Geological processes at subduction interfaces

on an example

of the southeastern flank of the Barrandien Neoproterozoic

Excursion topic: Geological processes in the area of subduction zones (convergent interfaces), flysch, accretionary prism, island arc, mélange, folding

A record of subduction processes in the southeast flank of the Barrandian Neoproterozoic

Introduction to the issue

Subduction zones are areas where one lithospheric plate subducts beneath another. A classic example of active subduction zones is the region of the western and eastern Pacific, where the Pacific plate is subducting under the Eurasian or North and South American plate. An example of continental subduction is the subduction of the Indian plate under the Eurasian plate.

Subduction zones are manifested by a whole series of characteristic geophysical, petrological, geochemical, geological and geomorphological signs, according to which areas of recent subduction can be recognized, but with the use of actualist approaches, it is also possible to locate zones that were connected with subductions that took place in the ancient past and whose manifestations they were obscured by subsequent geological processes such as continental collisions, repeated continental breakup and extensive erosion.

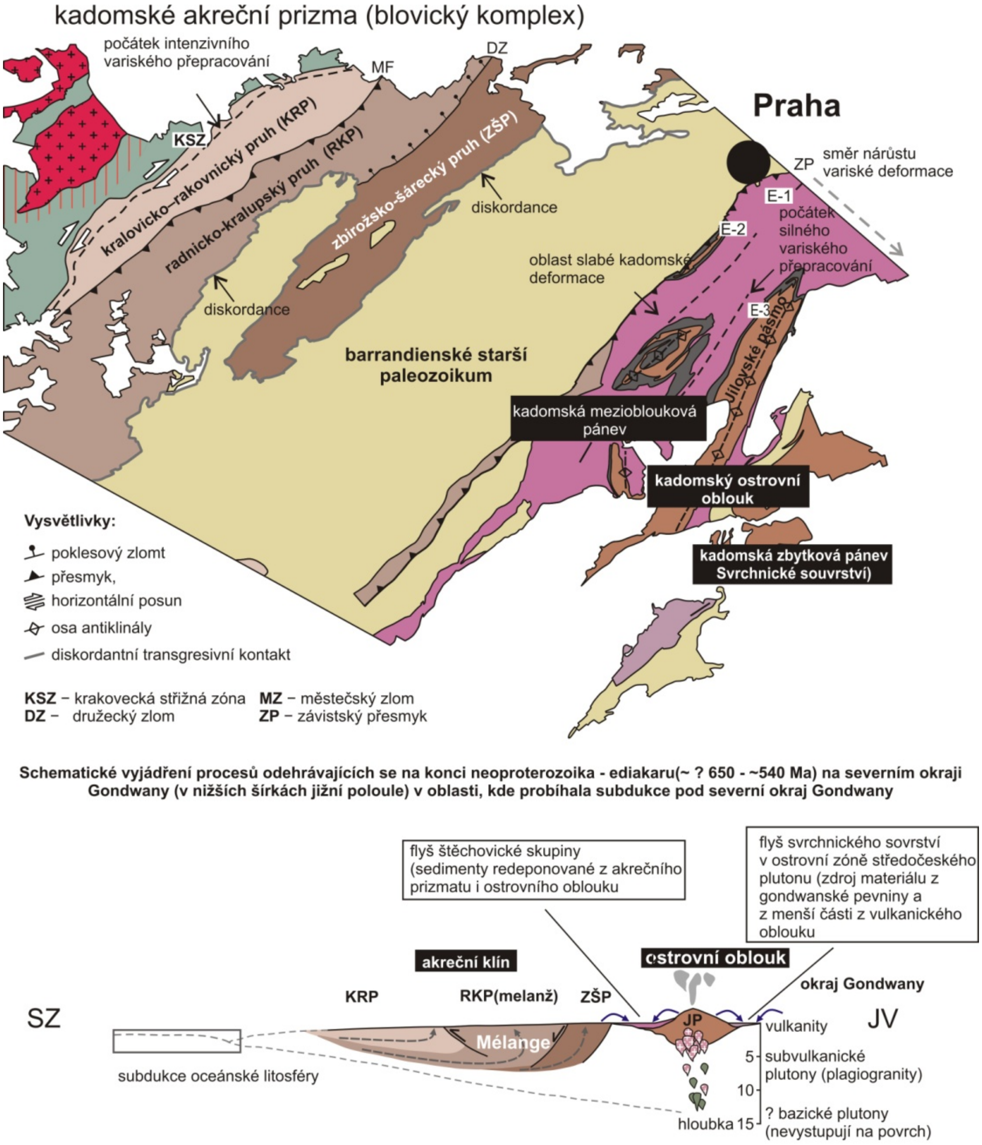
Morphologically, the boundary of the subducting plate is manifested by the formation of deep-sea trenches, followed by an area built mainly by sediments raked from the ocean floor, which we refer to as accretionary wedges or prisms, because they are inserted as a wedge between the subducting plate and the overlying plate. They tend to be strongly deformed and pre-arc basins can also form on the sunken parts of the prism, sometimes ridges emerge in the area before the volcanic arc. At greater distances from the trench, volcanic or magmatic arcs are formed. If subduction occurs inside the ocean, then the arcs form directly on the oceanic crust. Outflows of volcanic rocks gradually form a chain of volcanic islands, into which intrusive rocks subsequently penetrate in depth, increasing the thickness of the crust in the area of the arc. We have examples of such island arcs especially in the western Pacific (Aleutian Islands, Kuril Islands, Japan), where a very old and powerful oceanic lithosphere subducts under a steep tilt. Because the subduction is faster than the convergence of the Eurasian and Pacific plates, behind the arc of the arc basin, new oceanic crust is formed, similar to the mid-ocean ridges. Where the oceanic crust subducts directly under the edge of the continental lithospheric plate (the western edge of North and South America), a volcanic arc is formed only on the continent itself. Because island or continental arc volcanics form by melting of the mantle above the subducting plate, facilitated by the release of fluids during the dehydration of subducted sediments and altered rocks of the oceanic crust, they have a specific calc-alkaline chemistry that distinguishes them from other volcanics formed in other geotectonic settings. At the same time, its zonality was traced through long-term research, especially in the direction from the trench towards the continent. This is determined by the different depths of the magma source that originates above the subducting plate. The chemistry of volcanics also changes over time, from more primitive basaltic to basalto-andesitic rocks to differentiated rhyolites, which are formed by remelting the thicker crust of a wedge or overlying plate, whose deformed edge increases its thickness.

