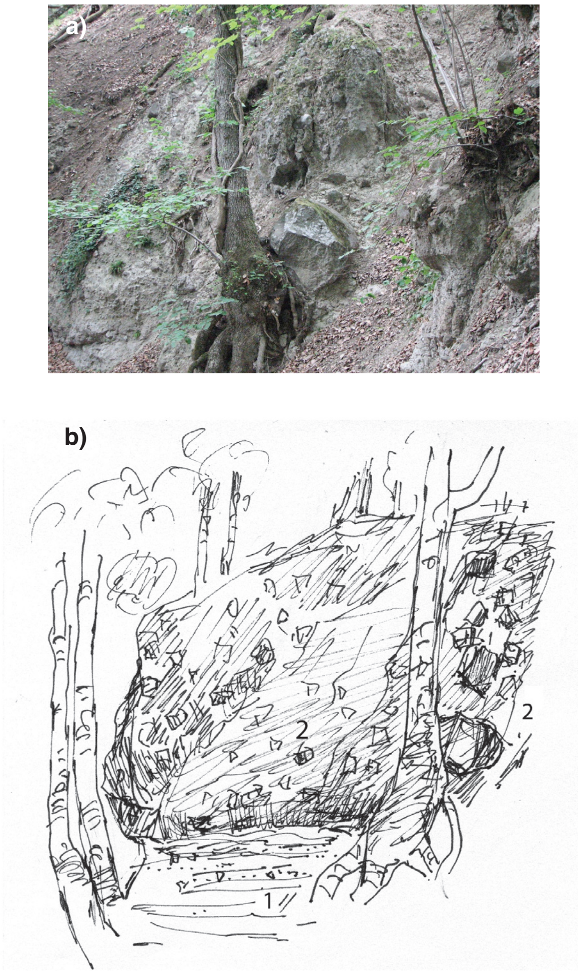


Fig. 60. Lahar breccia (scheme b/2) is exposed at level 380 m a.s.l. in the outcrop at foot of the ridge with e.p. 471 above bed of layered epiclastic volcanic sandstone (scheme b, photo a). Base of lahar breccia lies with sharp contact on underlying epiclastic volcanic sandstone (scheme b/1, photo a). Lahar breccia consists of angular to subangular and less frequent rounded andesite fragments with dimension 5–25 cm and rare blocks up to 50–60 cm large. Tuffitic sandy matrix with clay component and rich on small angular and also rounded andesite fragments represents about 80 % of the rock volume. Deposition of material is chaotic without signs of sorting and bedding.

Chaotic breccia of pyroclastic flow follows on the southern slope of the ridge with e.p. 381 at the level 426 m a.s.l. (Fig. 61).

Fig. 61. Chaotic breccia of pyroclastic flow is exposed in cliff on the southern slope of the ridge with e.p. 381 at level 426 (photo a). Breccia consists of vesiculated andesite fragments of subspheric shape and with dimensions 5–15 cm rare to 20 cm. Angular fragments with dimensions 20–40 cm and rare blocks up to 1.5 are dominant. Tuffaceous matrix is welded with smaller vesiculated fragments. In higher level about 440 m there is accumulation of blocks of greater dimensions in pyroclastic flow (photo b).

Chaotic breccia follows in rocky cliffs on the southern slope of the ridge up to the level 440 m a.s.l. In this level a higher accumulation of greater angular blocks with dimensions up to 1.3 m is observed with signs of reverse gradation (Fig. 61). Vesiculated subspheric fragments are less frequent. Tuffaceous matrix welded with small vesiculated fragments forms about 30 %. Lithology of chaotic breccia corresponds to pyroclastic flows of Merapi type.

According to the stony debris with angular and rounded blocks with dimensions up to 40–50 cm, the bed of *coarse to blocky epiclastic volcanic breccia* follows up to level 450 m a.s.l.

Second body of *chaotic breccia of pyroclastic flow* of Merapi type follows at the level 450 m a.s.l. above coarse to blocky epiclastic volcanic breccia (Fig. 62).

Lahar breccia is exposed in several cliffs at level 465 m a.s.l. above chaotic breccia of pyroclastic flow in the upper part of the ridge with e.p. 471. Breccia is characteristic with higher content of vesiculated, subspheric fragments and also with angular fragments

Fig. 62. In rocky cliff at level 450 m a.s.l. on the southern slope of the ridge with e.p. 381, the chaotic breccia of pyroclastic flow is exposed. Angular fragments up to 30 cm large and rare blocks to 60 cm large are dominant. Subspheric, vesiculated fragments with dimensions 5–20 cm occur in smaller amount. Tuffaceous matrix of the red-brown colour welded with small vesiculated fragments forms about 40 vol. %.

with dimensions 5–20 cm and rare blocks up to 40 cm. Rounded fragments and blocks are less abundant. Tuffaceous-sandy matrix with higher content of pumice, locally red coloured, is consolidated. Deposition of clastic material is chaotic. The higher content of vesiculated fragments and higher consolidation of matrix point on the hot state of some parts of material during the lahar movement. Breccia corresponds to the hot lahar type.

Three isolated relics of volcanosedimentary rock (three individual hills) are situated south of the Blh Plateau. They are crossed by two transversal profiles ***B-9*** and ***B-10*** trending W–E.

Complex of *epiclastic volcanic sandstones* was identified in the landslide scar on the western slope of the Vlčí vrch Hill with e.p. 442 at level 380 m a.s.l. (profile ***B-9***). Higher above the complex of epiclastic volcanic sandstones a *medium to coarse epiclastic volcanic conglomerate* follows in interval 380–400 m a.s.l., passing above into the bed of *fine to medium epiclastic volcanic breccia-conglomerate*. At level 410–420 m a.s.l. several blocks of lahar breccia are scattered on the slope of the hill. Lahar breccia consists of vesiculated subspherical fragments, as well as angular fragments of dimensions 5–20 cm up to 30 cm, having consolidated tuffaceous sandy matrix, locally of reddish colour. Breccia corresponds to the *hot lahar* type.

In vertical lithological succession at level 425 a.s.l. a *coarse to blocky epiclastic volcanic conglomerate* follows with rounded blocks large up to 30 cm in diameter (rare up to 90 cm), being deposited in subhorizontal beds. At this level a great block with texture of lamination with platy jointing is partly exposed. This block was probably produced by the destruction of lava flow.

In the summit area of Vlčí vrch, several blocks of *ash-pumice pyroclastic breccia* are scattered at the level about 400 m a.s.l. Fragments of subspheric and/or irregular shape with dimension 2–5 cm up to 10 cm are strongly vesiculated. Tuffaceous matrix of grey colour is strongly welded with small vesiculated fragments. Breccia is lithologically close to layer of ash-pumice pyroclastic flow on the northern slope of the Holý vrch Hill and the Dlhý vrch Hill on the northern edge of southern segment of the Blh Plateau.

Profile ***B-10*** is crossing isolated Mlynár hill with e.p. 407.5 (Fig. 63) and next hill to east (without e.p.). *Epiclastic volcanic sandstones* with intercalations of fine conglomerates, cropping out in lower levels of slopes of both hills, pass in upper part at level 380 m a.s.l. into the bed of *fine to medium epiclastic volcanic conglomerates*. Pebbles and rounded blocks with diameter 5–10 cm and rare to 30 cm belong to andesites and sporadic non-volcanic rocks (granitoids, quartz and crystalline schists).

Lahar breccia of the hot type lahar was identified on the top of Mlynár hill with e.p. 407.5.

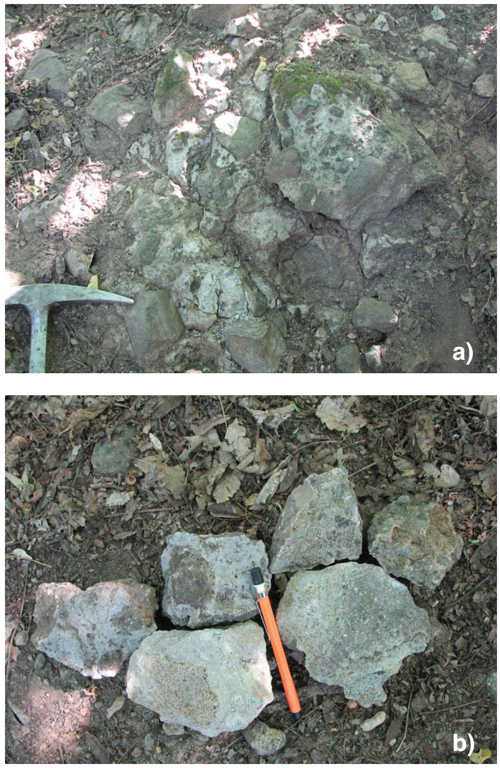


Fig. 63. On the top of the Mlynár hill with e.p. 407.5 in abandoned small pit quarry and in a several blocks in its surrounding a lahar brecccia was identified. Breccia is formed dominantly of smaller vesiculated fragments of subspheric shape with dimensions 5–10 cm, rare up to 25 cm (photo a). Tuffaceous matrix is light grey, locally reddish with clay component and content of dispersed pumices and small vesiculated fragments. Margins of vesiculated fragments against matrix are not sharp and irregular in many cases, which points on the hot state of fragments (photo b). Angular and rounded fragments in contrast show a sharp contures against matrix. Locally the pebbles of conglomerates are present in lahar breccia. Several signs, indicating the hot state of pyroclastic material, allow to suppose that in this case the original pyroclastic flow after its penetration into the lake environment and after absorption of water and mobilization of sedimentary material from the lake bottom was transformed into hot lahar.

III – Paleovolcanic reconstruction of the Vepor stratovolcano

In preceeding Part I, the analysis of relics of intrusive bodies in the central and proximal volcanic zone of the Vepor stratovolcano was done, including lithological characteristics of the facies, filling paleovalleys on the western slopes of the stratovolcano. It was completed in this Part II by data about facies on the southern slopes of the stratovolcano, as well as the volcanosedimentary complex in the sedimentary basin at the southern foot of stratovolcano, preserved in the Pokoradz and Blh plateaus. Analytical data in this second part of the paper allow to make further step for resolving problems of the stratovolcano structure and evolution and to answer main questions, appearing during the field research works: What was the original extent of the stratovolcano, what types of volcanic and intrusive forms originated during its development (what was the anatomy of the stratovolcano) and what types of eruptive processes participated on building of the stratovolcano. It is supposed that conditions for answering these questions are fulfilled in this region due to some useful circumstances.

1 – Due to a deep erosion, the volcanic structure was removed and subvolcanic intrusive complex of the central volcanic zone was exposed on the surface. The detail mapping and study of intrusive complex have significantly contributed to interpretation of its structure, extent, type of intrusive forms and intrusive succession. Also knowledge about contact-metasomatic processes of intrusive bodies with surrounding rocks was obtainable.

2 – As a result of denudation, also the more external parts of the central zone and the area of proximal zone, encompassing shallower intrusions, like sills, laccoliths, eventually extrusive dome-like bodies and necks, continuing upward into volcanic structures, are uncovered. They offer possibility to evaluate their position and function in evolution of stratovolcano and contributed to idea about reconstruction of inner structure of the stratovolcano. It is not necessary to emphasize that these conditons are not fulfilled in the case of recent and subrecent volcanoes with low degree of denudation.

3 – Paleovalleys on slopes of stratovolcano were used like a transport ways of volcaniclastic material to greater distances from the stratovolcano. Results of the study of lithology and succession of volcaniclastic facies, filling paleovalleys, allow to identify the stages of explosive activity when through the paleovalleys the pyroclastic material was transported by pyroclastic flows. Also relics of lava flow (as in our case the Klenovský Vepor lava flow) are important for the reconstruction of individual stages of effusive activity, as well as for the reconstruction of the extent of primary stratovolcanic structure. The study of paleovalleys fillings on the southern slopes of the Slovenské rudohorie Mts., being used for transport of volcaniclastic material to the southern sedimentary basin in different time intervals, has contributed also to reconstruction of events acting on stratovolcanic slope.

4 – The main information about the time evolution of stratovolcano and character of eruptive processes was provided by analyses of volcanosedimentary complexes of the southern volcanosedimentary basin. Volcanosedimentary complex of the Vyšná Pokoradz Formation rises now above surrounding relief as the Pokoradz Plateau and the Blh Plateau, being limited by steep slopes at their edges. They provide possibility to study facies of volcanic and sedimentary rocks from the bottom up to uppermost levels. Volcanic events during evolution of stratovolcano are recorded in lithological succession like chaotic breccias of pyroclastic flows, lahars and deposits of hyperconcentrated flows, which episodically invaded sedimentary basin. Actual explosive eruptions are also registered like intercalations and thin beds of pumice-tuffs in sequences of epiclastic volcanic sandstones. Detail study of volcanic products also allows identifying the plinian and/or vulcanian types of volcanic activity and the eruptions related to collapses and destructions of extrusive domes. Possibility of direct study of these volcanic products in vertical lithological profiles from the bottom to top levels of filling of primary sedimentary basin, exposed on steep slopes of the Pokoradz and Blh plateaus, represents a unique phenomenon in the Neogene volcanic field on inner side of the Carpathian orogene belt.

1 – Remarks to nature of primary volcanic structure

a – Central volcanic zone

In the past, several authors expressed their opinion about the primary volcanic structures related to remnants of volcanic and intrusive rocks as we mentioned in historical review. In short explanations to geological maps they expressed opinion about the existence of several volcanic structures without their more detail specification (Kuthan et al., 1963; Bacsó et al., 1964, 1969; Klinec, 1976). Burian et al. (1985) supposed the existence of two central volcanic zones: (a) group of diorite and andesite bodies (north of Tisovec town), named as the *Tisovec intrusive complex* and (b) diorite bodies in the area of Kľak (south of Závadka village).

With the Kľak central zone Burian et al. (1985) connected also two bodies of rhyodacites (Kochlovec and Za Kyčerou, located south of Závadka village), which, according to authors, are situated on concentric fault with the Kľak center. This interpretation is commented by following arguments: Concentric fault was not confirmed by detail field study, the rhyodacite bodies have ascended along linear fault zones of NE–SW direction, which separated two blocks of crystalline units according to Klinec (1971). In the Kľak area the remnant of small pyroclastic volcano Stožka was identified with andesite neck. This pyroclastic volcano was described in Part I (Konečný et al., 2015). The idea about the genetic relation of rhyodacite bodies, occuring at a distance about 7 km far from small monogenic pyroclastic andesite volcano, we do not consider as realistic.

Area with a group of andesite and diorite bodies of *Tisovec intrusive complex* (north of the Tisovec town) was interpreted by Burian et al. (1985) as the central zone of stratovolcano. “The subvolcanic andesites around Tisovec intrusive complex, connected with the concentric and radial faults, indicate the existence of the stratovolcano“ (l.c.). In our work, this complex, named as the *Magnetový vrch intrusive complex,* including diorite bodies, laccoliths and dykes, was identified as the *central volcanic zone of the Vepor stratovolcano*. Structure of the central volcanic zone of Magnetový vrch with intrusive bodies was described in Part I. Recent Part II expresses here some additions and remarks to this topic.

Central volcanic zone is considered as a source of multiple outputs of magma on the surface. In the deeper eroded volcanoes, the bodies of feeding system (necks, dykes), laccolith, sills and deeper subvolcanic intrusive complexes are exposed on the surface. Situation differs in monogenetic and polygenetic volcanoes, resp. stratovolcanoes.

In monogenetic volcanoes of the central type, the volcanic activity finishes after building of pyroclastic cone by filling of feeding channel with magmatic body. In deeply eroded volcanic structures we can find often bodies of lava necks and/or diatremes. Classic example is represented with the relic of Stožka pyroclastic volcano with central lava neck. Several examples can be presented in the Central Slovakian Neogene volcanic field and also in the area of alkali basalt volcanism in the southern Slovakia (lava necks Šomoška, Hradište and Steblova skala and diatremes Šurice and Hajnačka).

The situation is quite different in the case of deeply eroded structures of polygenetic volcanoes of greater dimensions like a stratovolcanoes with longer evolution. During longer time of activity with alternating explosive and effusive eruptions, there occurs a multiple destruction of older feeding systems and origin of younger ones. In advanced stages of evolution, the intravolcanic bodies like sills and laccoliths are placed in the lower levels of stratovolcanic structure and/or subvolcanic plutonic complexes are developed. During more advanced stages, resp. the final stages due the migration of eruptive centers many parasitic volcanoes (satellite volcanoes) on stratovolcanic slope originated. After deep erosion of stratovolcanic structure the bodies of feeding systems (dykes, necks), intravolcanic and subvolcanic intrusions in the area of central volcanic zones are exposed on the surface. They often show complicated time and space relations that must be solved beside field research also by application of complex methods, including geophysical methods, radiometric dating and petrological studies. These problems can be studied in the deeply eroded structures of andesite stratovolcanoes of the Central Slovakian Neogene Volcanic Field with subvolcanic complexes exposed on the surface (Štiavnica stratovolcano).

Especially favourable conditions for the study of structure of subvolcanic complexes and intrusive succession are represented with the Magnetový vrch intrusive complex, revealing structure of subvolcanic intrusive complexes in vertical range from 500 m a.s.l. to 960 m a.s.l. During the study of the Magnetový vrch intrusive complex, its multistage evolution has been demonstrated.

The evidence of the existence of primary feeding system (before development of subvolcanic diorite intrusion) was revealed by the study of xenoliths occurring in several parts of diorite plutonic intrusion. Xenoliths of andesite and diorite porphyries enclosed in diorite intrusion represent fragments of crushing and destruction of older feeding system (probably dykes) during intrusive processes and placement of diorite intrusion. Diorite intrusion did not occupy its subvolcanic position in one simple intrusive act, but its formation occurred during several stages (3 stages), as was stated in preceding Part I. Each stage of intrusive activity was connected with the destruction period of older parts of diorite intrusion. With the placing of the diorite intrusion the intrusive activity in the central volcanic zone had not finished, but it continued with the generation of younger multiphase dyke system of diorite to andesite porphyry, occurring during 4 phases. It is possible to suppose that some dykes, developed in the upper part of volcanic structure, represented feeding system for superficial volcanic eruptions. The youngest dyke system of basaltic andesites to basalts was probably connected with formation of parasitic (satellite) volcano on the southwestern slope of the stratovolcano.

b – Stratovolcanic cone

Existence of the central volcanic zone is linked with the existence of primary stratovolcanic cone. When volcanic cone is totally removed by denudation (like it was in the case of the Vepor stratovolcano), there is a question if there are available another data and arguments, which allow to reconstruct the form and dimensions of original stratovolcanic cone.