The tilt of the subducting plate also plays a significant role, with small tilt and shallow depths melting of the mantle does not occur; manifestations of volcanic activity are often absent. Another characteristic feature is the high explosiveness of volcanism, as the magma above subduction zones is rich in fluids. In the volcanic front above the subducting plate, linearly arranged cone-shaped and tall stratovolcanoes formed mostly of andesite or dacite lavas arise. The production of rhyolite and rhyodacite pyroclastics is mostly associated with caldera explosions.

Another sign of subduction zones is the formation of paired metamorphic belts. In the region of the trench and accretionary wedge, where the cold oceanic lithosphere subducts, there is a low heat flow, therefore low-temperature and high-pressure metamorphism dominates here, on the contrary, in the region of the volcanic front, the heat flow is high, therefore the metamorphic transformations have a high-temperature character, under low and medium pressures. These typical paired metamorphic belts were first described from the Japanese Islands, which were formed by repeated subduction from the Paleozoic to the present. Blue schists with glaucophane and high-pressure, low-temperature metapelites and low-temperature eclogites are a typical product of transformations in the region of subduction zones, in the Bohemian Massif they line, for example, the contact of the Saxo-Thuringian and Teplá-Barrandien plates.

An equally important feature of subduction zones is high seismicity localized in a narrow band. Earthquake foci often follow the tilt of the subducting plate, which is why we encounter both shallow, very dangerous earthquakes and earthquakes with hypocenters at depths of up to several hundred km.

One of the characteristic phenomena that can help to locate and study the zonality of fossil subduction zones are also accretion wedges. Such an accretionary wedge also represents with high probability the Barrandien Neoproterozoic, the rocks of which build large areas of central and western Bohemia. Therefore, it is necessary to get closer to what rock associations the wedge is made of and how it is formed. A Accretionary wedges (prisms) are very heterogeneous lithotectonic units (rock units limited by tectonic boundaries), formed mainly by sedimentary rocks, which are formed by the raking of sediments between a trench and an active continental margin or island arc. In cross-section, they have an approximately



triangular shape (see Fig. 1), which depends mainly on the shape of the continental margin and the thickness of the sediments that are deposited there. Shortly after their deposition,

Fig. 1: Upper part of the figure: Simplified geological map of the central and southeastern part of the Barrandian Proterozoic with the main units discussed in the text (modified from Hajná et al. 2011). In the lower part of the figure, there is a schematic profile of the

subduction zone areas applied to the development of the Barrandian Neoprotezoic in the interval between ca 650-540 Ma (modified from the work of Hajná et al. 2011).

mainly clastic (fragmentary) sediments are deformed brittlely (breaks appear) and plastically.

A significant role in this is played by the opening of cracks as a result fluids of high pore pressure, which are released during lithification of sediments and, at greater depths, during metamorphic transformations. Subduction of the oceanic plate with the sediments at the surface causes the shortening of space to often push older rocks over younger rocks in the direction from the continent to the deep-sea trench. In this process, older sediments are not only exhumed, but fragments of subducted oceanic lithosphere (ophiolites), or suboceanic mantle, or tectonic scales detached from volcanic arcs or continental margins can also be tectonically incorporated into the sediments. This results in very heterogeneous groups of rocks known as mélanges, the creation of which involves both tectonic forces and sedimentary processes (landslides, seismic tremors). The melange material includes deep-water, pelagic sediments, rhythmically arranged flysch sediments, deposited by turbidite currents, mudflows or submarine slides (olistoliths, olistostromes).

Recent accretionary wedges line the convergent interface of the Pacific, the northern edges of the Indo-Australian plate in Indonesia, etc. The best-known and best-studied accretionary wedges include the units building the California peninsula (San Francisco mélange). Similar to the present, accretionary wedges with melange and ophiolite complexes border areas where subduction processes took place in the ancient past.

Although we fortunately do not live in areas where these complexes are currently forming (e.g., eastern Japan) and are therefore protected from processes closely related to the subduction of the oceanic lithosphere, such as tsunamis and large earthquakes, we can deal with the manifestations of processes that took place in the area of active get to know on several excursions to the southern surroundings of Prague, where variously deformed sediments of accretionary prisms and the remains of rocks, whose chemistry corresponds to the rocks of recent island arcs, emerge.

Structure and evolution of the southeastern Barrandienian Neoproterozoic flank

The distribution of Neoproterozoic sedimentary and volcanic rocks shown in Fig. 1 corresponds to the structure of accretionary prisms studied in recent subduction zones in different places of the world. At the northwestern edge of the Teplál-Barrandian unit, we assume the existence of oceanic crust that subducted under the NW. edge of today's TBJ in the interval from ca 620 to 560 Ma (Sláma et al. 2009, Hajná et al. 2011). Variscan metamorphic relicts of this ca. 540 Ma old oceanic crust are today preserved in the Mariánské-Lázně Complex. Weakly metamorphosed mostly basaltic rocks (so-called spilites) also occur in several bands within the Neoproterozoic sediments of the accretionary prism. The largest concentration of spilite bodies is in the town Kralupy-Zbraslav belt (Fig. 1). Here, they mostly consist of bodies chaotically distributed in dark shales with inclusions of debris measuring km. Preserved textural types of pillow lavas, hyaloclastic lava breccias prove that these rocks represent submarine outpourings, later separated from their surroundings as a result of deformations inside the accretionary prism(referred to as Cadomian according to the age of the deformation that took place during and after deformation at the end of the Neporterozoic to the beginning of the Cambrian). Around these bodies, there are also debris rich in inclusions of weakly lithified rocks, or isolated blocks of debris can be found in the shales. For this reason, the association of these rocks can be described as a sedimentary and partly tectonic melange, in which the rocks are most deformed. In the model in Fig. 1, bottom, this is a band where obducted ocean floor scales wedged tectonically between the sediments and tended to emerge within the wedge. On the contrary, in the Kralovice-Rakovník Belt (KRB) the area is dominated by bodies of massive debris with subordinate positions of shale, which are characterized by a lower intensity of Cadomian deformation. In the northwest, this strip is bounded by a significant Variscan structure – the Krakovec Shear Zone (Hajná et al. in press), which separates the area with preserved Cadomian structures from the Variscan strongly reworked part of the Neoproterozoic accretionary wedge.