In the case of supposed Vepor stratovolcano, we can apply a relic of lava flow, covering top of the Klenovský Vepor ridge west of the central volcanic zone. Relic of lava flow with length about 2 km forms the uppermost part of paleovalley filling, directed WSW–ENE. The base of lava flow lies above epiclastic and pyroclastic rocks at the eastern edge of the ridge at level 1250 m a.s.l., at the western edge descending to level 1010 m a.s.l. The lava flow is inclined about 8–9° to west. Epiclastic volcanic complex underlying lava flow at the eastern edge of the Klenovský Vepor ridge with thickness about 100 m lies on crystalline rocks of the Veporic unit at the level 1150 m a.s.l. Above the basal fluvial sediments (sands and gravels with volcanic and non-volcanic rocks), the epiclastic volcanic conglomerates follow and higher, bellow the lava flow, reworked pyroclastic breccias and tuffs are present. Volcanosedimentary complex at the eastern edge of the Klenovský Vepor ridge was deposited in the area of transition from stratovolcanic slope to proluvial plain at the western foot of the stratovolcano. *Level about 1150 m a.s.l. is considered as the most probable level of original paleorelief, on which the Vepor stratovolcano was built-up*.

On the western edge of the Klenovský Vepor ridge the thickness of epiclastic volcanic complex is smaller – about 50 m and also its base is situated in lower altitude of about 960 m a.s.l. That level of volcanosedimentary complex at the western edge of the ridge represents the filling of shallow paleovalley with bottom below the level of paleorelief. Leaving the stratovolcano slope, the andesite lava flow has continued in movement to SW into the area of transition to proluvial plain (this area is indicated with ca 8–9° dip of the base), gradually turning westward and following in shallow paleovalley, where lava flow stopped and cooled. The distance from the western foot of stratovolcano with relict of lava flow to central volcanic zone with the Magnetový vrch intrusive complex is about 11 km. Based on this knowledge we can reconstruct the relief of stratovolcanic slope, respecting a typical concave profile of andesite stratovolcano with ca 32–35° dip in the middle part and steeper dip near the crater. This reconstruction has manifested the stratovolcano height about 2 450 m at an assumption of relativelly flat paleorelief, situated about 1150 m a.s.l. (Fig. 65). In the area of the Magnetový vrch intrusive complex (e.p. 964) for balancing with the paleorelief level 1150 m a.s.l., there is necessary to suppose about 150 m thickness of the Paleogene sediments, located above the Mesozoic rocks, before the evolution of stratovolcano. The Paleogene sediments and Mesozoic rocks, together with rocks of stratovolcanic cone, have formed the top wall of intrusive complex in the central volcanic zone during evolution of the stratovolcano.

Based on the field research and geological mapping, especially of the relics of volcaniclastic rocks in the filling of paleovalleys, we came to conclusion that the original volcanic structure removed by erosion had represented a typical andesite stratovolcano built--up of volcaniclastic rocks (pyroclastic and epiclastic), as well as the lava flows, which can be compared with the less denuded stratovolcanoes in the Middle Slovakian Neogene Volcanic Field (Javorie Stratovolcano). Except the lava flow on the top of the Klenovský Vepor ridge, the interpretation of stratovolcano is also supported by the occurrence of andesite blocks (often of great dimensions) in beds of coarse to blocky conglomerates. The andesite shows the platy laminar jointing, typical for lava flows. These blocks are present dominantly in higher levels of volcanosedimentary complexes, in filling of the paleovalleys, which proves the effusive activity in a more advanced stage of stratovolcano evolution.

We have a several additional remarks to suggested construction of the concave profile through the slope of the Vepor stratovolcano (Fig. 65) and to its height. Volcanic material produced during explosive and effusive activity (volcanic ash, pyroclastic breccias and lava flows) was accumulated on the slope of the stratovolcano, but it was also transported to foot of stratovolcano and deposited in proluvial plain, eventually in radial paleovalleys. Due to accumulation of volcaniclastic rocks, ash tuffs and lava flows in lower levels, the stratovolcanic slope obtained moderate inclination of about 15–20° and at the transition to accumulation of proluvial plain inclination was about 8–10°. That situation is ilustrated by the lava flow from the Klenovský Vepor ridge, which was set down on epiclastic volcanic complex with the westward dip of the base app. 8–9°.

On the other hand, the accumulation of the hot pyroclastic material bellow the summit crater during explosive eruptions and its agglutination, as well as accumulation of short lava flows, contribute to steeper volcanic slope (35–45°) below the summit of crater, forming concave profile which can be seen at many recent stratovolcanoes. That fact was also respected at reconstruction of probable profile through the Vepor stratovolcano (Fig. 65). In the volcanosedimentary complex of the Hájna hora paleovalley a larger block of agglutinated pyroclastic rocks, coming probably from the crater zone was found (in Part I – Fig. 62 – scheme b).

Stratovolcanoes during their growth only exceptionally reach the hight about 3 000 m; their summits are dominantly in height between 2 000–2 500 m, measured from their base. That is conditioned by dynamic relations between hydrostatic pressure in magma and the lithostatic pressure (weight of rocks above magmatic reservoir including the weight of the stratovolcano mass). Hight about 3 000 m in the case of stratovolcanoes seems to be limitig for the ascent of magma to level of summit crater, because of great lithostatic pressure of accumulated volcanic rocks. Magma in that case during ascent to surface uses fractures and suitable zones as a ways of lower lithostatic pressure at the lower levels of stratovolcanic slope, resulting in formation of the parasitic (satellite) volcanoes on stratovolcanic slope. In the case of the Vepor stratovolcano a distribution of dykes, necks and dyke swarms (especially dykes of basaltic andesite SW of central volcanic zone) indicates the existence of parasitic volcanoes on stratovolcanic slope. From that it is deduced that the Vepor stratovolcano could reach the estimated height is about 2 500 m in advanced stage of its evolution (Appendix 6)

c – Radial orientation of the paleovalleys

System of the erosive valleys on the slopes of stratovolcanoes with radial orientation, regarding the central crater, is a well known phenomenon of many recent stratovolcanoes, e.g. the stratovolcanoes Mount Damawant (Northern Iran), Mount Taranaki (New Zealand), Arenal volcano (Costa Rica), Merbaby volcano (Java), Popocatepetl (Mexico), a.o. Erosive valleys with radial pattern to central crater begin in higher levels of the stratovolcanic slope and continue to the foot of stratovolcano, where they extend and mouth into sediments of the proluvial plain (ring plain). Volcaniclastic material and ash tuffs are transported by ephemeral streams through these erosive valleys to the foot of stratovolcanoes into the proluvial plain, where they are deposited as the thick epiclastic volcanic complexes. Some erosive valleys with deeper cut in the volcanosedimentary complexes of the ring plain, eventually in basement rocks are often used as transport ways for lahars, pyroclastic flows and lava flows to greater distances from the volcano.

Westward of the central volcanic zone of the Vepor stratovolcano in a greater distance there were identified relics of three paleovalleys with radial orientation to central volcanic zone with outward inclination of their bottom. Radial pattern and lithology of their filling offer another argument supporting the existence of stratovolcanic cone. Destription of lithogical facies was set out in Part I. Here we only summarize several results.

1 – The southwestern relics of the Klenovský Vepor paleovalley filling, with lava flow in its upper level, forms an expressive ridge with e.p. 1338.2 and orientation WSW–ENE. Volcanosedimentary complex with thickness about 125 m beneath the lava flow at the eastern edge of the ridge is assumed to represent the deposits in transitional zone from stratovolcanic slope to proluvial plain at the western foot of the stratovolcano. Volcanosedimentary complex at the eastern edge of the ridge is deposited on crystalline rocks about 1150 m a.s.l. and that level is supposed as a *level of paleorelief*. In direction to western edge of the ridge, the base of paleovalley gradually descends to level 1 100 m a.s.l. and at the western edge to level 960 m a.s.l. Also thickness of volcanosedimentary complex bellow the lava flow is going down from the thickness app. 125 m at the eastern edge to 50 m at the western edge of the paleovalley filling. Base of the lava flow at the western side of the paleovalley is at the level 960 m a.s.l. From that there is evident that lava flow in the western part of the paleovalley was moving to west about 190 m bellow paleorelief.

2 – Relic of the paleovalley filling Zadná Kyčera (north of the Klenovský Vepor ridge) trending SW–NE represents relatively deeper cut of the paleovalley in the basement crystalline rocks, comparing to the Klenovský Vepor paleovalley. From the original filling of the paleovalley, only basal beds with epiclastic volcanic conglomerates are preserved. Bottom of the paleovalley also declines to SW – at the eastern edge it is situated at 960 m a.s.l., but at the western edge it is lower at about 920 m a.s.l., that means 190 and 230 m bellow the paleorelief.

3 – The locality Zvadie with e.p. 947 (south of the Chlípavica settlement) represents isolated relic of volcaniclastic rocks to NE of the paleovalley filling Zadná Kyčera. Above the basal fluvial sediments (sands and gravels with volcanic and non-volcanic rocks) at level 925 m a.s.l., the epiclastic volcanic conglomerate and lahar breccia follow. Higher in the summit area with e.p. 947, the outcrops of pyroclastic breccia with signs of bedding occur. We suppose that relic of volcaniclastic rocks with the base 925 m a.s.l. (225 m bellow the paleorelief) can represent isolated subsided blocks of deposits of stratovolcanic slope more than subsided block of the isolated paleovalley filling.

4 – The Hájna hora paleovalley (SE of the Brezno town) is distinguished by the most completely preserved volcanosedimentary filling among paleovalleys in the western side of the stratovolcano. Volcanosedimentary complex of the paleovalley forms a ridge with flat top with length about 7 km and NW–SE radial orientation to central volcanic zone with the Magnetový vrch intrusive complex. Distance from the eastern edge of the Hájna hora ridge to central zone is about 11 km and from the western edge of ridge about 18 km. The base of the paleovalley filling in the eastern edge is about 860–875 m a.s.l., westward it gradually declines and at the western edge the base of paleovalley filling is lower in about 700 m a.s.l. But to the northwestern edge, the base of paleovalley filling descends to 625 m a.s.l. (the axis of paleovalley of NW–SE orientation is at the northern edge of the Hájna hora ridge). Thickness of volcanosedimentary complex at the eastern edge of the Hájna hora ridge is about 100 m, towards the NW the thickness of volcanosedimentary complex gradually grows up to 260 m at the western edge. Comparing levels of the bottom of the Hájna hora paleovalley with the level of supposed paleorelief 1 150 m a.s.l. reveal that bottom of paleovalley at the eastern edge was about 275 m bellow the level of paleorelief and at western edge descends to 450 m and to 525 m below the level of original paleorelief. It demonstrates that the Hájna hora paleovalley represents really a deep canyon in which the deposition of volcaniclastic rocks, transported from the western slope of the Vepor stratovolcano, has occurred.

The Hájna hora ridge along its northern side is bordering with the Breznianska kotlina graben (in Part I – Fig. 6). Graben structure, limited with parallel faults trending NW–SE is filled-up with Paleogene sediments. Origin of the graben in relation to Hájna hora volcanosedimentary complex represents interesting problem to solve, especially concerning of its formation time. Thickness of the Paleogene sediments within graben is estimated to about 250 m. In the upper part of the Paleogene lithological sequence in the graben structure there are preserved the youngest members of the Horehronie cycle, represented by the fresh-watter sediments (sands, gravels and clayes). According to remnants of flora and leaves, they belong to Lower Oligocene and on the base of study of sporomorph to Oligo-Miocene. Sequence of Neogene volcanosedimentary rocks of the distal volcanic zone of the Vepor stratovolcano was not found above the Paleogene sediments. From that there can be deduced that the area with Paleogene sediments now preserved in the graben was out of the reach (radius) of volcaniclastic sedimentation. That fact points on younger tectonic formation of the graben structure with the Paleogene sediments, comparing the formation of the Hájna hora paleovalley filling. Erosive cut of the Hájna hora paleovalley west of stratovolcano has occurred at the beginning, when the Paleogene sediments formed the surface with flat paleorelief at the level about 1150 m a.s.l. and continued in basement complex of crystalline rocks up to level 625 m a.s.l. (about 525 m bellow the paleorelief). During younger stage, a crustal block with Paleogene sediments subsided along parallel faults of NW–SE direction, forming the recent Breznianska kotlina graben structure. The recent surface of the Paleogene sedimentary complex is subsided within the Breznianska kotlina graben to the level about 600–620 m a.s.l.

Summary of results from the study of the paleovalleys fillings on western slope of the Vepor stratovolcano

Origin of the system of paleovalleys with their radial orientation to the central volcanic zone (the Magnetový vrch intrusive complex) with outward deepening of their bottom, represents an argument prooving the existence of a high relief towards the east – that means the stratovolcanic cone. It is supposed that the system of radial paleovalleys has connected in the erosive channels and erosive valleys on stratovolcanic slope and continued towards the foot of stratovolcanic slope and into an area of proluvial plain (Klenovský Vepor paleovalley). The depth of erosive cut of the paleovalleys is gradually growing outward, similarly as the thickness of volcaniclastic rocks in their filling. The development of the paleovalleys has occurred in the different time as can be deduced from their lithology and depth of erosive cut. The earliest evolution reveals the Hájna hora paleovalley. In the basal level of the paleovalley filling at the western edge, the rhyodacite pyroclastic rocks are preserved. They are supposed as an initial stage of volcanic activity in this region. The origin of the Klenovský Vepor paleovalley with lava flow in the upper part of filling, according to shallow depth of erosive cut probably occurred in most advanced stage of evolution of the Vepor stratovolcano. That assumption is also supported by K/Ar radiometric dating providing the youngest age 11.56 $\pm$ 0.43 Ma, corresponding to Late Sarmatian.

Facies in filling of the Hájna hora paleovalley as lahars, pyroclastic flows and coarse to blocky epiclastic volcanic conglomerates often contain andesite blocks with large dimensions 3 x 1.5 m (Suchá ridge at altitude 827 m a.s.l.), 2 x 3 x 2 m (Koreňová ridge; 827 m a.s.l.) and 2 x 4 x 3 m (northern slope of Zrazy; 965 m a.s.l.). These blocks occurring about 15–18 km distance from the central volcanic zone document a great transporting gravitational energy, conditioned by the steepness and height of stratovolcanic slope and offer another argument for the existence of stratovolcanic cone of greater dimensions and height. Andesite blocks of greater to gigantic dimensions are present especially in the uppermost part of the volcanosedimentary complex of the paleovalley filling, what evidently corresponds to more advanced stages of the stratovolcano evolution, when stratovolcanic cone reached its maximum height.

d – Extent of the base of the stratovolcanic cone

SW sector of the stratovolcano

In the consideration of the planar extent of the base of stratovolcano there is taken into account the position of volcanosedimentary complex with the lava flow of the Klenovský Vepor paleovalley and its distance from the central zone. As we already mentioned, the epiclastic volcanic complex with thickness about 100 m and with a base located about 1150 m a.s.l. at the eastern edge of the Klenovský Vepor Hill is supposed to represent deposits in the zone with transition from stratovolcanic slope into the proluvial plain (ring plane) and the level about 1150 m is considered as probable level of the paleorelief on which the stratovolcano was built-up. Transition from stratovolcanic slope into the flat paleorelief of proluvial plain (ring plain) of the distal volcanic zone is confirmed also by a moderate westward inclination of the base of Klenovský Vepor lava flow by about 8–9°. Distance of that transitional zone (boundary between the proximal and distal volcanic zones) from the central volcanic zone is about 11 km. Accepting idea of roughly circular base of the stratovolcanic cone, the distance 11 km represents the radius of the base of supposed stratovolcanic cone. From that aspect we can judge the position of relics of volcanic and intrusive bodies, being exposed by the denudation on the surface within this area, limited by that roughly circular line with radius about 11 km in the NW sector of stratovolcano (Fig. 64).

Except of the Klenovský Vepor paleovalley filling (it was preserved because of the lava flow cover on the top of its filling), all summits of hills and ridges south of the Klenovský Vepor ridge are located in present time beneath of supposed level of the paleorelief (Pomyvačný grúň e.p. 1002, Báňovo e.p. 1039, Báňov vrch e.p. 1058, Strieborná e.p. 896, Kučelah e.p. 1141, and others). From that reason on their tops the relics of volcaniclastic rocks were not found, because they had been removed by erosion. Only the locality Zvadie e.p. 947, located north of Klenovský Vepor, which probably represents an isolated subsided block with volcaniclastic rocks on the top, is an exception from that. In locality Zvadie the base of volcaniclastic rocks is at level 925 m a.s.l. (about 225 m bellow supposed paleorelief). In a distance about 7 km from the central volcanic zone the volcaniclastic rocks probably belong to deposits of lower part of the stratovolcanic slope.

Relics of volcaniclastic rocks in the Zadná Kyčera paleovalley filling, with a base at 960 m a.s.l. (eastern part) and 920 m a.s.l. (western part), i.e. 190 m and 230 m bellow the paleosurface in a distance of about 10.4 km from the central volcanic zone, are situated in the transition zone from the stratovolcano slope to the proluvial plain (ring plain) of the distal volcanic zone.

NW sector of stratovolcano

Position of the Predná Priehybina intrusive-extrusive complex to the NW of the central volcanic zone in a distance about 12 km falls into zone close to foot of the stratovolcano slope with a transition zone to proluvial plain. The eastern side of the intrusive-extrusive complex represents transition from the marginal zone of autoclastic brecciation to epiclastic deposits on the surface. Intrusive-extrusive complex in the upper part has developed probably within volcaniclastic sequences of the proluvial plain.

The group of laccolith bodies, located NNE of the central zone in a distance 10.6–12.6 km (Strúhanka, Baniarka and Vysoká), shows similar position in the area ať the foot of stratovolcanic slope with transition into the proluvial plane. The origin of these laccolith bodies in shallow level near the surface requires the existence of the complex of overlying rocks (probably complex of volcaniclastic rocks).

Northern sector of the stratovolcano

The extrusive rhyodacite bodies Kochlovec and Za Kýčerou (south of the Závadka nad Hronom village), distant app. 13.6 km to north from the central volcanic zone, have developed out of the stratovolcanic slope, but it is not excluded that this area was covered by deposits of the distal volcanic zone like epiclastic volcanic sandstones, conglomerates and lahar breccias.

Northeastern sector of the stratovolcano

The Stožka small monogenic volcano, distant app. 9 km to NE of the central volcanic zone with a base located 1330 m a.s.l., has originated on the surface of Mesozoic rocks. This volcano, due to its higher position above the paleorelief, was probably not reached by volcaniclastic products of the Vepor stratovolcano.