The Zbiroh- Šárka belt differs from the Kralupy-Radnice belt by the lack of volcanics and, on the contrary, the predominance of slates and cherts with abundant clods (silicites, lydites), so it can be considered a separate segment within the accretionary prism, which was formed in a different environment and possibly even time. Its greater part, as well as the narrow strip of the Neoproterozoic in the Příbram region, is transgressively overlain by discordantly deposited younger rocks of the older Paleozoic (Cambrian, possibly Ordovician to Devonian) Barrandien s.s. The narrow úassage then separates this more strongly deformed part of the accretionary prism from the very weakly metamorphosed part of the cadomian accretionary prism built by the flysch of the Štěchovice group (siltstones, cherts, slates with insets of Dobříš conglomerates). From its underground, they emerge in anticlinal zones in several places (the territory adjacent to the south of Zbraslav, the anticlinorium between Davle and Mníšek pod Brdy, the so-called Kozí hory south-west of Nové Knín and in the Jílové belt. Rocks of the Davlel Formation, outcroping in the Jílové belt correspond to the rocks , which are currently emerging in the area of island arcs.

In addition to volcanic basalto-andesites, andesites and rhyolites, pyroclastics and mixed volcaniclastic rocks and fine-grained albitic granites (plagiogranites) are abundantly represented at the ceiling of the Davle Formation - excursion L-3 to the vicinity of Štěchovice). Dating of rhyolite boulders in the Dobříšské conglomerates and plagiogranites of the clay belt showed that volcanic and magmatic activity took place in a relatively long time interval between 620-560 million years. Therefore, this segment of the Barrandian Neoproterozoic is considered a separate basin, which was formed in the vicinity of the arc, and after the end of volcanic activity and its erosion, it also partly overlaps it. The flysch of the Štěchovicé group is therefore certainly younger than the rocks of the Davle Formation and most likely also of the entire Blovice complex (in the sense of Fig. 1 - Hajná et al. 2011).

Evidence for this is the number of small boulders, slates, but also spilites and rocks originating from the Davel Formation in the so-called Dobříšské conglomerates in Modřanská Rokle. Another piece of evidence is the dating of zircons from debris in the roof pendant of the Variscan Central Bohemian Pluton – Sláma et al. (2008), which showed that the sedimentation of this formation took place from approximately 560 million years until the turn of the Proterozoic and Cambrian (540 million years). The abundance of quartz boulders, quartzites, and other relatively stable rocks supports the interpretation that this youngest part of the Neoproterozoic remnant basin was situated closest to the then Gondwana mainland.

Discordant deposition of lower Cambrian on folded Proterozoic rocks proves that the main so-called Cadomian deformation took place during the deposition of flysch of the Štěchovice Group and the Upper Formation at the end of the Proterozoic. After that, parts of the Proterozoic accretionary prism were eroded, which is evidenced by the predominance of boulders of Neoproterozoic rocks in the basal conglomerates of the Žitec-Hluboš Formation of the Brdy Cambrian.

Tasks for students theoretical part:

Before the excursions:

1. Find and explain the following terms in recommended literature or on the web (Wikipedia or other encyclopedias): lithospheric plate, oceanic crust, continental crust, island arc, accretionary wedge (prism), orogeny, Cadomian orogeny, flysch, Variscan orogeny, alkaline - igneous rocks, basalts of mid-ocean ridges, oceanic crust, lithosphere, etc.

2. Print a profile of the oceanic crust from the Internet or a textbook and mark where the above-mentioned morphostructures lie, or where individual geotectonic processes occur.

3. Prepare any larger hammer, notepad, pencil and paper, or camera, so that you can dig up a rock sample, draw or photograph some sedimentary or tectonic structure on the excursion. Newspapers or bags for wrapping the samples and a marker to describe the location of their collection, or the name of the rock.

3. If you own one, take a hiking map with you to better orient yourself in the terrain and to assess things in spatial contexts.

4. At the school, borrow a compass or a geological compass, if the school has its own, or a GPS, which also has a compass function (perhaps some more modern mobile phones with GPS also have it).

Excursion to the Vltava valley between Třebenice and Štěchovice, clay belt, outwash and volcaniclastic rocks, plagiogranites, Variscan metamorphism and deformation of Neoproterozoic rocks, Central Bohemian pluton

Fig. 2. Localization of excursion locations more closely characterized in the text

Topic of the excursion: The Jílové Belt, a relic of the Neoproterozoic island arc, formed inside the Neoproterozoic accretionary prism, (pillow lavas, pyroclastics, volcanoclastics, mixed volcano-sedimentary rocks of the Davel Formation), plagiogranites of the Jílové Belt, granitoids of the Central Bohemian Pluton,

The Jílové Belt is several tens of km long, relatively narrow strip of Cadomian and Variscan deformed mainly volcanic, volcaniclastic and intrusive rocks, which form an anticlinal structure closing in the northern vicinity of Jílové near Prague, after which it got its name. To the W, NW, and N, it emerges from the bedrock of the Lečice strata and the Štěchovice group, which partially overlie it (Fig. 3). It is limited to the E and SE by the intrusion of the Variscan Central Bohemian Puton, partial intrusions of which intruded the rocks of the Štěchovice Group and the Jílové Belt between approximately 355 and 340 million years ago. The positions of acidic intermediate tuffs and tuffites in the bedrock of the Lečice layers correspond to the Davle Formation south of Prague. In the bedrock of these volcaniclastic rocks, effusive bodies of basalts and andesites are also present, alternating with acidic to intermediate effusives and tuffs. They are intruded by bodies of light biotitic or amphibole biotitic albitic granites (formerly known variously as plagiogranites, trondhjemites or alaskites). The granites enclose numerous inclusions of xenoliths ore screens, especially basaltic blocks of various sizes (Photos 2, 3), which testifies to their close genetic relationship.

Based on the rock chemistry that develops from island arc tholeiites, through andesites to dacites to the youngest layers of rhyolitic tuffs and their outwash equivalents, the clay belt can be interpreted as the remnant of an island arc that began to form on the oceanic crust in the area between the trench and the mainland. Radiometric dating of boulders of acid volcanics originating from the Davle s. and clay belt in the Dobříšské conglomerates, Cambrian Žitec conglomerates and plagiogranite boulders from the Vletice conglomerates of the island zone show that the arc began to form around 620 million years ago and existed until ca 560 Ma (Linneman et al. 2004, Sláma et al. 2008). Then it was eroded and partially covered by flysch sediments of the Štěchovice Group and, in the island zone, also by the overlying assemblage, which represent the very youngest rocks in the southeastern wing of the Barrandien Neoproterozoic.