Eastern sector of the stratovolcano

The eastward extent of the primary volcanic structure is not known. As a consequence of uplifting of regional block east of the NW–SE trending fault zone in the Rimava valley (crossing central diorite intrusion), the stratovolcanic structure together with Mesozoic rocks and Paleogene sediments and volcanic rocks have underwent denudation and have been completelly removed.

SW, S and SE sectors of the stratovolcano

To south and southeast of the central volcanic zone (southward of the Magnetový vrch intrusive complex), in the area of supposed extent of stratovolcanic structure also the highest summits of hills are below the level of paleorelief representing the base of the stratovolcano (Rangaska e.p. 866, Poľana e.p. 882 and others) and relics of stratovolcanic structure are not present, as these were removed by erosion. Small relic of epiclastic volcanic conglomerates on the summit of the Babiná ridge (north of the Klenovec village) in a distance of app. 8.4 km to south, with the base at level 750 m a.s.l., represents filling of the paleovalley trending to the south. Also a relic of epiclastic volcanic conglomerate on the western slopes of the Rovinka ridge (e.p. 963; to north of the Polom village), with the base at level 750 m a.s.l. and 12 km distance from the central volcanic zone belongs to filling of the paleovalley.

2 – Structure of the Vepor stratovolcano

After reconstruction of probable relief and the dimensions of the stratovolcanic cone and extent of its base, there is presented an idea about the structure of the stratovolcano. As demonstration of this idea there serve geological sections directed from the central zone to peripheral zone of the stratovolcano with the position of intrusive and extrusive bodies and remnants of superficial volcanic structure, identified during geological mapping. During these paleoreconstructions there were detected several important facts in volcanic field during geological mapping. The first fact represented a position of the lava flow of the Klenovský Vepor (its position a.s.l. and inclination to west) with epiclastic volcanic complex beneath, which enabled to determine zone of transition from the stratovolcanic slope into the proluvial plain and from that to deduce the level of paleorelief. The second was the determination of the central volcanic zone. Third important point was the assumption of relativelly flat relief formed by Paleogene sediments on which the stratovolcano was built-up. On the base of that facts there was made a reconstruction of probable relief the of stratovolcano with concave relief of stratovolcanic slope, with hight about 2500 m developed on flat paleorelief about 1150 m a.s.l. It is necessary to remark that altitude 1150 m a.s.l represents a recent situation as the regional block of the Western Veporicum underwent the large uplift in the post-volcanic stage during Upper Miocene and Pliocene.

Relics of Paleogene sediments of the Subtatric Group (Hutinská Formation, Eocene-Miocene) are preserved in an area located north of the central volcanic zone within the graben structures. Paleogene sediments at level about 700 m a.s.l. are exposed in the major extent in the Breznianska kotlina graben, limited by subparallel faults of NW–SE direction, sediments are represented by claystones and siltstones of the Huta Formation and polymict gravels of the Vajskovské conglomerate beds. The Paleogene sediments crop out at level 750 m a.s.l. in the SE continuation of the fault system in the Zbojské locality (at northern margin of the Kučelah massif of Mesozoic rocks).

In the northern part of the region, the Paleogene sediments are exposed in the graben between villages Bacúch and Heľpa, being limited by faults of WWS–EEN direction. The surface level of the Paleogene sediments within the smaller graben is about 670 m a.s.l. Differences among individual levels a.s.l. of the Paleogene sediments within the graben structures are evidently a result of their different degree of subsidence. As a real original position of the Paleogene sediments (not modified by the subsidence) is considered the outcrop on the eastern slope of the Magnetový vrch Hill, where they form siltstones with globigerines, sandy siltstones and fine sandstones (Vojtko, 2000), being deposited on the surface of Wetterstein limestones and dolomites at the level about 900 m a.s.l. with thickness about 50 m. Comparing with the paleorelief level at 1150 m a.s.l., it is necessary to count app. 190–200 m original thickness of Paleogene sediments in the area of the Magnetový vrch Hill. The Paleogene sediments, now occurring as a separate relics, subsided in the grabens, originally formed more continual flat relief on which the stratovolcano has developed.

3 – Paleovolcanic reconstruction of the Vepor stratovolcano

Paleovolcanic reconstruction is demonstrated in 5 profiles with orientation from the central volcanic zone to distal volcanic zone (Fig. 64).

SW sector of the stratovolcano

Profile No 1 (Appendix 6) begins in the central volcanic zone with diorite intrusion and continuing to SW it is crossing dyke swarm of basaltic andesites and basalts on the SW slope of Pacherka ridge and further to SW it passes through the intrusive-extrusive bodies on the northern slope of the Rozsypok ridge and in final part it continues in the Klenovský Vepor ridge with lava flow on the top of the paleovalley filling. Subvolcanic intrusive complex exposed on the eastern slopes of the Magnetový vrch Hill from level 550 m a.s.l. (bottom of the Rimava river valley) up to summit with e.p. 964 forms the diorite pluton (1) with transition into several sills, penetrating through the Mesozoic carbonate rocks and Paleogene sediments (more detail description of diorite intrusion see in Part I). Younger dyke swarms of andesite to diorite porphyry, dominantly trending WSW–ENE, penetrates through the diorite intrusion. Dominant part of dykes was consolidated in stratovolcanic structure and in the basement rocks (dykes of diorite porphyry with more advanced degree of crystallization of the groundmass). Several andesite to andesite porphyry dykes, reaching the surface of the stratovolcano, probably represented the feeding system of explosive and effusive eruptions and of parasitic (satellite) volcanoes on the upper part of stratovolcanic slope. Extent of the dyke swarms of diorite porphyry to andesite and andesite porphyry overlaps the dimensions of the central diorite intrusion, which indicates the further expansion of magmatic reservoir. Dyke system of basaltic andesites to basalts on the western slope of the Pacherka ridge is exposed from the level 550 m a.s.l. up to top of the ridge with altitude 930 m a.s.l. Dyke system follows fractures of ENE–WSW to E–W orientation. The main concentration of basaltic dykes (2) at the distance of about 2.5 km to SW from the central diorite intrusion, continuing up through the stratovolcanic structure to surface, was probably connected with the development of smaller parasitic volcano, placed in the higher part of the stratovolcanic slope at level about 2000 m a.s.l. Several dykes of basaltic dykes ascended along fractures near the margins of central diorite intrusion (top of the Pacherka ridge and its eastern slope).

In a greater distance to SW from the central zone in the area corresponding to lower stratovolcanic slope, there occur three intrusive-extrusive bodies of amphibole to pyroxene andesite, exposed by denudation on the northern slope of the Rozsypok ridge (Fig. 64) in subvolcanic (intrusive) level. Andesite body bellow e.p. Rozsypok (9) in the distance about 9 km from the central zone is uncovered in the level 1025–1065 m a.s.l. (about 35 m below the paleorelief). Next body (10) near to central volcanic zone with a distance of about 8 km, cropping out on the ridge below the e.p. 1128, is exposed at level 1088 m a.s.l. (about 120 m below paleorelief). Both andesite bodies (9, 10) after their ascend on the stratovolcanic slope have formed the dome-like extrusive bodies and represent probably the sources of the block and ash pyroclastic flows of the Merapi type. The third smaller body of pyroxene andesite bellow an e.p. 1088 (11), located 7.6 km from the central zone, being exposed at the level 925 m a.s.l. (175 m below the paleorelief), corresponds probably to lava neck, connected with parasitic volcano on the surface (Fig. 65). Three intrusive-extrusive bodies in their position exhibit binding on fault zone of WSW–ENE direction with radial orientation to central volcanic zone.

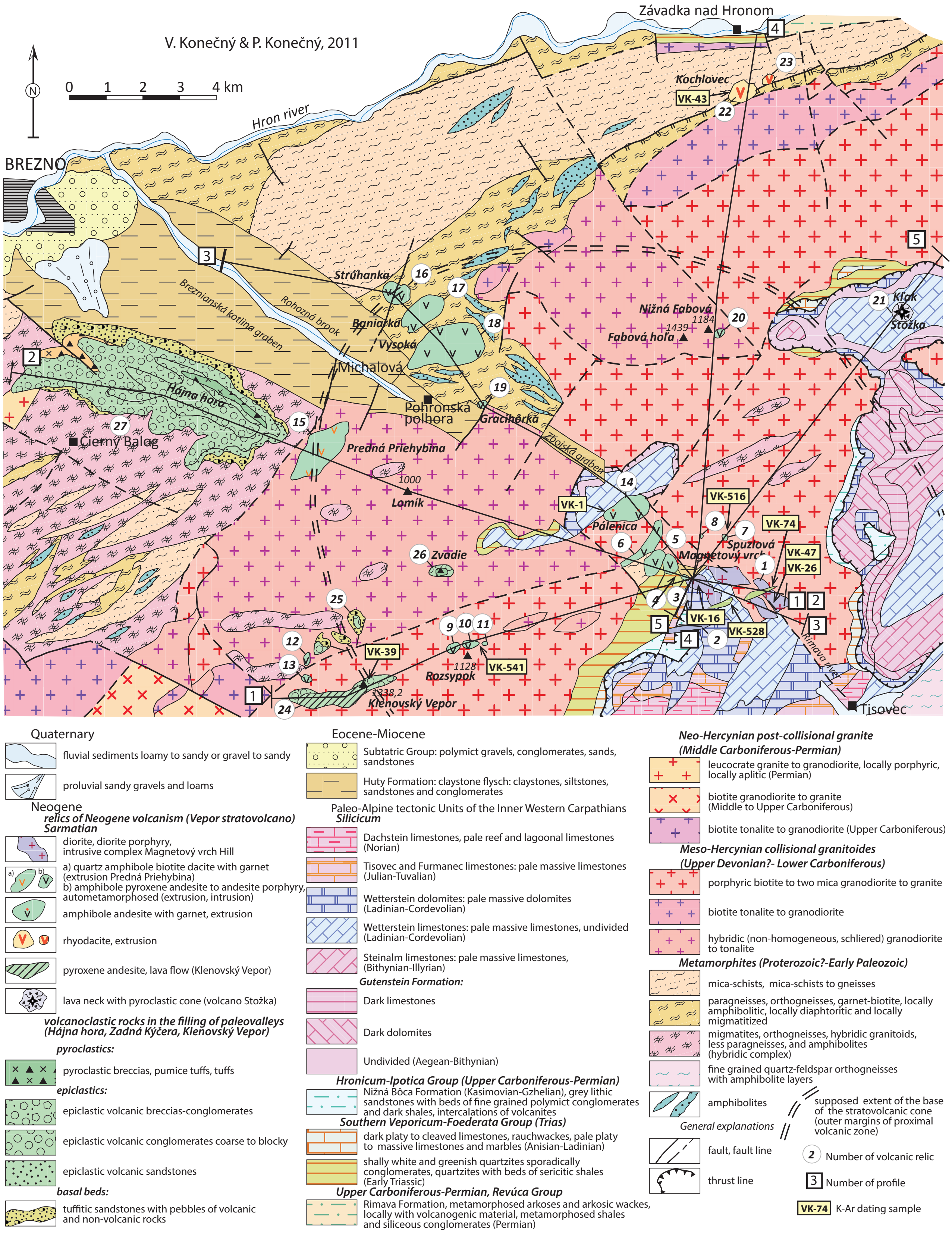


Fig. 64. Orientation of the paleovolcanic reconstruction profiles is indicated in the scheme of the western Veporic unit with relics of Neogene volcanism. Profile numbers are enclosed in squares.

In the distal external volcanic zone, situated about 12 km to SW from the central volcanic zone, there are identified two bodies on the northern slope of the Klenovský Vepor ridge. Body of autometamorphosed amphibole andesite porphyry (12) is exposed on the Molčanov grúň at the level from 850–925 m a.s.l. (175 m bellow the paleorelief). The second body of amphibole-pyroxene andesite (13) in higher part of ridge of Molčanov grúň is exposed about 950 m a.s.l. (150 m bellow paleorelief). We suppose that bodies represent feeds to small monogene extrusive volcanoes on the surface at foot of the Vepor stratovolcano.

The Klenovský Vepor like imposant highest ridge with e.p. 1338.2 represents relic of superficial original stratovolcanic structure removed by erosion. Lava flow (24) directing to west (with inclination of its base about 8–9° to west) forms the uppermost part of the paleovalley filling. The base of epiclastic volcanic complex beneath the lava flow, deposited on the crystalline rocks at the eastern side at level 1150 m a.s.l., is supposed as the level of the original paleorelief (that problem has been in more details already discussed before). The lava flow probably continued within the paleovalley further to west and finished in proluvial plain.

NW sector of the stratovolcano

The NW sector represents an area with maximum concentration of intrusive and extrusive bodies, including the Hájna hora Hill volcanosedimentary complex in the filling of the paleovalley. The NW sector is dissected by the expressive fault zone trending NW–SE (Fig. 64). The central diorite stock intrusion is divided by the fault zone of NW–SE direction in the Rimava river valley into two parts. In more subsided crustal block the Mesozoic carbonate rocks and relics of Paleogene sediments are preserved on the SW side of the fault zone. Mesozoic and Paleogene sediments on the eastern slope of the Magnetový vrch Hill are intruded by several sills from dorite intrusion and dissected by numerous dykes. On the NE side of the fault zone the Mesozoic complexes and Paleogene sediments in uplifted crustal block were completely removed by erosion, together with supposed apophyses of diorite intrusions. Fault zone continuing to NW divides (separates) the Kučelah massif with Mesozoic carbonate rock into two parts, more subsided block on the SW side of fault and relativelly uplifted block on the NW side of the fault (Klinec, 1975). Along the southern edge of Mesozoic rocks, the more subsided western block the Pálenica extrusive body of hyperstene–amphibole andesite with garnet (6) is placed (Fig. 64). From the NE edge of the Kučelah massif the fault zone continues to NW, where the limiting narrov Zbojské graben occurs with subsided Paleogene sediments. Further to NW after interruption also the graben of the Breznianska kotlina Depression with subsided Paleogene sediments was formed along this fault system.

Profile No. 2 (Appendix 6) with NW orientation begins in the central intrusive complex (1) and passes through the system of laccoliths of diorite to andesite porphyry and further to NW through the Predná Priehybina intrusive-extrusive complex and in the final part of section through volcanosedimentary complex of the Hájna hora Hill. On the NW side of the central Magnetový vrch intrusive complex a system of four laccolith intrusions of diorite to andesite porphyry is exposed. Relativelly small intrusive body (3) penetrates in the higher level of the western slope of the Magnetový vrch Hill through the Paleogene sediments and diorite sill. Next intrusive body (4) far to NW with isometric shape with, in a distance about 250 m from the central intrusive complex is exposed on flat top of hill at level 850 m a.s.l. (about 200 m below the paleorelief). The elliptical shape body Pred Nemcovou (5) far to NW with e.p. 757 in a greater distance from the central intrusive complex is exposed about 390 m below the paleorelief. The most distant Nemcová intrusive body (6) of elliptical shape with N–S orientation forms a ridge with e.p. 795 and continues to SW on the slope of the valley. The Nemcová intrusive body, located app. 1 200 m from the central intrusive complex, is exposed 350 m below the paleorelief. Based on geomagnetic survey and revealed shape of bodies, we suppose laccolith forms placed into the Mesozoic-Paleogene basement rocks eventually at the base of the stratovolcanic structure.

The Predná Priehybina more extended intrusive-extrusive complex of quartz amphibole-biotite dacite (15) in a distance of about 12 km to NW from the central zone is situated at the NW edge of the stratovolcano slope in a zone of transition into the proluvial plain. Complex of numerous intrusive-extrusive bodies is exposed from the level 620 m a.s.l. up to summit with e.p. 868. It is supposed that magmatic bodies during their ascent to surface have intruded through the overlying Paleogene sediments, respectively volcanosedimentary rocks of proluvial plain. After reaching the surface, the viscous magmatic bodies probably formed the extrusive domes. The orientation of the intrusive-extrusive complex indicates the preference of the NE–SW trending fault system.

In its final part the cross-section No. 2, passing through the Hájna hora Hill volcanosedimentary complex (27), presents the filling of the paleovalley, which continues from the foot of stratovolcano to NW. In recent relief the Hájna hora volcanosedimentary complex forms a NW–SE trending ridge with flat top and length app. 8 km. Bottom of paleovalley (base of the volcanosedimentary filling) at the eastern edge is in 850 m a.s.l., westward it descends to 650 m a.s.l. In corresponding direction also thickness of volcanosedimentary complex increases from 130 m to 200 m. Maximum depth of erosive cut in the basement crystalline rocks is about 500 m bellow the paleorelief. From the northern side, the Hájna hora volcanosedimentary complex is divided from the graben of Breznianska kotlina Depression by the fault zone of NW–SE direction. Along this fault zone the crustal block with Paleogene sediments in its uppermost part has subsided within the graben during the post volcanic vertical tectonic movements.

Profile No. 3 (Appendix 6) begins in the central diorite intrusive complex (14) and continues to NNW through the Nemcová body (6), Pálenica extrusive complex (14), the Kučelah massif with Mesozoic carbonates and along the Zbojské graben with Paleogene sediments, through the Gracihôrka intrusive body (19) and the complex of intrusive and extrusive bodies of autometamorphosed andesite porphyry north of Michalová village (18), (19), (20). Turning west, the profile No. 3 finishes in the graben structure of the Breznianska kotlina Depression.

The Pálenica extrusive complex (14) of hypersthene-amphibole andesite with garnet at the southern edge of subsided block of the Kučelah massif in the distance about 3.6 km from the central volcanic zone is exposed by denudation from the bottom of Čertova dolina at level 540 m a.s.l. up to the summit with e.p. 869 (about 280 m below the paleorelief). Extrusive complex consists of a number of extrusive bodies with zones of brecciation at margins. From the steep to vertical fluidal structures there can be deduced that after ascend on the surface of stratovolcanic slope, the extrusive domes were formed and surrounded by volcaniclastic material produced after their destruction.

The Gracihôrka intrusive body (19) of autometamorphed amphibole-pyroxene andesite porphyry of isometric shape located east of the Pohronska Polhora village is app. 8.8 km far from the central volcanic zone. Intrusive body of isometric shape is uncovered by denudation within the interval 725–775 m a.s.l. (corresponding to level about 375 m below the paleorelief). Stock-like intrusive body is situated near the fault zone of NE–SW direction, crossed by fault of NW–SE direction, limiting the graben structure. It is supposed that the stock-like body intruded through the Mesozoic and Paleogene rocks into lower levels of volcanic structure.

Profile No. 3 in a greater distance from the central volcanic zone passes through the complex of shallow intrusive bodies north of Michalová village near the northeastern edge of the graben structure of the Breznianska kotlina depression.