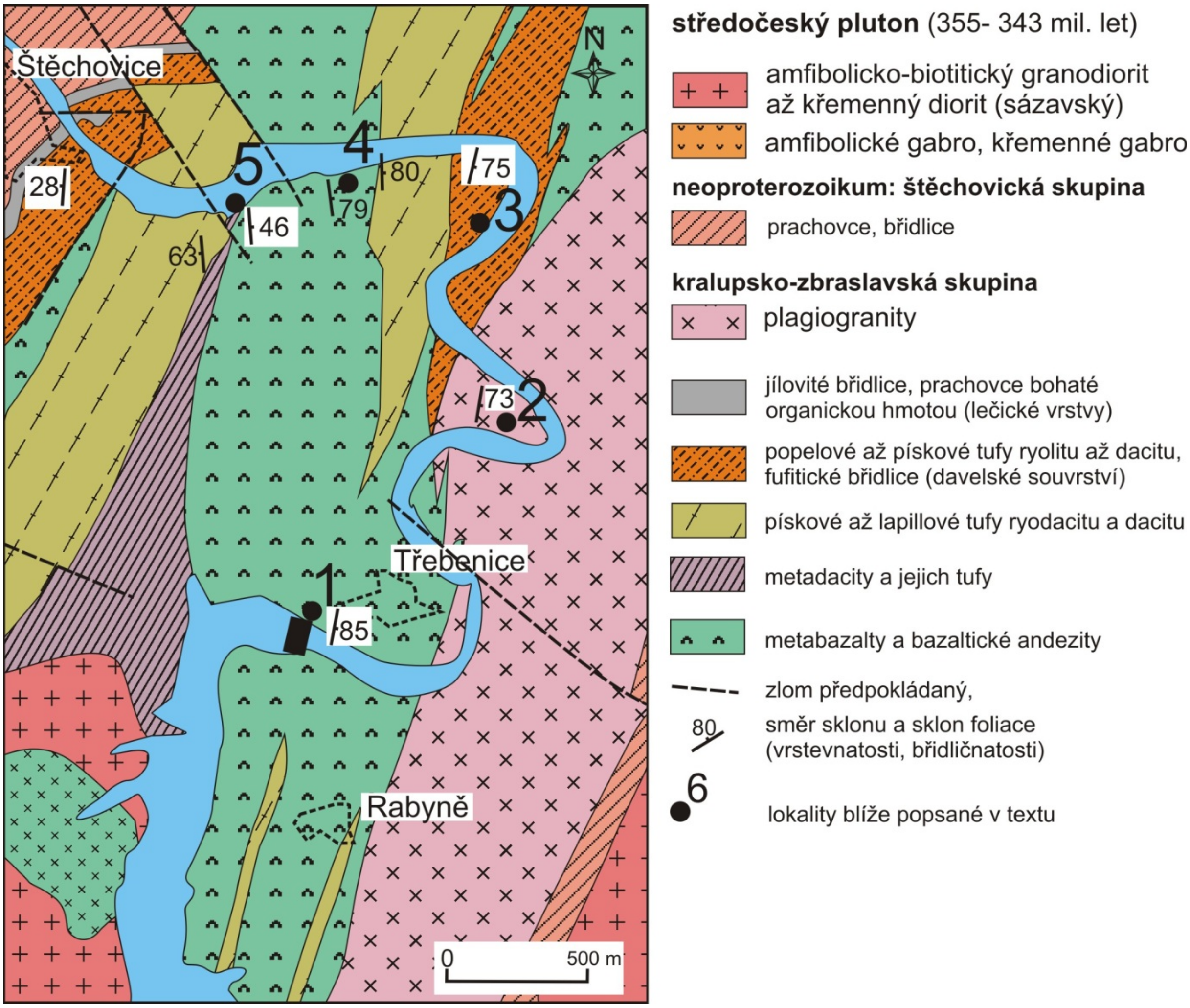


Fig. 3: Geological map of the Jílové Belt, adjacent parts of the SW flank of the Barrandian Neoproterozoic and the Central Bohemian pluton (simplified and modified according to the geological map of the Jílové Bbelt 1:25,000 (Morávek, Röhlich, Váňa 1985-1990).

Locality 1: Metamorphosed and strongly deformed pillow lavas of basaltic composition - outcrops at the Slapské dam, basalts of the clay belt, Neoproterozoic

About 20 m long and several meters long defile is located in a cut of the asphalt road on the left side of the Vltava valley at the level of the dam of the Slapy dam. Similar, albeit stronger, schistose pillow lavas are also found on the outcrops below the dam dam on the left side of the Vltava River valley, where you can go down the paved road from Třebenice. Pillow lavas are formed during subaquatic lava flows (in seas or lakes), when the rapid cooling of the lava in contact with seawater causes the formation of a crust that cracks and the still liquid lava begins to flow out of the pillow and form another one. By the pressure of the water column especially in the seas, it does not allow the rapid release of gases, explosive processes do not usually occur, and pillow lavas create lava blankets or shield volcanoes with flat slopes.

The pillow lavas are part of a several hundred meters thick mostly heterogeneous schist complex of basaltic or basalto-andesitic lavas (Fig. 3), which is characterized by a steep metamorphic schist sv. – from the south direction with bows either to the SE or the WSW. Exceptionally, in the area of less intense deformation and metamorphic recrystallization of the original basalts, pillow shapes are preserved, although they are often flattened in the plane of the nearby metamorphic schist. Nevertheless, especially in the lower part of the picture E-3.1, finer-grained and darker rims of the pillows, which were quickly cooled to a glassy state, and from which, during the subsequent metamorphosis, a larger amount of dark green chlorite is formed, which emphasizes their morphology, can be discerned. According to the asymmetric development of the pillows, even if they were deformed, it appears that the layer sequence is not overturned and the base of the outpouring was on the left side of the image. The original structure of the basalt is obscured by the recrystallization of the original clinopyroxene grains into uralitic amphibole and chlorite. Also, basic feldspars recrystallize to albite, and the liberated calcium enters epidote or carbonates. The association with albite chlorite actinolite or hornblende is typical of the transition between greenschist and epidotic amphibolite facies metamorphism. Since the outcrop is not too far from the intrusion of the Central Bohemian pluton, where, in addition to granodiorites and quartz diorites (tonalites), there are also gabbro bodies that solidify at higher temperatures, static recrystallization and contact metamorphism subsequently occurred in the thermal aureole of the pluton, which overheated its surroundings. Despite significant material transformations, metabasalts retain the geochemical characteristics of ocean island tholeiites. The deformation of the basalts took place during the Variscan orogeny (around ca. 355-350 Ma) because the structural plan of the deformation of the rocks of the clay zone coincides with the oldest, older stage of the deformation of the rocks in the oldest in the tonalities of the Sázav type of the Central Bohemian Pluton. (Žák et al. 2005). In this stage, the oblique compression of the edge of the thermal-Barrandian plate at its junction with the Moldanubian plate dominated, and therefore a dense system of subvertical surfaces, the so-called clay cleavage, was formed, according to which the rocks of the clay zone were deformed.

Tasks for students: 1. Take a sample of metabasalt and draw a detail of several pillows visible in the wall of the cut. 2. According to the asymmetry of their flattening and the relationship of the individual pillows, try to estimate the bedrock and the bedrock of the lava flow. 3. Try to measure the axes of several pillows and find out in which direction they were compressed and in which direction they stretched? 3. In the more deformed part of the rock defile, measure the slope direction and the slope of the schist in the metabasites. Bring them to the map again.

Photo 1: Relicts of pillow lavas metamorphosed in the facies of green slates to epidotic amphibolites subsequently affected by contact metamorphism in the thermal aureole of the Central Bohemia pluton. Outcrops on the left bank side of the Vltava valley at the Slapy dam south of the village of Třebenice. Location No. 1 in Fig. 2,3.

From the dam we descend into the Vltava valley and then follow the marked hiking trail to Štěchovice, we pass through the fenced fields and after a few tens of meters we stop at the contact of plagiogranites with dacite tuffs, or basalt bodies, which are enclosed in metabasites. In the place of St. John's currents, the best outcrops of plagiogranites are light, greyish, in places ochre-weathering rocks, which, unlike the previous ones, are rich in quartz (they have over 70% SiO_2). Plagiogranites, probably formed by melting of a subducted oceanic plate. The magma was highly fractionated during ascent (either by separation of dark minerals rich in Mg and Fe or by separation of melts) and therefore the resulting magma has a significantly more acidic chemistry than the source rocks from which it was formed. Proof that the plagiogranite magma was probably formed by the melting of basalts are the frequent inclusions of different sizes and shapes of basalts inside the plagiogranites. We will see them on the rock walls on the left and across the river and on the right side of the meander - darker greenish subvertically stretched discontinuous stripes (photo 2). The isotopic characteristics also support the interpretation that plagiogranites were formed by melting and differentiation of basaltic oceanic crust in an island arc environment. Although it was not possible to date them radiometrically due to the lack of zircon in strongly differentiated rocks, it is more likely from geological and geochemical contexts that they are intrusions of Neoproterozoic age, which represent shallow subvolcanic intrusions, situated below volcanic centers in the island arc. Larger bodies of metabasites have sharp tectonic contacts and, as a result of easier recrystallization of minerals in greenschist to amphibolite facies conditions, there is a pronounced metamorphic schist in them.

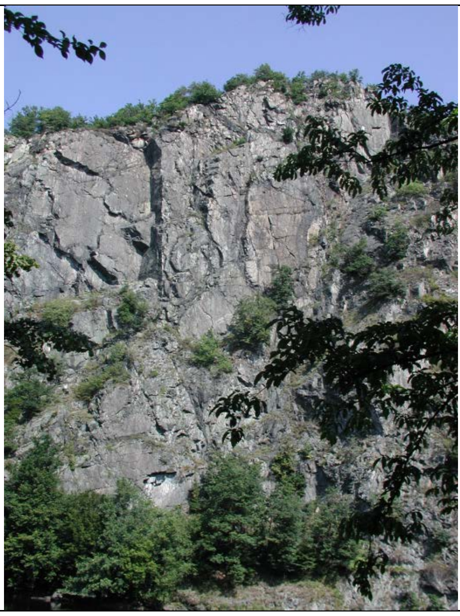


Photo 2: The deep canyon of the Vltava, near Svatojánské currents north of the Slapská dam: The Vltava was forced to create a path in some of the most resistant rocks of the clay zone, which represent fine-grained quartz-rich biotic plagiogranites, possibly metaryolites and their tuffs in their contact. Location No. 2 on Fig. 2, 3. Right bank of the Vltava.