Intrusive body Vysoká (18), distant about 10.6 km from the central intrusive complex, was exposed by denudation from the level 625 m a.s.l. up to summit with e.p. 928 m a.s.l. (top of summit is about 225 m below the paleorelief). Geomagnetic survey revealed inhomogeneous inner structure of the complex consisting probably from numerous intrusive-extrusive bodies and/or shallow laccoliths. It is supposed that overlying complex was formed dominantly by the Paleogene sediments and higher above by volcaniclastic rocks of the northern stratovolcanic slope. Orientation of the body exposed in subsurface level indicates the preference of the NE–SW trending fault system.

The Baniarka intrusive body (17), distant about 12 km from the intrusive complex of the central zone, is exposed between levels 640–780 m a.s.l. (about 370 below the paleorelief). On the base of geomagnetic survey a laccolith-type body is supposed. The *Strúhanka intrusive body* (16) distant about 12.6 km from the central intrusive complex also represents laccolith and/or sill of smaller dimensions. Intrusive body is uncovered by denudation level about 650–675 m a.s.l. The Baniarka and Strúhanka laccoliths are located in the zone of proluvial plain. As a top wall of laccolith intrusions (16, 17) during their evolution by the Paleogene sediments and volcaniclastic rocks of proluvial plain are supposed.

NE sector of the stratovolcano

In the eastern sector of stratovolcano only sporadic relics of intrusive and extrusive bodies and a small pyroclastic volcano Stožka were identified.

Profile No. 4 (Appendix 6) with orentation to NNE begins in the central volcanic zone with diorite intrusion and crosses the intrusive body in the valley of Strieborný potok Brook (8), next intrusive body Nižná Fabová (20) and in a greater distance the rhyodacite body Kochlovec (23) south of Závadka nad Hronom village and after crossing the Hron river the profile finishes in the graben with Paleogene sediments between Bacúch and Heľpa villages. Intrusive body in the valley of Strieborný potok (8) exposed at level 675 m a.s.l. (about 475 m below the paleorelief) was probably consolidated in Mesozoic carbonate rocks and/or in stratovolcanic structure as a small stock-like body. The Nižná Fabová intrusive body of amphibole- pyroxene andesite porphyry (20) in a distance of about 6.5 km from the intrusive complex of central zone is exposed on the Nižná Fabová ridge with e.p. 1148 (east of Fabová hoľa e.p. 1430) within the level 1100–1140 m a.s.l. Intrusive body of elliptical shape with dimensions 150 x 200 m is supposed as a feeding system (neck) of parasitic volcano on the northern slope of the stratovolcano. The presence of Mesozoic carbonate rocks forming original paleorelief in this area remains an open question. The closeness of the carbonate Mesozoic massif of the Muránska planina Plateau about 2 km eastward makes that presence as probable.

The Kochlovec rhyodacite body (22) distant app. 13 km from the intrusive complex of the central volcanic zone forms hill with e.p. 825 south of Závadka nad Hronom in the northern area. Rhyodacite body is exposed about 325 m bellow the paleorelief in the environment of crystalline rocks at tectonic fault zone, separating a block of crystalline schists on the northern side of the fault from Hercynian granitoids on its southern side (Fig. 64). The rhyodacite body represented probably an extrusive dome-like form and/or thick laccolith, developed within Paleogene sediments. Eastward of Kochlovec body a smaller separate *rhyodacite body Za Kýčerou* (23) is also situated along the above mentioned fault zone.

It is supposed that the rhyodacite bodies after their origin were covered by younger Upper Miocene-Pliocene fluvial sediments and in consequence of it they were preserved from complete denudation. After their exhumation on the surface their original thickness was reduced by erosion. Profile No. 4 ends in Paleogene sediments preserved in the graben structure between Bacúch and Heľpa villages.

Profile No. 5 (Appendix 6) starts in the central diorite intrusion and towards NE it crosses intrusive body Spuzlová (7), further passes from the crystalline rocks on massif of Muránska Planina Plateau, built of Mesozoic carbonate rocks and after crossing Stožka pyroclastic volcano (21) with e.p. it continues in Mesozoic rocks and finishes in complex of crystalline rocks. At reconstruction of the pre-volcanic paleorelief of the profile No. 5, there is assumed the presence of Mesozoic carbonate rocks above crystalline basement at the northeastern side of the diorite intrusive complex and to some distance also the Paleogene sediments.

Remnants of the monogenic Stožka pyroclastic volcano, forming a hill with e.p. 1049 (21) at a distance 9 km to NE of the central intrusive complex, are deposited immediately on the surface of Mesozoic carbonate rocks with the base located about 1000 m a.s.l. Paleogene sediments and also volcaniclastic rocks of the Vepor statovolcano were not identified below the Stožka pyroclastic volcano. It is assumed that the high relief of the Muránska Planina Plateau was not covered by volcanic products of the Vepor stratovolcano and/or volcaniclastic rocks were removed by erosion before development of the Stožka pyroclastic volcano. Pyroclastic volcano of smaller dimensions consists of lapilli tuffs and scoria, often agglutinated with volcanic bombs. It was built-up during hawaian and strombolian eruptions. In the final stage the feeding channel was filled with the basalto-andesite magma, forming after consolidation the lava neck, which after the denudation of pyroclastic cone became exposed on the surface.

S and SE sector of the stratovolcano

In the area south of the Klenovský Vepor and Magnetový vrch hills with central diorite intrusion, there were not preserved relics of the stratovolcanic structure. As we mentioned before, a denudation advanced in this area below level of paleorelief 1150 m a.s.l. (base of stratovolcano) and original stratovolcanic structure was completely removed. To SW of the central volcanic zone there are exposed the dyke swarms of basaltic andesites in subvolcanic level and far to south a several relics of fillings of the deeper paleovalleys are preserved on the southern slopes of the Slovenské rudohorie Mts.

4 – Volcanic processes building the stratovolcano

Informations about volcanic processes during development of stratovolcano are recorded in the lithology of volcanosedimentary sequences, filling the paleovalleys on the western and southern slopes of the stratovolcano and also in the volcanosedimentary complexes of sedimentary basin of Vyšná Pokoradz Formation at the southern foot of the stratovolcano, now exposed on steep slopes of the Pokoradz and Blh plateaus. Volcanic events, occurring on the surface of the stratovolcano as e.g. volcanic eruptions, are recorded in sedimentary basin in lithological succession as intercalations and layers of fallen pummice tuffs and/or bodies of chaotic breccias of pyroclastic flows and lahars. From the analyses of their lithology, textures and petrography, there can be deduced types of volcanic eruptions, their intensity and also types and mechanism of transport of volcaniclastic material and its deposition. Based on this knowledge, the reconstruction of the stratovolcano evolution can be worked out.

1 – Volcanic activity of acid volcanism

First sign of volcanic activity of acid volcanism of andesite-dacite and dacite character is recorded in the region by the deposition of chaotic pyroclastic breccia of pyroclastic flow on the base of the Hájna hora Hill paleovalley filling, at its western side. Chaotic breccia consists dominantly of angular to subangular fragments, often glassy and vesiculated, of variable dimensions 5–30 cm, rare blocks up to 40 cm. Less abundant are small strongly to extremely vesiculated fragments of spheroidal shape. Fragments with phenocrysts of plagioclase, amphibole, hypersthene and biotite correspond to andesite-dacite and dacite. Tuffaceous ash-pumice matrix with crystalloclasts of plagioclase, amphibole, hypersthene and biotite with fragments of volcanic glass and smaller fragments andesite-dacite is low welded. Chaotic deposition of volcaniclastic material without signs of sorting and bedding points on transport and deposition by pyroclastic flow (Part I, Fig. 47). From the lithology of breccias there can be assumed that explosive destruction and collapse of extrusive dome had been probable a source of pyroclastic flow. The reworked pumice-ash tuffs with glassy andesite-dacite fragments with signs of sorting and bedding, following above chaotic breccia, indicate continuing explosive eruptions of plinian to phreatoplinian type. Ash-pumice tuff after fluvial transport was deposited at bottom in the western part of the paleovalley.

Up to now the position of eruptive center was not exactly localized as denudation in the region had advanced below the level of original paleorelief. Near the base in the eastern part of the Hájna paleovalley filling, there is a large block with dimensions about 15–20 m, being probably produced by the destruction of the andesite-dacite extrusive dome. Large block was transported and deposited on the bottom of paleovalley by gravity from relativelly near source. Eastward from the edge of the Hájna hora Hill in the distance about 600 m, there is exposed the Predná Priehybina intrusive-extrusive complex of quartz-amphibole-biotite dacite (15). Complex consists of a group intrusive-extrusive bodies uncovered by denudation about 280 m below supposed paleorelief. To correlation with deposits of pyroclastic flow on the bottom of Hájna hora paleovalley at the western edge must be based on petrological investigations.

2 – Evolution of andesite stratovolcano in the early stage

Early stage of evolution of the andesite stratovolcano was represented by the dominancy of explosive eruptions with discharge (output) of a great volume of ash tuffs. That is demonstrated by the thickness of tuff sandstones and/or epiclastic volcanic sandstones, deposited on the bottom of the Hájna hora paleovalley filling and also on the base of southern sedimentary basin of the Vyšná Pokoradz Formation (see geological-lithofacial map of the Hájna hora, Part I, appendixes 5 and 6, Fig. 76) and geological map and profiles of Vyšná Pokoradz Formation (appendixes 3 and 4).

Lahars (hyperconcentrated flows, debris flows)

Among processes transporting volcaniclastic material to greater distances from the volcano, the *lahars* occupy an important place. Within the lahars category, there are included the *hyperconcentrated* flows, transporting dominantly the fine ash-muddy tuff material. On the other side of a wide spectrum of mass flows, there are *debris flows,* which except of ash-muddy material transport also variable portion of the coarse to blocky clastic volcanic material. Between both types of lahars there exist continual transitions. The transport of the fine ash-muddy tuff material and its deposition in the area of sedimentation occurs also in volcanic fields by the dilute and muddy streams, as well as stream flows, which according to some authors, are not included into the cathegory of lahars in a more strict sense. For the origin of lahars there is necessary to meet some conditions: 1 – sufficient content of water, 2 – free, non-consolidated material, 3 – inclined relief, and 4 – initiation mechanism. Sufficient content of water is often secured by the heavy rains, accompanying eruptions, by the breakdown of the crater lake dam, the deposition of hot pyroclastic material on slope covered by snow, invading of hot pyroclastic flow into river and/or water basin, etc.). The initiation mechanism, which started to move masses of non-consolidated material, encompasses a rapid accumulation of the ash-tuff during eruption, seismic shocks, etc. Lahars with causal relation to volcanic activity or directly conditioned by volcanic processes are called as primary or syneruptive lahars. The lahars without direct relation to volcanic activity are secondary or postvolcanic lahars.

Study of lithology of lahars in filling of paleovalleys and in southern sedimentary basin allows to consider the conditions of their origin, relation to volcanic activity and composition of volcanic rocks on the stratovolcanic slope.

Hyperconcentrated flows

Masses of ash tuffs accumulated on slopes of stratovolcano during explosive eruptions have been oversaturated by water and after loosing of gravity stability (seismic shocks) they started to move as a mass like a *hyperconcentrated flow* to lower relief of sedimentary basin at the foot of stratovolcano directed by gravity energy. Beside the mass flows episodically mobilized on the stratovolcanic slope also the ash-tuff material was washed down during heavy rainfalls, which often accompanied explosive eruptions and the fine ash-tuff material was transported down by dilute watter streams and fluvial streams. The fine volcanic ash was also deposited during vulcanian and the plinian eruptions by ash fall directly from vulcanian cloud. This stage of stratovolcano evolution corresponds to growing of primary pyroclastic cone and/or ash cone. Mobilization of hyperconcentrated flows was frequent in early stage of building of the tuff cone and/or tuff-scoria cone. That fact is documented by lithology of deposits which consists dominantly of fine sandy-tuff material with content of pumice and andesite fragments of pyroclastic type. Higher content of pumice fragments (locality on SE slope of Viničný vrch) indicates actual explosive volcanic activity.

On the western slope of Pokoradz Plateau at locality Vyvieračka (NE of the Vyšný Skálnik village) a sedimentary sequence begins with deposition of lake siltstones with thin layers of ash and ash-pumice tuffs as products of the fall from volcanic cloud during initial vulcanian and ultravulcanian eruptions. Higher above the basal bed the bodies of massive non-bedded tuff-sandstones follow with dispersed pumices and andesite fragment representing deposits of hyperconcentrated flows. Higher above the bedded epiclastic volcanic sandstones there follows with fine clastic andesite material.

Thick lower complex of epiclastic volcanic sandstones on the base of the Vyšná Pokoradz complex is also exposed in abandoned quarries on the southern slopes of the Pokoradz Plateau (NE of Vyšná Pokoradz village). Bodies of massive non-bedded tuff-sandstones, deposited by hyperconcentrated flows, are separated by thin layers of lake siltstones (Fig. 24). Intercalations and thin layers of pumices in silstone layers document continuing explosive activity of vulcanian and plinian type.

Bodies of non-bedded epiclastic volcanic sandstones deposited by hyperconcentrated flows are also present in basal level of the Vyšná Pokoradz Formation on the southern slope of the Viničný vrch Hill north of the Španie Pole village (Fig. 7) and on the western slope of the Blh Plateau in locality at foot of the Veľká Lysá north of the Hostišovce village (Fig. 43).

Based on evidences presented above we can summarize that in the initial stage of evolution of the andesite stratovolcano there dominated the eruptions of vulcanian, plinian and ultravulcanian types with a great production of ash tuff and ash-pumice tuffs, being later followed by strombolian eruptions.

Information about the structure of stratovolcanic slope in the early evolutionary stage can be obtained from the study of the outcrop with pyroclastic rocks in subsided block at locality Zvadie on the summit of hill with e.p. 947 (at the settlement Chlípavica). In the lower part of the outcrop the breccia contains signs of sorting and higher there follows pyroclastic material with alternating lapilli tuffs with scoria and vulcanian breccias. This sequence is a result of vulcanian and strombolian type of eruptions.

Lahars-debris flows

More advanced early stage of evolution of the primary volcanic cone is reflected in the southern sedimentary basin by deposition of coarser clastic material by the debris flow resp. lahar. This situation can be documented by analysis of lahar deposits on the southern edge of the Pokoradz Plateau. In rock walls of abandoned quarries on the southern slopes of the Pokoradz Plateau (bellow e.p. 526 Stráň) above the sequence of bodies of hyperconcentrated flows, the chaotic breccia of the debris flow is exposed at the level 450 m a.s.l. (Fig. 26). The lahar breccia consists of fragments of variable dimensions (5–25 cm up to blocks 40–60 cm), where beside angular to subangular fragments also the vesiculated pyroclastic fragments of subspheric shape are present. Tuffaceous matrix with dispersed pumices and small angular to subangular and vesiculated pyroclastic fragments from 1–3 cm up to 5 cm large is dominant and forms about 80 % of the breccia. Lithology of the lahar breccia indicates that volcanic slope in this stage was built-up dominantly of pyroclastic material (lapilli, scoria volcanic bombs) from hawaian, strombolian and vulcanian eruptions Lahar breccia consists of lapilli-scoria pyroclastic material with scarse blocks up to 40 cm large. Smal angular fragments are present in less volume. Tuffaceous matrix is reddish, higher consolidated with signs of hot stage of the part of pyroclastic material during transport and deposition which corresponds to type of *hot lahar*. Mobilization of lahar occurred immediately after plinian eruption as it is proved by the presence of pumice material in thin siltstone interbed immediatelly beneath lahar. Imprints of flora and hollows after the trees in tuff at the base of lahar breccia (exposed on ceiling of exploited caves) confirm that the area of lower part of the stratovolcano slope was covered with vegetation and was forested. Lithological character of lahar indicates that it initiated in higher slopes of stratovolcano, formed dominantly of the tuff-scoria material, probably due to its rapid accumulation during eruption. Scarse rounded blocks in lahar breccia with dimensions 20–40 cm were mobilized from conglomerate beds in littoral zone at the southern foot of stratovolcano slope during movement of lahar (kinetic sieving). The kinetic sieving represents process when small particles migrate downward in lahar body and they are dispaced by larger ones which gradually migrate upward. It is reflected in reversal gradation of several lahar breccia.

Lahar body of different lithology is exposed on the southern slope of the Blh Plateau in lower part of the sequence at level 417 m a.s.l. (locality on the southern slope of Deravá skala). Composition of clastic material is significantly polymict (Fig. 56). Except angular andesite fragments with dimensions 3–10 cm and larger 30–40 cm subangular and rounded blocks, there are frequent fragments and blocks of crystalline schists, granitoids, Paleozoic sediments and migmatitized gneisses with dimensions up to 20 cm. Tuff-sandy matrix with higher content of clay component and with dispersed pumices is dominant and represents about 80 % of the volume. Lahar moving from volcanic slope and further within paleovalley to south has disturbed the pre-volcanic basement rocks of the walls and bottoms of the paleovalley which consists of different geological units. Lahar was initiated probably on the lower volcanic slope covered by epiclastic volcanic breccias and conglomerates. According to lithology, lahar belongs to cathegory of ***cold lahars*** to postvolcanic and/or secondary lahars. Position and polymict character of lahar corresponds to early stage of evolution of stratovolcanic cone.

Next lahar body is exposed on the summit of Mlynár Hill with e.p. 407.5. Lahar body is placed near the base of the Pokoradz Formation on the sequence of lower epiclastic volcanic sandstones with fine conglomerates. Lahar breccia consists of small strongly vesiculated subspheric fragments with dimensions 5–10 cm, rarely 25 cm (Fig. 63). Tuffaceous matrix of the light grey colour, locally reddish is consolidated with vesiculated fragments and dispersed pumice fragments. Beside pyroclastic vesiculated fragments also rounded andesite fragments are present in smaller amount, coming from underlying conglomerate bed. Part of vesiculated fragments points on hot state during their transport. Lahar transporting dominantly pyroclastic material was probably mobilized on higher volcanic slope during volcanic eruption and belongs to category of ***hot lahars***. From the position of lahar body near the base of lithological sequence there can be deduced that in the early evolutionary stage the volcanic cone was built-up with pyroclastic rocks.

Lithology of lahars of the higher levels of volcanosedimentary complex, corresponding to more advanced stage of evolution of the stratovolcano, is different. Lahar breccias are characterized with higher content of coarse to blocky material and missing and/or only sporadic presence of non-volcanic material. The lahar breccias can be examplified in outcrops located in the higher level of the southern slope of the Blh Plateau (locality Deravá skala at the level 483 m a.s.l.). Breccia in rocky cliff consists dominantly of pyroclastic fragments (vesiculated and subspheric shape) with dimensions 5–15 cm, less frequent there are subangular and angular fragments with dimensions 20–60 cm and scarse rounded blocks (Fig. 59). In the breccia there are sporadic fragments and greater blocks of sediments. Sandy-tuffaceous matrix with the content of small vesiculated and non-vesiculated fragments is non-welded, only stronger consolidated and locally reddish. Structure of the breccia is heterogeneous (locally higher accumulations of coarse to blocky material in other places with dominancy of sandy-tuffaceous material with content of smaller fragments). Lithology and composition of lahar breccia with dominancy of pyroclastic material and the presence of greater blocks indicate that mobilization of lahar has occurred during the pyroclastic eruption on higher levels of stratovolcanic slope. Higher degree of consolidation of tuffaceous matrix with smaller vesiculated fragments gives the evidence about hot stage of some part of pyroclastic material during its transport and deposition. Another alternative represents the pyroclastic flow invading into water environment, which after cooling, absorbing greater amount of water and mixing with older material was transformed into hot lahars. Both processes are leading to origin of hot lahars, respectively syneruptive and/ore primary lahars. In the higher level of the lithological profile on the southern slope of the Blh Plateu often alternation of hot lahars with pyroclastic flows was observed, reflecting the growth and space expansion of stratovolcanic structure in more advanced stage.

c – Eruptions of pyroclastic flows in the early stage

Eruptions of pyroclastic block and ash flows are phenomena which essentially contributed to growing and expansion of stratovolcanic structure in the early stage of evolution. Eruptions of vulcanian type from the central crater are characterized by lower eruptive column and after its collapse they generate the block and ash pyroclastic flow, moving down from the volcanic slope by gravity energy. Deposits of pyroclastic block and ash flows in the early stage of stratovolcanic evolution are identified in the NW sector of stratovolcano in filling of the paleovalley Hájna hora and also in the southern sedimentary basin of the Vyšná Pokoradz Formation.

In the lower level of the Hájna hora paleovalley filling on the nothern slope, the bodies of chaotic breccia of block and ash pyroclastic flows are exposed in the level 850–905 m a.s.l. Chaotic breccia consists dominantly of vesiculated fragments of variable dimensions from 5 cm to 30 cm up to blocks large 60–80 cm with subspheric shape, angular fragments are less abundant. Tuffaceous matrix is consolidated to partly welded with small vesiculated fragments (Part I. Fig. 59). Matrix represents 60–80 % of the breccia volume. Lithology of breccia corresponds to block and ash pyroclastic flows, generated during vulcanian type of eruptions. On the northern slope of the Hájna hora Hill at level 875 m a.s.l., the andesite block of large dimensions 3 x 6 m is present with agglutinated scoria at its edge (Part I, Fig. 62a, b). Andesite block coming from the destruction of the feeding system in crater zone and/or cryptodome? was thrown out on the volcanic slope during the vulcanian eruption. After the collapse of eruptive column it was probably transported with mass of pyroclastic flow, controlled by the gravity energy and deposited on the bottom of the Hájna hora paleovalley.

In the southern sedimentary basin of the Vyšná Pokoradz Formation, the early phase of eruptions of pyroclastic flow is demonstrable in outcrops of chaotic pyroclastic breccias near the Kyjatice village at level 444–470 a.s.l. (NE edge of the Pokoradz Plateau) and to W of Kraskovo village at level 375–380 up to 450 m a.s.l. (NW edge of the Pokoradz Plateau). Chaotic breccias deposited immediately on the surface of pre-volcanic basement rocks (Mesozoic carbonates and Paleozoic schists) are classified according their position as a ***layer-1***. Into the early phase of eruptions of pyroclastic flows there belong also relics of chaotic breccias at the level 270 m a.s.l. in subsided block of NE part of the Lučenská kotlina Basin along fault zone of NNW–SSE direction. Different altitudes of breccias indicate morphologically uneven relief during eruptions of the early phase of pyroclastic flows. Common feature of breccias encompasses the vesiculated fragments of subspheric shape of pyroclastic type (angular non-vesiculated fragments are less frequent) and higher content of tuffaceous matrix (70–80 %), often strongly welded with smaller vesiculated fragments. Greater angular blocks coming from the destruction of feeding systems (lithic blocks) are scarce. Lithology of breccias corresponds with the origin of pyroclastic flows during collapses of eruptive columns of the vulcanian type of eruptions from the central crater. Above relics of chaotic breccias of pyroclastic flows the coarse to blocky conglomerate beds are deposited in the littoral zone at the northern edge of the Pokoradz Plateau. There is evident that majority of primary chaotic breccia deposits underwent destruction in the littoral zone with further redeposition of clastic material.

Position of relics of chaotic breccia of pyroclastic flows at levels 330 and 342 m a.s.l. east of Rybník at the eastern edge of the Blh Plateau (locality Hlinisko-Fižliška) on the base of paleovalley filling allow to classify breccias as a *layer-1*. Breccia is characterized by vesiculated fragments of subspheric shape and by dominancy of tuffaceous matrix (70–80 % of volume) with signs of strong welding with vesiculated fragments. Block and ash pyroclastic flows at the eastern edge of the Blh Plateau are also supposed as products of the vulcanian type eruptions.

3 – Problem of lava effusions during formation of stratovolcanic cone

Chaotic breccias of pyroclastic flow evidently are not the only one source of clastic material of beds of the coarse to blocky epiclastic volcanic conglomerates, deposited in the littoral zone. It is supposed that essential volume of conglomerate material comes from the destruction of lava flows. But it is still open question about the measure of the lava flows contribution except pyroclastic rocks as ash tuffs and breccias to building of the primary stratovolcanic structure. In the present time there is preserved only one relic of the lava flow (the Klenovský Vepor ridge).

Andesite blocks with subparalel platy jointing along planes of lamination typical for lava flows are frequent in beds of coarse to blocky epiclastic volcanic conglomerates, pointing on their origin from destruction of lava flows. These blocks often of dimensions 2–4 m with laminar textures were several times documented (Figs. 20 and 32). Coming from the consideration of masses of rounded coarse to blocky andesite material, forming coglomerate beds of the Vyšná Pokoradz Formation in the area of southern sedimentary basin, altogether 5 to 6 beds of coarse to blocky conglomerates with thickness 5 to 15 m were identified. There is necessary to add also amounts of rounded coarse to blocky material in the paleovalleys filling. We are coming to conclusion that only minor part of volume of andesite blocks in conglomerate beds represents a product of destruction of chaotic breccias of pyroclastic flows, but dominant share is from lava flows. Lava flows descending down from stratovolcanic slope due to their higher viscosity finished at foot of stratovolcano forming thick accumulations in proluvial plane. Some lava flows on the southwestern slope of the stratovolcano continued far from it, moving due to the deepening of the paleovalley (the Klenovský Vepor ridge). The lava flows reaching the southern coastal zone of the sedimentary basin underwent destruction in the littoral zone with redeposition of the blocky material forming beds of coarse to blocky conglomerates. That consideration about structure of stratovolcano leads to conclusion that lava flows, except of pyroclastic rocks, have formed an essential part of the volume of the stratovolcano.

The conglomerate beds have developed due to continuing syngenetic destruction (degradation) of volcanic structure during its evolution. From the number of coarse to blocky conglomerate beds and their southward progradation in the sedimentary basin there can be indicated the gradual expansion of stratovolcanic structure and growing of its height. The constructive (aggradation) processes, building the stratovolcanic cone by explosive and effusive activity, have dominated above syngenetic destructive processes.

During evolution of conglomerate beds in the coastal zone, the explosive eruptions of vulcanian and plinian type continued in the area of stratovolcano, producing great volumes of ash and pumice tuffs. Phases of explosive activity are recorded by repeating supply of masses of ash-pumice tuffs, transported from stratovolcanic slopes by the dilute stream flows, hyperconcentrated flows, mud flows and lahars and deposited in the southern sedimentary basins like ash-tuffs and epiclastic volcanic sandstones. Sequences of epiclastic volcanic sandstones with thickness from several m up to 10–15 m alternate with beds of the medium to coarse blocky conglomerates (see geological-lithophacial map of the Vyšná Pokoradz Formation, Appendix 3 and 4). Actual explosive eruption of vulcanian and plinian type are recorded like intercalations and layers of vitrocrystal tuffs and pumice fall tuffs in sequences of epiclastic volcanic sandstones and tuff sandstones (Fig. 45).

4 – Block and ash pyroclastic flows in more advanced evolution of the stratovolcano

During the more advanced evolution of the stratovolcanic cone, the eruptions of pyroclastic flows became more frequent. Bodies of chaotic breccias of pyroclastic flows form the essential part of deposits of the Pokoradz and Blh plateaus in the southern sedimentary basin at southern foot of stratovolcano. During geological mapping, several thick layers with greater spatial distribution were distinguished. From the lithology and structures of chaotic pyroclastic breccias there was possible to deduce their different origin and mechanism of transport and conditions during their deposition and demonstrate it on several selected examples.

Chaotic breccia of pyroclastic flow – layer-2 with the base about 455–460 m a.s.l. is deposited at the NE edge of the Pokoradz Plateau above bed of coarse to blocky epiclastic volcanic conglomerate, forming flat top of the ridges Konková and Bankov vrch Hill east of Babinec village. Chaotic breccia continuing south is gradually spreading and cover the whole surface of the high Pokoradz Plateau (area south of Horné Zahorany village). In the southern part of the Pokoradz Plateau the base of chaotic breccia descends to the level 430–440 m a.s.l. Deposition of chaotic breccia of pyroclastic flow has occurred on the flat relief of bottom sedimetary basin with moderate inclination to south. Chaotic breccia in its areal extension is not lithologically uniform. In the northeastern part of the Pokoradz Plateau (ridges Konková and Bankov vrch Hill), the chaotic breccia is distinguished with dominancy of angular fragments and blocks up to 60–80 cm and relativelly low content of vesicular subspherical fragments and tuffaceous welded matrix (Fig. 9). Chaotic breccia of this lithology is probably a product of explosive destruction of massive dome-like andesite body, ascending in the crater zone (Merapi type of pyroclastic flow) and/or cryptodome packing the feeding system.

In the southern part of the Pokoradz Plateau (locality Ping) above breccia of Merapi type there is chaotic breccia of pyroclastic flow of different lithological type with the base at level 450 m a.s.l. Breccia consists of strongly to extremely vesiculated subspheric fragments with dimensions 8–20 cm, and rare blocks up to 50 cm and dominancy of tuffaceous intensively welded matrix of brown-red colour (Fig. 19). Breccia of younger pyroclastic flow and/or flow unit, following after destruction of cryptodome and opening of the feeding system, was generated during collapses of eruptive column of vulcanian type. Deposition of chaotic breccia of pyroclastic flows of layer-2 above thick complex of epiclastic volcanic silstones, alternating with several beds of coarse to blocky conglomerates, documents that eruptions of pyroclastic flows have occurred in a more advanced stage of stratovolcano evolution.

In the northern segment of the Blh Plateau, representing the eastern part of the original sedimentary basin, the chaotic breccia of pyroclastic flows corresponding to ***layer-2*** with maximum thickness about 50 m is deposited on the bed of coarse to blocky epiclastic volcanic conglomerate with the base at 440–445 m a.s.l. The base of chaotic breccia of layer-2 building flat top relief of the high plateau in direction to south gradually descends to level about 425 m a.s.l. at the southern edge. In rocky cliff near the northern edge of the plateau (at e.p. 436 m south of Španie pole village), the chaotic breccia is exposed in app. 15 m vertical profile (Fig. 42). In the lower part of outcrop the strongly welded tuffaceous matrix with smaller vesiculated fragments is dominant, forming about 60–70 % of the volume, vesiculated fragments of subspheric shape and dimensions 5–25 cm are in minority. In higher level of the rocky wall a gradual tendency to accumulation of coarser fragments to greater blocks was observed, forming reverse gradation. Several blocks show disintegration along radial and concentric fissures which documents their hot state during transport in pyroclastic flow. Light colours of incrustations along fissures and on the surfaces of hollows indicate ways of fumarols (Fig. 42). Lithology of chaotic breccia corresponds to pyroclastic block and ash flows, generated during collapses of eruptive columns of the vulcanian type.

In the northern segment also other lithological types of breccia of pyroclastic flow are present. In the southern part of the plateau of the northern segment (profile PF-34 on the Jablonka ridge), the chaotic breccia, deposited on the coarse to blocky epiclastic conglomerate with the base about 425 m a.s.l., consists dominantly of angular fragments with dimensions 5–25 cm up to blocks 40–60 cm and rare up to 1 m and with minor content of vesiculated fragments of subspheric shape (Fig. 47). Tuffaceous matrix is partly welded. Breccia is supposed as a product of explosive destruction of the extrusive body (extrusive dome), resulting in pyroclastic flow of the Merapi type. In higher position in the same ridge in rocky cliffs, the chaotic breccia with base at 442 m a.s.l. contains dominant strongly to extremely vesiculated fragments of subspheric shape with dimensions 5–30 cm (locality Pivničník). Tuffaceous matrix of reddish colour is strongly welded up to homogenized with vesiculated fragments (Fig. 48). Breccia corresponds to pyroclastic flow generated probably during collapses of eruptive columns of vulcanian type. From that is coming out that several types of pyroclastic flows of different origin took part in building of the northern segment of the Blh Plateau.

Layer-2 of the chaotic pyroclastic breccias in the southern segment of the Blh Plateau (after interruption caused by erosion), with the base app. at 430 m a.s.l., continues forming the upper parts of several ridges (Hradište e.p. 457.3, ridge Nad horárňou with e.p. 450–457.6, and ridge Dlhý vrch with e.p. 481.5). Chaotic breccia, exposed in rocky cliffs with dominancy of coarse to blocky andesite material, corresponds to Merapi type, generated by explosive destruction and collapses of extrusive domes (detailed description of breccia is presented in locality Hradište e.p. 457.3, Fig. 50).

Layer of ash-pumice flow breccia below chaotic breccia of layer-2 is exposed in abandoned quarry on the northern slopes of the ridge with e.p. 450–457.6 (Fig. 53). Smaller vesiculated fragments of subspheric and irregular shape with dimensions 5–15 cm, forming about 7–8 %, are strongly welded up to homogenized with pumice-ash matrix. Tuffaceous matrix, rich on pumice fragments, is dominant, forming app. 90 % of volume. Lithic fragments coming from older volcanic bodies are rare and they form about 2–3 %. Rounded andesite fragments coming from underlying conglomerate beds are scarse. Ash-pumice flow breccia was probably generated during the collapse of eruptive column of the plinian type. Bed of ash-pumice flow breccia was identified in several places of the northern slopes of Dlhý vrch e.p. 481.5 at level 433 m a.s.l. and also in the same level on the northern slope of the Holý vrch ridge with e.p. 487 m. The ash-pumice flow breccia evidently forms distinct horizont below chaotic blocky breccia of Merapi type in the northern part of the southern segment of the Blh Plateau.

In the gorge on the northern slope of the Holý vrch e.p. 487 a more complex vertical profile is exposed (in detail this profile is documented in Fig. 54). The analysis of lithological succession of this profile allows to reconstruct the volcanic events:

1 – In the lower part of outcrop in gorge, the layer of reworked tuff and pumice tuff with intercalations of fine andesite fragments is exposed at level about 430 m a.s.l. above conglomerate bed. Imprints of leaves, remnants of flora and signs of layering show on deposition in shallow limnic environment.

2 – Ash-pumice flow breccia deposited above reworked tuff dominantly consists of ash-pumice tuffaceous matrix, forming 80–90 % of the volume with smaller subspheric strongly vesiculated fragments. Angular andesite fragments are rare.

3 – Chaotic breccia block and ash pyroclastic flow follow in higher level above the ash-pumice flow breccia. Vesiculated 5–15 cm andesite fragments of subspheric shape are frequent, angular non-vesiculated fragments and lithic blocks large 30–40 cm are rare. Tuffaceous matrix with higher content of pumice is welded with smaller vesiculated fragments. In the vertical profile a higher concentration of andesite blocks in the upper part of outcrop can be observed, showing reversal gradation.

4 – In top part of the Holý vrch ridge e.p. 489 a chaotic breccia of pyroclastic flow of Merapi type is exposed in several rocky cliffs. Breccia is characteristic with dominant content of angular fragments and blocks up to 60–80 cm and tuffaceous welded matrix with minor content of vesiculated fragments.

The volcanic events, recorded in lithological succesion, can be summarized as follows: Volcanic activity had begun with huge eruptions of the plinian type, producing great masses of ash-pumice tuffs. Ash-tuff material fallen down was washed from the stratovolcanic slope and accumulated in limnic environment at the southern foot of the stratovolcano. Continuing plinian eruptions during collapses of eruptive columns produced the ash-pumice pyroclastic flows. Pyroclastic flows, moving down from the southern stratovolcanic slope, reached sedimentary basin, where pyroclastic material has deposited on its bottom. After plinian type of eruptions, the vulcanian eruption have followed and during collapses of the lower eruptive columns the block and ash pyroclastic flows have been mobilized. Block and ash pyroclastic flows, beside the ash and coarse vesiculated pyroclastic material, have transported also scarse blocks coming from the destruction of the feeding system and older parts of the volcanic structure. Following series of pyroclastic flows of Merapi type, building the uppermost part of lithological succession (top part of the ridges of Hradište e.p. 457.3, Nad Horárňou e.p. 450–457.6, Dlhý vrch e.p. 481.5 and Holý vrch e.p. 487), is characteristic with dominant content of coarse to blocky material. Block and ash pyroclastic flows of this type were probable related to destruction and collapses of extrusive domes, growing in the central crater and/or on stratovolcanic slope.

Chaotic breccia of pyroclastic flow – layer-3 with base at 475 m a.s.l. is exposed in several rocky cliffs on the southern edge of the Pokoradz Plateau below e.p. 526.4 and 524 Stráň (north of the Vyšná Pokoradz village). Breccia of pyroclastic flow overlies the bed of coarse to blocky epiclastic volcanic conglomerate. Breccia consists dominantly of angular fragments with dimensions 15–30 cm up to blocks 1.5 m large (Fig. 31). The subspheric and vesiculated fragments with dimension 10–15 cm are in minority. Tuffaceous reddish matrix is welded with small vesiculated fragments. Accumulation of fragments and blocks with greater dimension in the upper part of outcrop can be observed pointing to effect of kinetic sieving. In several outcrops of layer-3 big blocks to gigantic blocks are present with dimensions 4 x 5 x 3 m (e.p. 470.8 Háj), being produced by the destruction of extrusive dome and/or lava flow and transported together with material of pyroclastic flow (Fig. 32). The high energy of pyroclastic flow corresponds to high and steep stratovolcanic slope in a more advanced stage of its evolution.

Chaotic breccia of pyroclastic flow – layer-4 represents the uppermost unit of pyroclastic flows succession on the southern edge of the Pokoradz Plateau. Chaotic breccia is deposited on the surface of coarse to blocky conglomerate bed at the base at level 494–500 m a.s.l. Thickness of chaotic breccia about 30 m and lateral extent are pointing to presence of several pyroclastic flows as it was confirmed by study of outcrops. In the rocky cliffs bellow e.p. 512.7 Kozinec the chaotic breccia consists dominatly of subspheric vesiculated fragments with dimension 5–25 cm (Fig. 35). The angular fragments are less frequent, forming about 10–15 % of the volume. Tuffaceous matrix representing about vol. 60 % is strongly welded up to homogenized with small vesiculated fragments. Locally the reverse gradation of clastic material occurs.

In the outcrop in higher level of the slope below e.p. 512.7 Kozinec, two beds of chaotic breccia are separated with a thin ash tuff bed (Fig. 36). Chaotic breccias with dominancy of tuffaceous matrix and smaller vesiculated fragments of the layer-3 are probably generated by the collapses of eruptive columns of the vulcanian type.

Chaotic breccia of block and ash flow of different lithology with base about 505 m a.s.l. is exposed in rocky cliff below e.p. 514 at the eastern edge of Pokoradz Plateau (Fig. 38). In the lower part of rocky wall there is breccia with dominancy of strongly welded tuffaceous matrix and higher content of small vesiculated fragments. In the middle level of rocky wall, the amount of angular fragments with dimensions 10–20 cm is growing, tuffaceous matrix forms about 50 %. In the uppert part of the rock wall the angular fragments and blocks with dimensions up to 40–60 cm are dominant, tuffaceous matrix forms 10–15 %. In vertical section of the outcrop a distinct reversal gradation is observed, corresponding to effect of kinetic sieving during the movement of block and ash flow. Chaotic breccia of this flow type is supposed to be a product of explosive destruction and collapses of extrusive dome, ascending in the crater area (Merapi type) and/or extrusive domes like monogene parasitic volcanoes on the stratovolcanic slope. It can be summarized that in the more advanced stage of stratovolcano evolution the eruptions of pyroclastic flows were produced by collapses of eruptive columns of the vulcanian type and also by explosive destruction of extrusive domes (Merapi type). With the last eruptions of pyroclastic flows, the volcanic activity of stratovolcano probably culminated (because the younger products of volcanic eruptions in the southern sedimentary basin are missing). Deposition of the last pyroclastic flows filled sedimentary basin, eliminated sedimentation in essential part of the basin and created the flat relief of recent Pokoradz High Plateau and the Blh High Plateau.

5 – K/Ar radiometric dating and time of volcanic activity

Controversal opinions about the age of volcanosedimentary complex, forming the Pokoradz and Blh plateaus (the Vyšná Pokoradz Formation) at the northern edge of the Rimavská kotlina Basin, were expressed in previous geological investigations. The Explanatory book to geological map 1 : 200 000 (Kuthan et al., 1963) states the Badenian (that time Tortonian) age of volcanosedimentary complex, despite the results of biostratigraphical dating of the flora remnants in tuff-siltstone sediments at the lower level of the volcanosedimentary complex near the Nižný Skálnik village (north of the Rimavská Sobota town) indicated the Sarmatian age (Nemejc, 1960). The Sarmatian age of basal sediments of the volcanosedimentary complex was later confirmed again by the study of flora remnants (leaves) in localities near the Nižný and Vyšný Skálnik villages by Nemejc (1967), as well as Sitár and Dianiška (1979).

The first radiometric dating of rocks of volcanosedimentary complex was carried out by Repčok (1981) using FT method. Two samples of andesite rocks were dated – the andesite pebble from the conglomerate bed north of Višňové village yielded the age 16.4 ± 0.6 Ma (amphibole) and the andesite fragment from breccia of pyroclastic flow at the Chvalová village – the age 16.2 ± 0.8 Ma (amphibole), both belonging to Badenian.

Relics of scattered intrusive and intrusive-extrusive bodies exposed on the surface in the western part of the Veporic unit (now included to Vepor stratovolcano) have not been dated radiometrically up to now. Numerous geologists, working in this area, because of the advanced stage of denudation of the volcanic edifices, prefer the Badenian age (Kuthan et al., 1963; Burian et al., 1985; Vojtko, 2000), respectively longer interval of volcanic activity lasting from Badenian to Sarmatian (Bezák et al., 1999a, b).

New K/Ar radiometric dating and time of volcanic activity (discussion)

Ten samples of intrusive and volcanic rocks were analysed by conventional K/Ar technique in the Laboratory ATOMKI of Hungarian Academy of Science in Debrecen (DSc Pécskay Z.). Two samples were from the central diorite intrusion, one sample from the ryodacite extrusive body, two samples from extrusive bodies of andesite porphyry, one sample of diorite porphyry intrusion, three samples of dykes and one sample of the lava flow (localities of samples and analytical age are given in Tab. 1). The petrological examination in thin section proved that all samples were suitable for dating except of samples VH-74 and VK-516.

In the case of the dyke of diorite porphyry (VH-74), we would conclude that inheritance ("excess argon") of radiogenic argon is most probably to have occurred, because the presence of xenoliths of the older rocks (Hercynian granitoids and crystalline schists). Consequently this K-Ar age obtained on this sample has not any geological meaning, it can be considered only as an "analytical age". The intensively hydrothermally altered intrusion of dorite porphyry in locality Spuzlová (VK-516) may have been affected by the fluids related to the hydrothermal effect.

Rhyodacite body Kochlovec (VK-43), south of Závadka village, provided the age 12.53 ± 0.42 Ma. This supports the geological evidence that silicic magmatism preceded the intermediate andesite volcanism in this area. First manifestations of the dacite-rhyodacite volcanism is represented with the breccia block and ash pyroclastic flow and reworked ash-pumice tuffs, deposited on the base of the Hájna hora Hill paleovalley at its western edge below andesite volcanosedimentary complex.

Central diorite intrusion (pluton) was dated to 12.28 ± 0.42 Ma (sample VK-47) and 12.08 ± 0.42 Ma (sample VK-26). These data correspond to time of formation of subvolcanic intrusive complex below stratovolcano in subvolcanic level. The development of extrusive complexes on the stratovolcanic slope, dated to 12.25 ± 0.50 Ma (sample VK-541 of extrusive body below the Rozsypok ridge) and 12.10 ± 0.38 Ma (sample VK-1 of extrusive body Pálenica) shows the

Tab. 1. Table of radiometric K/Ar ages.

No.	locality	type of body	rock	volcanic zone	age (Ma)	K (%)	$^{40}Ar_{rad}$ ($10^{-6} cm^3/g$)	$^{40}Ar_{rad}$ (%)
VK-39	Klenovský Vepor ridge e.p. 1338.2	lava flow	pyroxene andesite	proximal	**11.56 ± 0.43**	1.77	0.80	47.30
VK-16	NE of Magnet Hill e.p. 964.8	dyke	amphibole pyroxene andesite porphyry (PxM)	central	**11.94 ± 1.00**	0.92	0.43	16.50
VK-528	W of Pacherka ridge e.p. 959.6	dyke	basaltic andesite (B)	central	**12.02 ± 1.05**	1.87	0.88	15.80
VK-26	valley of Rimava river, quarry	diorite intrusion, 3rd phase	diorite (D1)	central	**12.08 ± 0.47**	0.83	0.39	43.00
VK-1	quarry on W slope of Pálenica ridge	extrusion	amphibole andesite with garnet	proximal	**12.10 ± 0.38**	1.70	0.80	78.80
VK-541	ridge with e.p. 1088 to NE of Rozsypok	extrusion	amphibole pyroxene andesite	proximal	**12.25 ± 0.50**	1.65	0.79	40.10
VK-47	valley of Rimava river at e.p. 536	diorite intrusion, 3rd phase	diorite (D1)	central	**12.28 ± 0.42**	1.53	0.73	55.10
VK-43	quarry on W slope of Kochlovec hill, e.p. 825 to S of Závadka village	extrusion	rhyodacite	proximal	**12.53 ± 0.42**	1.77	0.86	60.80
VK-516	quarry on W slope of Spuzlová valley	intrusion	diorite porphyry, autometamorphosed	proximal	{14.16 ± 0.73}[1*]	1.49	0.82	28.50
VK-74	slope to E of Rimava river, cliff	dyke	diorite porphyry, altered, actinolitized (H1)	central	{29.49 ± 1.06}[2*]	0.90	1.04	49.90

[1*] unreliable age due to strong alteration, [2*] unreliable age due to contamination by older material

time overlap with formation of subvolcanic intrusive complex. The concordancy of the K-Ar ages obtained from the extrusive domes (VK-1 and VK-541) manifests that these volcanic forms were emplaced within a short time interval.

The younger dyke system intruding through the central diorite intrusion was dated to 12.2 ± 1.05 Ma (sample VK-528 Ma, dyke of basaltic andesite) and 11.94 ± 1.0 Ma (sample VK-16, dyke of amphibole-pyroxene andesite).

On the basis of the K/Ar age determination there is concluded that the main intrusive magmatism in internal and external structure of the stratovolcano has occurred in interval 12.28–11.50 Ma (samples VK-528 and VK-16). There are no grounds for supposing that the age of the extrusive magmatism could be much older than actual time of intrusions. On the other hand we are not able to exclude the possibility that some slight rejuvenation has occurred, which can be correlated with increasing alteration and weathering of the dykes (see the high atmospheric argon percentages in these samples). Consequently, within the context of our new data, the similarity (within the analytical error limits) of the dykes age and of the extrusions age is a strong indication that andesitic extrusions and the subsequent dyke intrusions are virtually contemporaneous.

The lava flow of pyroxene andesite, forming summit of the Klenovský Vepor ridge (e.p. 1338.2), analysed in this study with the age of 11.56 ± 0.43 Ma (sample VK-39), indicates that a temporary distinct volcanic phase clearly exists app. at 11.6 Ma. Taking into consideration that all K-Ar ages, obtained on these intrusive/intrusive-extrusive bodies and volcanic rocks, belong to different horizons of the Vepor stratovolcano, so the age of the lava flow may reflect the termination of volcanic activity in this area. The results of the radiometric dating contributed in a great measure to compiling a model of evolution of the stratovolcano during the Sarmatian time and they are in good correlations with biostratigrafic data of the southern volcanosedimentary complex of the Vyšná Pokoradz Formation.

6 – Paleovolcanic reconstruction of the Vepor stratovolcano evolution related to southern sedimentary basin of the Vyšná Pokoradz Formation

Acid volcanism preceeding evolution of the Vepor andesite stratovolcano

Beginning of the activity of acid volcanism has occurred in extensional regime in the western part of Veporic unit, being accompanied with its disintegration into separate blocks and their vertical movements. The origin of dispersed intrusive-extrusive bodies of dacite-rhyodacite composition was related to the fault zones of NE–SW direction, eventually their crossing with faults of transversal NW–SE system. The extrusive bodies like extrusive domes and complexes were formed (Kochlovec, Za Kýčerou, Predná Priehybina). Due to the explosive destruction and collapses of extrusive domes, the block and ash pyroclastic flows originated, transporting volcaniclastic material far from volcanic centers and being followed by explosive eruptions of ash-pumice tuffs (deposits of chaotic breccia and ash-pumice tuffs on base of the Hájna hora paleovalley filling). Volcaniclastic rocks and bodies of acid volcanism have been later removed by erosion (with an exception of several strongly eroded bodies and relics of volcaniclastic rocks, preserved on the bottom of the Hájna hora paleovalley fill).

Evolution of the Vepor stratovolcano related to development of southern sedimentary basin

The results obtained from the study of volcaniclastic complexes in filling of the paleovalleys and sedimentary basin allow to reconstruct the dynamic evolution of the Vepor andesite stratovolcano related to sedimentary basin of the Vyšná Pokoradz Formation located south of the stratovolcano with distinguishing several stages (Fig. 70):

1st stage. Activity of andesite volcanism started with explosive eruptions of ash-pumice tuffs of large volumes (eruptions of the vulcanian, ultravulcanian and plinian types). Explosive eruptions of this stage are recorded in deposition of the ash-tuff and sandy tuffs on the bottom of the Hájna hora (eastern part) and especially on the bottom of subsiding depression with fluvial-lake sedimentation at the southern slope of the stratovolcano. On the beginning of volcanic actity, the ash-tuff material was transported into originating sedimentary basin by washing down from the volcanic slope during heavy rainfalls and by mudflows, diluted muddy flows and streams, eventually as ash-falls directly from the vulcanian cloud. In the sedimentary filling of the southern sedimentary basin, the volcanic activity of this beginning stage is represented by thin interbeds of vitrocrystal tuffs, ash-tuffs and ash pumice tuffs, alternating with the fine lake silts and siltstones often with remnants of flora and imprints of leaves. During the continuing eruptions of the ash-pumice tuffs, the ash-tuff pyroclastic cone was gradually built-up northward of subsiding sedimentary basin. The non-consolidated fresh ash tuffs masses have accumulated on the stratovolcanic slope due to oversaturating by the water (heavy rains often accompanying volcanic eruptions) and after seismic shocks they started to move like a mass flows-hyperconcentrated flows down from stratovolcanic slope, being controlled by the gravity energy and directed to depressions and paleovalleys at the foot of stratovolcano. The deposits of hyperconcentrated flows, like bodies of non-bedded sandy tuffs, were identified in the lower levels of the volcanosedimentary sequences of the Vyšná Pokoradz Formation in the southern sedimentary basin and Hájna hora paleovalley filling. After decreasing intensity of ultravulcanian and plinian explosive eruptions, the eruptions of strombolian and vulcanian types follow, producing scoria-lapilli tuff, fine and coarse pyroclastic rocks, as well as scoria with volcanic bombs, covering slopes of stratovolcano. After loosing stability of pyroclastic material, accumulated on stratovolcanic slope, it started to move like a lahars (debris flows) down from the stratovolcanic slope. That stage of evolution of the volcanic cone is documented in the southern sedimentary basin by deposition of chaotic lahar breccia, exposed in walls of abandoned quarries on the southern slope of the Pokoradz Plateau (locality be-

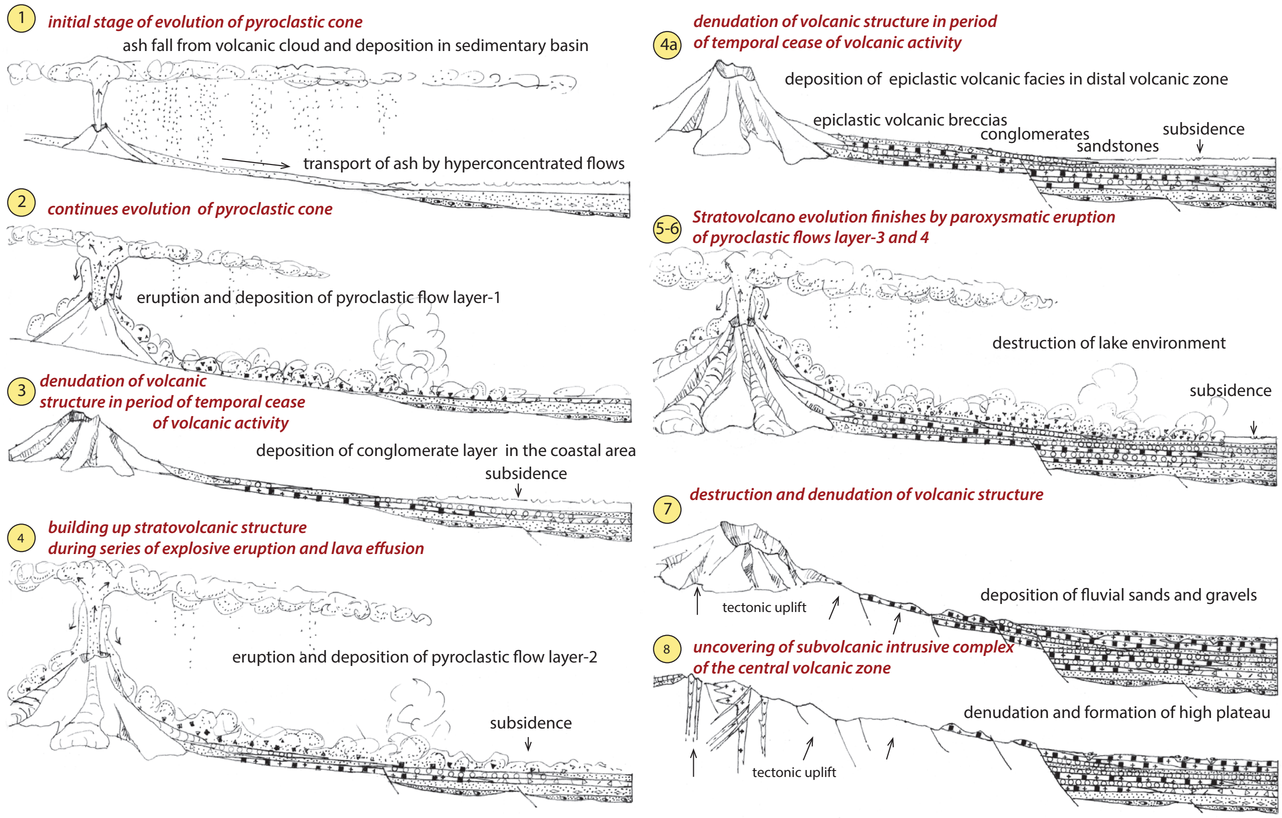


Fig. 65. Scheme of evolution of the Vepor stratovolcano related to the south located sedimentary basin.

low e.p. 453 Stráň northeast of the Vyšná Pokoradz village, Fig. 26). Lahar breccia consists dominantly of pyroclastic material with higher degree of consolidation, indicating hot state during the transport – hot lahar. Cavities after trees, transported by the lahar, document the fact that in this stage of the volcanic cone evolution, the area at the southern slope of volcano was forested. This stage of evolution of volcanic cone documents also lithology of the lahar breccia NE of the Horné Zahorany village (locality below e.p. 436 Remešík at level 410 m a.s.l.) with dominancy of pyroclastic material, scoria and volcanic bombs (Fig. 10).

2nd stage. In the more advanced stage of the volcanic cone evolution the eruptive mechanism has changed. During eruption and collapses of low eruptive columns of vulcanian type, rich in coarse to blocky pyroclastic material, the block and ash pyroclastic flows were generated. Pyroclastic flows moving down from the volcanic slope often reached the northern edge of the southern sedimentary basin, where the pyroclastic material has deposited. This stage of evolution is represented by bodies of chaotic pyroclastic breccia, deposited directly on the surface of Paleozoic-Mesozoic basement rocks at the northern edge of the Pokoradz Plateau. Pyroclastic flows in their ways follow separated lines conditioned by morphologic elevation of pre-volcanic basement rocks in the area around Kraskovo village. Eastern line represents pyroclastic flow finished in the Kyjatice village surrounding at the level 444–475 m a.s.l. Western line was followed by the pyroclastic flow, directing to SW into the Lučenská kotlina Basin. Relics of chaotic breccias were found at level 440 m a.s.l. (west of Kraskovo village) and continuing to SW they were deposited in lower level of app. 375–380 m a.s.l. (locality Rimavická hora). Pyroclastic flow follows the line to SW in the northern part of Lučenská kotlina Basin. Now the relics of chaotic breccias of pyroclastic flow filling original paleovalley in the north-eastern part of this basin occurred at level about 295–300 m a.s.l. This lower position comparing with northern part of the Pokoradz Plateau is caused by later tectonic subsidence of the block of NE part of the Lučenská kotlina Basin. Different altitudes of relics of chaotic breccias of pyroclastic flows document an uneven morphological relief in the northern part of sedimentary basin.

Pyroclastic flows generated during collapses of eruptive columns of vulcanian type contribute to building of volcanic slope. Several pyroclastic flows, reaching the southern sedimentary basin after invading into the lake environment due to cooling and mixing with water and lake sediments, were transformed into hot lahars, resp. cold lahars. Bodies of hot lahars were identified on the southern edges of the Blh Plateau and on the top of isolated hill with e.p. 407.5 Mlynár (Fig. 63). Pyroclastic and epiclastic volcanic material accumulated on stratovolcanic slope after loosing its stability (oversaturating by the water, seismic shock) was moving down from the volcanic slope as mass flow-lahar (debris flow) and further to south on the bottom of the sedimentary basin as a cold lahar, reaching great distances from the volcano. Bodies of cold lahars are identified dominantly on the southern slope of Blh Plateau in lowest levels. Below the ridge with e.p. 471 at level 380 m a.s.l., the chaotic breccia of cold lahar is exposed. Breccia consists of angular and partly rounded fragments with dimensions 5–15 cm and rare rounded blocks up to 50 cm large. Sandy-tuffaceous matrix forms about 60–70 % of the volume. Next body of cold lahar with up to 30 cm large blocks is exposed in cliffs on the southeastern slope of the Deravá skala Hill at level 417 m a.s.l. (Fig. 56). Breccia is characteristic with the dominancy of sandy tuffitic matrix with higher content of argillite component and polymict clastic material. Except of smaller andesite fragments with 3–10 cm dimensions and rare blocks up to 30 cm large, there is frequent clastic material of granitoids, crystalline schists and Paleozoic sediments. Polymict composition of clastic material indicates that lahar, before reaching of sedimentary basin south of volcano, was moving in the paleovalley, which has cut the different crystalline rocks and Paleozoic sediments. Lahar was mobilized in the early stage of the volcanic cone evolution probably at its lower slope.

3rd stage. Relativelly long time of continuing subsidence of the southern sedimentary basin is accompanied with the deposition of coarse to blocky epiclastic volcanic conglomerate beds, alternated with thicker beds of epiclastic volcanic sandstones. In the sedimentary basin during this stage there are not direct evidences for making decisions about the stratovolcanic cone forming processes, except of intercalations and thin interbeds of pumice tuffs in beds of epiclastic volcanic sandstones between conglomerate beds.

Within the conglomerate beds in the southern sedimentary basin, the frequent andesite blocks with laminar platy jointing prove their origin owing to destruction of the andesite lava flows. It indicates that during this stage the lava flows also contributed to growth of the stratovolcanic slope. Lava flows, leaving the stratovolcanic slope, episodically reached edges of sedimentary basin, where in the coastal zone they underwent the destruction. Originating coarse clastic material has contributed to development of beds of coarse to blocky epiclastic volcanic conglomerates. Lava effusions were not the only manifestations of volcanic activity during this stage. Great volumes of volcanic ash-tuffs falls from vulcanian, ultravulcanian and plinian eruptions were washed down from the stratovolcanic slope and surrounding area, being next transported by the dilute flows, streams, hyperconcentrated flow and lahars to the southern sedimentary basin and deposited like a thick beds of epiclastic volcanic sandstones, alternating with conglomerate beds. Direct proofs of the plinian and ultravulcanian eruptions, passing from summit of the stratovolcano, represent intercalations and thin interbeds of vitrocrystal and ash-pumice tuff, fallen from the volcanic cloud (Fig. 45). Transport and deposition of masses of ash-tuffs and sandy tuffs during growing of andesite stratovolcano and its space expansion was compensated with gradual subsidence of sedimentary basin and southward progradation of the coastal zone. The maximum subsidence in the southwestern part of the sedimentary basin is indicated by the accumulation of volcanosedimentary rocks thick about 200 m. In the southwestern side of the volcanosedimentary complex, altogether 5–6 beds of the coarse to blocky conglomerates, alternating with the thick beds of epiclastic volcanic sandstone, were identified. We suppose that during relativelly long lasting 3rd stage, the stratovolcanic structure reached its essential dimensions and height and represents a typical andesite stratovolcano built-up of pyroclastic and epiclastic rocks, as well as the lava flows. The results of radiometric dating within the interval 12.28 ± 0.50 to 12.08 ± 0.47 indicate at the end of this stage the formation of intrusive diorite complex under the volcano, as well as the origin of scarn mineralization at the contact with carbonate rocks.

4th stage. Begining of volcanic activity is characterized by the huge explosive eruptions of plinian and vulcanian types. During repeated collapses of eruptive columns the block and ash pyroclastic flows generated. Moving down from the stratovolcanic slope southward they covered the proluvial plain at the foot of the stratovolcano and invaded the basin with fluvial-limnic sedimentation. Deposition of pyroclastic flows, covering flat surface of coarse to blocky conglomerates in the proluvial plane and the northern part of the basin, has formed the layer of chaotic breccia in the thickness of about 25–30 m named as ***layer-2***. The base of this layer at the northern edge of the Pokoradz and Blh plateaus is in level 445–460 m a.s.l. and at the southern edge at level about 430 m a.s.l., indicating flat relief of the bottom of sedimentary basin with moderate dip to south. Lithological composition of the layer-2 is vertically and laterally heterogeneous. There were identified deposits with dominancy of pyroclastic material with welded tuffaceous matrix, which are supposed as products of collapses of eruptive columns of vulcanian type and on other places the deposits of ash blocky breccias, related to explosive destruction and collapses of extrusive domes. This situation can be explained on the profile in the erosive cut below e.p. 489 on the northern slope of the southern segment of the Blh Plateau (Fig. 54). Volcanic activity begin with plinian eruption. Ash-pumice tuff after fall down from volcanic cloud on the stratovolcanic slope and higher topographic levels in the surrounding has been replaced – washed down into local depressions in the proluvial plain. During continuing series of plinian eruptions and collapses of eruption columns, the ash pumice pyroclastic flows with content of strong to extremely vesiculated fragments have generated, reaching the southern part of the sedimentary basin. After decline of eruptions intensity (due to degasing of magmatic reservoir), the block and ash pyroclastic flows were formed by collapses of the lower eruptive columns of vulcanian type. The block and ash pyroclastic flows are characteristic with a higher content of vesiculated pyroclastic fragments welded with tuffaceous matrix and with the presence of larger blocks coming from the destruction of the feeding system. The following sequence of block and ash-flows with dominancy of blocks of larger dimensions, forming the upper part of lithological profile (Fig. 50), was probably related to ascend and collapses of extrusive domes in the central crater and/or on stratovolcanic slope (Merapi type). It is supposed that stratovolcano in this stage reached the maximum height and dimensions. After the destruction of central feeding system, the ascend of magma and eruptions probably occurred from the eruptive centers of parasitic volcanoes on the upper and lower stratovolcanic slope. This idea is supported by the results of radiometric data of extrusive bodies of amphibole andesite in the Rozsypok locality on western part of stratovolcano, dated to 12.25 ± 0.50 Ma, and the extrusive complex of hypersthene amphibole andesite with garnet in locality Pálenica (NW side stratovolcano) with the age of 12.10 ± 0.38 Ma. By the deposition of chaotic breccias of pyroclastic flows – layer-2, the extended flat cover originated in the area of the southern proluvial plain at the southern slope of stratovolcano. Dominant part of the uppermost flat relief of the Pokoradz and Blh plateaus was formed by the deposits of chaotic breccia of layer-2. Continuing evolution of the southern proluvial plain during the temporary break of volcanic activity is represented by the deposition of incoherent layers of coarse to blocky conglomerates, epiclastic volcanic sandstones and lahars in local depressions. On the southern edge of the Blh Plateau, above chaotic breccia of pyroclastic flow, there lies a body of lahar breccia and higher coarse to blocky epiclastic volcanic conglomerate. The stage of temporary break of volcanic activity is designated as stage 4a.

5th stage. New stage of volcanic activity, following after temporary break, has started with energic eruptions, generating the southward directed block and ash pyroclastic flows from the stratovolcanic slope into the southern proluvial plain. Deposits of chaotic breccia of pyroclastic flows represent **layer-3**. On the southern edge of the Pokoradz Plateau the chaotic breccia of block and ash pyroclastic flow – layer-3 is deposited on the surface of coarse to blocky conglomerate at the level 475 m a.s.l. (southern slopes below e.p. 526.4 Stráň). Chaotic breccia consists dominantly of angular fragments with dimensions 5–30 cm up to blocks 1.5 m large, smaller vesiculated fragments are less frequent (Fig. 31). Tuffaceous matrix is strongly welded. Reverse gradation with accumulation of larger blocks in the upper part of the breccia body indicates the process of kinetic sieving. Block and ash pyroclastic flow of this type was probably generated during the explosive destruction and collapse of extrusive dome in the summit area of the stratovolcano. Above chaotic breccia, the bed of coarse to blocky epiclastic volcanic conglomerate is deposited.

On the southern edge of the Blh Plateau, the chaotic breccia of the lithology, corresponding to layer-3, is deposited with the base at 465 m a.s.l. on the surface of coarse to blocky epiclastic volcanic conglomerate. Higher the breccia of hot lahar follows with the base at 483 m a.s.l. (Fig. 59). Lahar breccia probably represents pyroclastic flow, which after entering into water environment was transformed into hot lahar. It is supposed that during this stage the volcanic eruption occurred also from several centers of parasitic volcanoes on the western slopes of the stratovolcano. In the sedimentary basin at the southern foot of the stratovolcano during this stage there continued the subsidence with local deposition of conglomerate material and epiclastic volcanic sandstones in the local depressions. The area was episodically reached by lahars.

6th stage. After short break without volcanic activity, the sedimentary basin in the southern part of the Pokoradz Plateau has recorded the huge eruptions of pyroclastic flows of a final stage of volcanic activity. The chaotic breccias thick about 30 m, representing ***layer-4***, were deposited above conglomerate bed. They consist evidently of several pyroclastic flows with different lithology. Chaotic breccia of pyroclastic flow on the southern edge of the Pokoradz Plateau below e.p. 512.7 Kozinec at level 495–500 m a.s.l. consists dominantly of vesiculated subspheric fragments with dimension 5–15 cm up to 25 cm, angular fragments represent about 10–15 %. Tuffaceous matrix is strongly welded and homogenized with vesiculated fragments (Fig. 35). Several blocks with radial and concentric jointing (Fig. 35) and signs of fumarolic activity (Fig. 35) document hot stage of pyroclastic material after its deposition. Lithology of breccia indicates its origin from collapses of eruptive slopes of the vulcanian type.

Chaotic breccia at the southeastern edge of the Pokoradz Plateau below e.p. 514, deposited above the bed of coarse to blocky epiclastic volcanic conglomerate with the base at level 505–508 m a.s.l., shows the contrastly different lithology. Dominantly angular, coarse to blocky andesite material, forming breccia (subspheric vesiculated material is less frequent) with reverse gradation, indicates an effect of kinetic sieving (Fig. 38). Chaotic breccia corresponds to block and ash pyroclastic flows, produced by explosive destruction and collapses of extrusive domes (Merapi type). We can summarize that during the final stage of the stratovolcano activity the eruption of block and ash pyroclastic flow came from different centers, being generated by different processes. It is supposed that the final eruptions of block and ash pyroclastic flows were accompanied with the extensive destruction of the summit area of volcano and they probably finally finished volcanic activity of the stratovolcano.

The deposition of thick bed of chaotic breccia of several pyroclastic flows (layer-4) finished the lake sedimentation in sedimentary basin and consequently flat relief originated (recent flat surface of the Pokoradz and Blh plateaus). Lake sedimentation has shifted further southward as is proved by the rare relics of volcaniclastic rock (epiclastic volcanic sandstones, siltstones and fine conglomerates) and to SE to app. 15 km distance from the southern edge of the Blh Plateau (near the Šafárikovo town). On the earlier proluvial plain (of preceding sedimentary basin of the Vyšná Pokoradz Formation), the fluvial sediments were deposited by numerous rivers, transporting material from the slopes of eroded stratovolcano. Fluvial sediments as epiclastic volcanic sandstones and fine to coarse conglomerates were filling erosive cuts and local depressions on the surface of thick bed of chaotic breccia on the flat top of the Pokoradz and Blh plateaus (Fig. 37).

Concerning to final stage of volcanic activity of the 6th stage, the knowledge from the southern sedimentary basin of the Vyšná Pokoradz Formation demonstrates that in this final stage the eruptions occurred probably from several eruptive centers in the summit area and also on stratovolcanic slopes from parasitic volcanoes. Except eruptions of the vulcanian type, producing block and ash pyroclastic flows, during the collapse of eruptive columns in the summit area of the stratovolcano and also on stratovolcanic slope, numerous extrusive domes were formed. Their ascent and growing was associated with explosive destruction and collapses, generating block and ash-flows, moving down from the stratovolcanic slope southward to sedimentary basin, where they finished. Idea of a number of parasitic volcanoes is supported by evolution of younger dyke system of pyroxene amphibole, amphibole andesites and andesite porphyry, which planar extent overlaps margins of the central diorite intrusive complex. Activity of this dyke system is indicated by K/Ar dating to 12.0 and 11.94 ± 1.0 Ma. Many dykes probably represented the feeding system of parasitic volcanoes on the slope of the stratovolcano. Dyke system of the basalt-andesites to basalts grouped in the area SW of the central zone (west of Pacherka e.p.) dated by K/Ar method to 12.02 ± 1.05 Ma was probably connected with development of parasitic volcanoes. Also the isolated neck on the Nižná Fabová ridge, probably served as feeding system to parasitic volcano on stratovolcanic slope. North of the Vepor stratovolcano a small monogene Stožka volcano developed on the surface of Mesozoic rocks. Relic of lava flow in the uppermost part of the Klenovský Vepor paleovalley filling, dated by K/Ar method to 11.56 ± 0.43 Ma, represents the youngest manifestation of effusive activity of the stratovolcano. Its relations to eruptions of pyroclastic flows, which finished the evolution in the southern sedimentary basin, remains unclear, i.e. whether the effusion of lava flow has preceded the eruptions of pyroclastic flows or followed after these eruptions. It must be solved by further dating. We prefer more realistic idea that during the huge paroxysmatic eruptions, accompanied by generating of sequences of pyroclastic flows, the destruction and demolition of the summit level of the stratovolcano have occurred, including its central feeding system. Despite, there is not possible to eliminate an alternative of continuing activity from several parasitic volcanoes in lower levels of the stratovolcanic slope. Also in the case of Stožka pyroclastic volcano north of the Vepor stratovolcano, the time of its activity must be ascertained by radiometric dating.

7th stage. During Pannonian and Pontian time the updoming and uplifting of the regional block of the Veporic unit has occurred which accelerated the destruction and denudation of stratovolcanic structure. Clastic material coming from the denudated stratovolcano and surrounding uplifted areas of the pre-volcanic basement rocks, was transported by rivers and brooks and partly deposited on the surface of the flat relief of proluvial plain (relics of fluvial sediments were identified on the surface of the Pokoradz and Blh plateaus). Volcaniclastic material was dominantly transported through the deep erosive valleys and canyons, dissecting the original plateau and being deposited in the Lučenec an Rimava basins like the Poltár Formation.

8th stage. During the Pliocene and Quaternary due to uplifting of the western block of the Veporic unit, the stratovolcanic structure was gradually removed and subvolcanic intrusive complex of central volcanic zone was uncovered on the surface, similarly as the intrusive-extrusive bodies in the proximal volcanic zone. At the western foot of the stratovolcano, the preserved relics of paleovalleys filling occur (Hájna hora Hill, Klenovský Vepor Hill and Zadná Kýčera). A larger number of relics of paleovalleys filling is preserved on the southern slopes of the Slovenské rudohorie Mts. The area of original sedimentary basin of the Vyšná Pokoradz Formation due to continuing erosive processes in the uplifted area was gradually transformed into the relief of high isolated plateaus of the Pokoradz Plateau and the Blh Plateau and several isolated hills. Due to the denudation, the southern volcanosedimentary complex of the Vyšná Pokoradz Formation was drastically shortened in its lateral extension. We suppose that from its original lateral extension is preserved about 1/3 part.

Acknowledgements. This work was supported by the Ministry of Environment of the Slovak Republic in research project Update of the geological setting of problematic areas of the Slovak Republic at a scale 1 : 50 000. We thank to RNDr. Ľubomír Hraško, PhD. for project management and support in research and to Ing. Zoltán Németh, PhD., for careful language correction and helpful advices. We appreciate comments and suggestions of the reviewer RNDr. Ladislav Šimon, PhD.

References

Bacsó, Z., 1964: Post-Triassic skarn deposits at Tisovec. *Geol. Práce, Zpr., 31, 13–45. (In Slovak with English Summary.)*

Bacsó, Z. & Valko, P., 1969: Final report and computation of resources, 1. part: Horehronie, locality Tisovec-Hnúšťa, survey of Fe-bearing raw materials, state to 1. 11. 1968. GP Spišská Nová Ves – GS Rožňava. *Manuscript. Geofond Archive, Bratislava, 1–200. (In Slovak.)*

Bezák, V. (ed.), Dublan, L., Hraško, Ľ., Konečný, V., Kováčik, M., Madarás, J., Plašienka, D. & Pristaš, J., 1999a: Geological map of the Slovak Ore Mts. 1 : 50 000 – western part. *GSSR, Dionýz Štúr Publishers, Bratislava. (In Slovak with English Summary.)*

Bezák, V., Hraško, Ľ., Kováčik, M., Madarás, J., Siman, P., Pristaš, J., Dublan, L., Konečný, V., Plašienka, D., Vozárová, A., Kubeš, P., Švasta, J., Slavkay, M. & Liščák, P., 1999b: Explanations to geological map of the Slovak Ore Mts. – western part, 1 : 50 000. *GSSR, Dionýz Štúr Publishers, Bratislava, 1–178. (In Slovak with English Summary.)*

Bezák, V., Polák, M., Konečný, V. (eds.), Biely, A., Elečko, M., Filo, I., Hók, J., Hraško, Ľ., Kohút, M., Lexa, J., Madarás, J., Maglay, J., Mello, J., Olšavský, M., Pristaš, J., Siman, P., Šimon, L., Vass, D. & Vozár, J., 2008: General geological map of the Slovak Republic 1 : 200 000, sheet 36 – Banská Bystrica. *State Geol. Inst. of D. Štúr, Bratislava. (In Slovak with English Summary.)*

Burian, J., Slavkay, M., Štohl, J. & Tözsér, J., 1985: Metallogenesis of Neogene volcanites in Slovakia. *Alfa, Bratislava, 1–269. (In Slovak with English Summary.)*

Caban, L., 2009: Lithostratigraphy of the Pokorádza Formation and its relation to Tisovec intrusive complex. Diploma work. *Comenius University of Natural Sciences, Bratislava*.

Elečko, M., Gaál, Ľ., Mello, J., Pristaš, J., Vass, D. & Vozárová, A., 1985: Geological map of the Rimavská kotlina Basin and surrounding part of the Slovak Ore Mts. *GÚDŠ, Bratislava. (In Slovak with English Summary.)*

Frnčo, M., Marček, R., Vráblová, M., Demian, M., Hrašna, M., Husár, R., Liščák, P., Holzer, R., Pánek, M. & Letko, V., 1990: The Blh-Pokoradz Plateau – landslides, orientation survey. *IGHP, Žilina. (In Slovak.)*

Hrašna, M. & Liščák, P., 1995: Geodynamic development of the Pokoradzská tabuľa Plateau. *Slovak Geol. Mag., 3, 229–234.*

Klinec, A., 1976: Geological map 1 : 50 000 – Slovak Ore Mts. – central part, Nízke Tatry – eastern part. *GÚDŠ, Bratislava. (In Slovak with English Summary.)*

Konečný, V. & Konečný, P., 2011: Geological profiling and structure of products of Neogene volcanism in the northern part of the Rimavská kotlina Basin (Pokoradz Formation). Partial report to a project: Update of geological setting in the problematic areas of the Slovakia in a scale 1 : 50 000. *Geol. Ústav D. Štúra, Bratislava*.

Konečný, V., Konečný, P., Kubeš P. & Pécskay, Z. 2005: Paleovolcanic reconstruction of the Neogene Vepor stratovolcano (Central Slovakia), part I. *Mineralia Slovaca, 47, 1–76*.

Kuthan, M. et al., 1963: The investigation project under consideration of the deep underground and megastructures of Neogene volcanites of the central Slovakia. *Věst. Ústř. Úst. geol., Praha. (In Slovak.)*

Němejc, F., 1960: Report about the flora-stratigraphic investigation in the Carpathian Neogene (focussed mainly on the southern Slovakia). *Zpr. geol. výzk. v roce 1958, Praha, 112–114. (In Slovak.)*

Němejc, F., 1967: Paleo-flora studies in the Slovak Neogene. *Sbor. Nár. Muz. (Praha), Ř. B. 23, B/1, 1–32.*

Repčok, I., 1981: Dating of some central Slovakian Neogene volcanites by the uranium fission track method. *Západ. Karpaty, Sér. Mineral. Petrogr. Geochém. Metalogen., 8, 59–104. (In Slovak with English Summary.)*

Schmincke, H. U., 2004: Volcanism. *Springer Science & Business Media, 324 p.*

Sitár, V. & Dianiška, J., 1979: Flora in the Late Tertiary volcanites from the Vyšný Skálnik and Nižný Skálnik villages. *Západ. Karpaty, Sér. Paleont., 4, 147–159. (In Slovak.)*

Vass, D., 1981: Alpine molasses of the Western Carpathians. Doct. dissert. thesis. *GÚDŠ, Bratislava. (In Slovak.)*

Vass, D. et al., 1982: Explanations to general geological map, sheet 36-442 Poltár/2. *Manuscript. Geofond archive, Bratislava. (In Slovak.)*

Vass, D., Elečko, M., Pristaš, J. & Konečný, V. (eds.) 1985: Explanations to gelogical map, sheet 46-214 Lučenec/4. *Manuscript. Geofond Archive, Bratislava. (In Slovak with English Summary.)*

Vass, D., Elečko, M., Pristaš, J., Lexa, J., Hanzel, V., Modlitba, I. & Jánová, V., 1989a: Geology of the Rimavská kotlina Basin. *GÚDŠ, Bratislava, 1–162. (In Slovak with English Summary.)*

Vass, D., Bodnár, J., Elečko, M., Gaál, Ľ., Hanáček, J., Hanzel, V., Lexa, J., Mello, J., Pristaš, J. & Vozárová, A., 1989b: Explanations to geological map of the Rimavská kotlina Basin and neighbouring part of the Slovak Ore Mts. *GÚDŠ, Bratislava, 1–187. (In Slovak with English Summary.)*

Vass, D., Elečko, M. & Konečný, V. (ed.), 2007: Geology of the Lučenská kotlina Basin and the Cerová vrchovina Upland. *Monograph., St. Geol. Inst. of D. Štúr, Bratislava, 1–284. (In Slovak with English Summary.)*

Vojtko, R., 2000: Are there tectonic units derived from the Meliata-Hallstatt trough incomporated into the tectonic structure of the Tisovec karst ? (Muráň karstic plateau, Slovakia). *Slovak Geol. Mag., 6, 4, 335–346.*

Vozárová, A. & Vozár, J., 1982: New lithostratigraphic division of the basal part of the South Veporic cover. *Geol. Práce, Spr., 78, 169–194. (In Slovak with English Summary.)*

Vozárová, A. & Vozár, J., 1992: The Middle Carboniferous flysch in the Western Carpathians – contribution to tectonics of the southern part of the Slovak Ore Mts. based on the results of borehole BRU-1, Brusník. *Miner. Slov., 24, 1, 53–62. (In Slovak with English Summary.)*

Paleovulkanická rekonštrukcia neogénneho veporského stratovulkánu (stredné Slovensko), časť II

Oblasť kryštalického masívu západného veporika (východne od oblasti neogénneho vulkanizmu stredného Slovenska) bola v období neogénu areálom andezitového a ryodacitového vulkanizmu. Svedčia o tom početné rozptýlené relikty intruzívnych a intruzívno-extruzívnych telies dioritov, dioritových porfýrov, andezitových porfýrov a ryodacitov, odhalené na povrchu denudačným zrezom po odstránení povrchovej vulkanickej stavby. Z povrchovej vulkanickej stavby sa zachovali len sporadické zvyšky výplní pôvodných paleodolín na západnom svahu pôvodného stratovulkánu v podobe vulkanoklastických hornín, vrátane lávového prúdu Klenovského Vepora. Po odstránení stavby stratovulkanického kúžeľa je v oblasti centrálnej vulkanickej zóny denudačným zrezom odkrytý subvulkanický dioritový intruzívny komplex Magnetový vrch s prejavmi skarnovej mineralizácie na styku s mezozoickými karbonátmi. Dioritový komplex je prenikaný systémom mladších dajkových telies. V predchádzajúcej časti tejto práce (časť I – Mineralia Slovaca, 47, 1, 2015) bola uvedená detailnejšia analýza stavby intruzívneho komplexu centrálnej vulkanickej zóny, ako aj rozptýlených intruzívnych a intruzívno-extruzívnych telies vrátane charakteristiky litofácií vulkanoklastických hornín vo výplni paleodolín na západnom svahu stratovulkánu a ich vzťahu k predpokladanému andezitovému stratovulkánu.

V nadväznosti na problematiku uvedenú v I. časti v tejto druhej časti predloženej práce je prevedená analýza reliktov vulkanoklastických hornín na južných svahoch Slovenského rudohoria, ako aj analýza stavby vulkanosedimentárnych komplexov, ktoré budujú náhorné plošiny Pokoradzskej a Blžskej tabule pri severnom okraji Rimavskej kotliny. Relikty vulkanoklastických hornín zachované vo vrcholových oblastiach horských chrbtov na južných svahoch Slovenského rudohoria sú na základe štúdia ich litológie a stavby považované za zvyšky výplní pôvodných paleodolín na južných svahoch veporského stratovulkánu. Litológia vulkanoklastických hornín a ich stavba je doložená geologicko-litofaciálnou mapou a sériou profilov v smere od SZ, S na JV, J. Okrem epiklastických vulkanických hornín sa na výplni pôvodných paleodolín podieľajú aj polohy chaotických brekcií pyroklastických prúdov a laharov, jednoznačne dokazujúce, že paleodoliny predstavovali komunikačné cesty, ktorými bol klastický vulkanický materiál v priebehu vývoja veporského andezitového stratovulkánu transportovaný na juh do sedimentačného priestoru pri južnom úpätí stratovulkánu. Južný sedimentačný priestor, kde bol vulkanoklastický materiál deponovaný vo fluviálno-limnickom prostredí, predstavoval oblasť proluviálnej roviny – delty. Vulkanosedimentárny komplex vo výplni južného sedimentačného bazénu reprezentuje *vyšnopokoradzská formácia* (podľa typovej lokality severne od obce Vyšná Pokoradz). Zvyšky tejto výplne sa zachovali v podobe náhorných plošín Pokoradzskej a Blžskej tabule pri severnom okraji Rimavskej kotliny. Litologická výplň pôvodného sedimentačného bazénu odkrytá na strmých svahoch na okrajoch Pokoradzskej a Blžskej tabule predstavuje unikátny záznam vulkanických udalostí v období vývoja andezitového stratovulkánu. Stavba a litolológia vulkanosedimentárneho komplexu je dokumentovaná geologicko-litofaciálnou mapou v pôvodnej mierke 1 : 20 000 odvodenej od pôvodnej mapy 1 : 10 000 doplnenou geologickými rezmi generálne v smere Z – V. V stavbe vulkanosedimentárnych komplexov Pokoradzskej a Blžskej tabule sú podobne ako vo výplni paleodolín identifikované fácie epiklastických vulkanických hornín reprezentované najmä polohami epiklastických vulkanických pieskovcov, často s vložkami vitrokryštálových tufov a pemzových tufov (ktoré dokumentujú prebiehajúce explozívne erupcie), ako aj polohami drobných konglomerátov. Jemnozrnný tufový materiál bol zo svahov stratovulkánu do sedimentačného bazénu transportovaný splachom prostredníctvom fluviálnych zriedených tokov, ako aj v podobe hyperkoncentrovaných prúdov (polohy nezvrstvených epiklastických vulkanických pieskovcov). Na báze vulkanosedimentárneho komplexu je uložená nesúvislá poloha fluviálnych sedimentov v podobe tufitických pieskov s vložkami štrkov s vulkanickým aj nevulkanickým materiálom hornín predvulkanického podložia vo variabilnej hrúbke. Okrem epiklastických vulkanických pieskovcov sa na stavbe vulkanosedimentárneho komplexu podieľajú polohy epiklastických vulkanických konglomerátov (stredných až hrubých a hrubých až blokových), ktoré pochádzajú z deštrukcie vulkanickej stavby, t. j. primárnych uložením vulkanických brekcií a lávových prúdov. Uloženie polôh hrubých až blokových epiklastických vulkanických konglomerátov v oblasti sedimentačného priestoru reprezentuje obdobie dočasného vulkanického pokoja, v ktorom prebiehala deštrukcia vulkanickej stavby. Striedanie polôh hrubých až blokových epiklastických vulkanických konglomerátov s polohami epiklastických vulkanických pieskovcov v južnejších častiach formácie dokumentuje postupnú subsidenciu sedimentačného priestoru.

Hruboúlomkový vulkanoklastický materiál bol do sedimentačného priestoru transportovaný prostredníctvom masových prúdov – laharov (úlomkových prúdov) – a uložený v podobe chaotických laharových brekcií. K vzniku pohybu laharov dochádzalo v dôsledku porušenia stability tufových uložením na svahu stratovulkánu (presýtenie vodou po výdatných dažďoch, v dôsledku rýchleho nakopenia materiálu počas vulkanickej aktivity, po seizmickom otrase a pod.). Na základe litológie boli identifikované uloženiny brekcií *studených laharov*, ktorých materiál pochádzal zo starších uložením v oblasti stratovulkanického svahu, a *horúcich laharov*, ktorých časť vulkanického materiálu sa nachádzala v horúcom stave. Lahary posledného typu boli iniciované v súvislosti s priebehom aktuálnej vulkanickej erupcie, prípadne predstavovali pôvodné pyroklastické prúdy, ktoré sa po vniknutí do vodného prostredia v dôsledku ochladenia a mobilizácie sedimentov na dne bazénu menili na horúce lahary. Na južných okrajoch Pokoradzskej tabule v stenách opustených lomov a v strope umelých jaskýň sú dutiny po stromoch a odtlačky vegetácie, ktoré dokazujú, že lahar pri svojom pohybe zo svahu stratovulkánu prechádzal cez zalesnenú oblasť.

Významným procesom, ktorý sa podieľal na stavbe výplne južného sedimentačného priestoru, boli pyroklastické prúdy, ktoré boli mobilizované v bezprostrednej súvislosti s prebiehajúcou explozívnou aktivitou, prípadne v súvislosti s explozívnou deštrukciou a kolapsom extruzívneho dómu. V rámci uložením pyroklastických prúdov sú na základe ich litológie identifikované nasledujúce hlavné typy pyroklastických prúdov: a) *uloženiny popolovo-pemzových prúdov* (späté s kolapsmi eruptívnych stĺpov plínijského typu), b) *chaotické brekcie pyroklastických prúdov* tvorené prevahou pyroklastického napeneného materiálu a tufovým spekaným matrixom (produkty kolapsov eruptívnych stĺpov vulkánskeho typu), c) *chaotické brekcie popolovo--blokových prúdov* s prevahou hruboúlomkového až blokového materiálu s angulárnym obmedzením produkované pri explozívnej deštrukcii a kolapsoch extruzívnych dómov. Uvedené typy pyroklastických a blokovo-popolových prúdov sú rozšírené najmä v stavbe vrchných úrovní vulkanosedimentárneho komplexu v oblasti Pokoradzskej a Blžskej tabule.

Obsahom záverečnej časti predloženej práce je *paleovulkanologická rekonštrukcia veporského stratovulkánu* na základe analytického materiálu prezentovaného v predchádzajúcej časti I a časti II. V úvode sú opísané dôkazy, ktoré zdôvodňujú opodstatnenosť predpokladu, že širšia oblasť Magnetového vrchu s vývojom subvulkanického intruzívneho dioritového komplexu a mladších dajkových systémov predstavuje oblasť centrálnej vulkanickej zóny s opakovaným výstupom magmatických hmôt. Existenciu pôvodného stratovulkanického kužeľa (neskôr odstráneného denudáciou), budovaného pyroklastickým materiálom a lávovými prúdmi, potvrdzuje relikt lávového prúdu v oblasti Klenovského Vepora pri západnom úpätí stratovulkánu, ako aj ďalšie relikty výplní paleodolín s radiálnou orientáciou k centrálnej vulkanickej zóne. Na základe pozície lávového prúdu v nadloží vulkanoklastických hornín uložených s úrovňou bázy 1 150 m nad morom (predpokladaná úroveň paleoreliéfu) a vzdialenosti od centrálnej vulkanickej zóny cca 11 km je prevedená rekonštrukcia konkávneho reliéfu pôvodného stratovulkanického kužeľa. Pri zohľadnení pozície intruzívneho komplexu centrálnej vulkanickej zóny a reliktov intruzívnych a intruzívno-extruzívnych telies v oblasti prechodnej vulkanickej zóny (proximálnej zóny) je prevedená paleovulkanická rekonštrukcia stavby veporského stratovulkánu v podobe 5 profilov smerujúcich od centrálnej zóny k jeho periférii. V oblasti centrálnej vulkanickej zóny sa v nadloží subvulkanického intruzívneho komplexu predpokladá pôvodná hrúbka mezozoických a paleogénnych sedimentov okolo 190 m.

Na základe výsledkov štúdia litofácií a ich sukcesie v oblasti výplne sedimentačného bazénu vyšnopokoradzskej formácie (odkrytej na svahoch Pokoradzskej a Blžskej tabule) boli rekonštruované vulkanické procesy a typy vulkanických erupcií, ako aj vývoj stratovulkanického kúžeľa v priebehu niekoľkých štádií. Prevedené rádiometrické datovania K/Ar metódou (Dr. Pécskay, Lab. ATOMKI, Hung. Acad. Sci., Debrecén) prispeli k spresneniu vývoja vulkanickej aktivity a časovej pozície jednotlivých intruzívnych a vulkanických telies. Aktivita ryodacitového vulkanizmu je datovaná na 12,5 mil. r., vývoj andezitového stratovulkánu prebiehal v období sarmatu od 12,28 mil. do 11,56 mil. r. V závere práce je opísaná evolúcia veporského stratovulkánu vo vzťahu k vývoju južného sedimentačného bazénu vyšnopokoradzskej formácie v priebehu 8 štádií.

List of appendixes

Appendix 1/A, B, C, D. Geological-lithological map of the Blh Plateau and the paleovalley fillings on southern slopes of the Slovenské rudohorie Mts. (scale 1 : 20 000).
Appendix 2A. Geological-lithological profiles of the paleovalley fillings on the southern slopes of the Slovenské rudohorie Mts. from NW to SE, profiles 1 to 19 (scale 1 : 20 000).
Appendix 2B. Geological-lithological profiles of the Blh Plateau from W to E, B-1 to B-10 (scale 1 : 20 000).
Appendix 3/A, B, C. Geological-lithological map of the Pokoradz Plateau (scale 1 : 20 000).
Appendix 4A. Geological-lithological profiles of the Pokoradz Plateau (northern part) from W to E, PF-1 to PF-9 (scale 1 : 20 000).
Appendix 4B. Geological-lithological profiles of the Pokoradz Plateau (southern part) from W to E, PF-10 to PF-15 (scale 1 : 20 000).
Appendix 5. Explanations to geological-lithofacial map of the Vyšná Pokoradz Formation and to series of geological-lithological profiles.
Appendix 6. Paleovolcanic reconstruction, profiles 1–5.