Photo 3: Closed dykes of strongly shaly metabasalts of the clay belt, which are enclosed in biotic plagiogranites (trodhjemites) of the clay belt. Outings on the tourist trail from Třebenice to Štěchovice, the meander of the St. John's stream. Location dtto photo 2 (left bank of the Vltava on the hiking trail)

Tasks for students: 1. On the route, try to find the boundary between plagiogranites and volcanics in their mantle on the south and north sides of the St. John's Current meander. 2. Find thickets of strongly shaly metabasites enclosed in plagiogranites and do not draw details of some bodies. 3. In schistose types of metabasites or plagiogranites, try to find and measure the direction of inclination and the inclination of the schist, or the alignment of minerals in the foliation surfaces (so-called lineation). 4. Take samples of all rock types and describe and locate them. Lok. 3: Strmě k VJV ukloněné kyselé ryolitové až ryodacitové metatufy jílovského pásma pronikané žílou ryolitu.

The site is located in another meander of the Vltava River (Fig. 2, Fig. 3). The best exits are on the southern side of the river bend (Fig. 2,3). On the rock defile, various types of gray sand tuff whose composition corresponds mainly to rhyolites emerge along the hiking trail. In places like in photo 4, 5, they are penetrated by several dm thick, tectonically deformed (budinized) rhyolite to rhyodacite veins with a very fine-grained ground mass, feldspar growths and, to a lesser extent, quartz. To the right of the hiking trail, on the rock falling into the Vltava valley, it is possible to observe coarse-grained lapilla tuffs with several cm large sharp-edged and rounded fragments of volcanic rocks scattered in the sandy tuff matrix. In this section, the acidic volcanics are also strongly deformed, the steep clay cleavage NNW dominates here. – jjz. direction with an inclination to the NE, in places the inclination decreases to 30-40°. Smaller tuff rocks can also be seen on the slopes on the northern side of the meander in the space between the holiday cottages. Further to the west, the path from acidic rhyolite tuffs passes into a strip of darker, more chlorite-rich gray-green sandy tuffs, in which the steep clay cleavage is not so penetratively developed, on the contrary, the original stratification of tuffs is preserved, which dip at small to medium angles.

Photo 4: A light discordant vein of metaryolite piercing the sandy tuffs of the Davle Formation. The vein is tectonically boudinated. Exits on the hiking trail (loc. no. 3 in Fig. 2,3).

Photo 5: Plagioclase and potassium feldspar growth in a metarhyolite vein. Location dtto photo 4.

Tasks for students: 1. Try to recognize pyroclastic or volcaniclastic rocks from rhyolite or rhyodacite tuffs. 2. State how they will differ. 3. Measure the direction of the slope of the clay cleavage and its inclination, try to measure also the stretching of clasts (lineation) in pyroclastic rocks on suitable outcrops. 4. Take samples of typical rocks, write down their location and describe their appearance.

Locality 4: Heavily deformed lava breccias and pillow lavas of the Jílové Belt with distinct steeply dipping metamorphic foliation. Heavily altered in places.

The location is located about N.W. 500 m west from the previous location on the slope above the shore of the dam Lake, which has approx. direction (Fig. 2, 3). A rocky outcrop up to 4 meters high and several meters wide rises directly above the hiking trail. It is formed by rocks formed by metamorphosed basalts, which have a variably developed subvertical clay cleavage that dips to the ESE. It is the same band of basic rocks as at site No. 1, but unlike this site, much more intensive deformation and recrystallization of the original basalts are visible here, in which the relics of the original magmatic structure and texture are very poorly visible. Nevertheless, in the less deformed parts of the outcrops, altered and broken relics of lava pillows can be found (Photo 6), or only fragments of lava floating in the strongly schistose matrix metabasite (Photo 7). The same metabasalts can still be observed on a number of outcrops up to the SE. around the cottage settlement, however, the intensity of recrystallization is usually weaker and the metamorphic schist (clay cleavage) is no longer so intensively developed here. The outcrop demonstrates that loaded Variscan deformation is mainly localized in basic rocks, while acidic rocks more easily preserve primary volcanological textures and layering.

Tasks for students: 1. Try to identify the relics of the original lava structures and textures in the metabasalt, draw a detail of what you found. 2. Attempt to measure dip direction and dip of metamorphic schists in densely foliated parts of the outcrop. 3. Take samples of strongly deformed metabasites and compare them with lavas at loc. 1.

	
Photo 6: Lava breccias formed by the breakdown of pillow lavas heavily surrounded by dense schistose metabasite, which surrounds a more massive bed of metabasite. Along the fissures, the basaltic rock is strongly hydrothermally altered. Location No. 4 in Fig. 2,3	Photo 7: Subvertical schist (clay cleavage) and strongly flattened lava clasts in it, sometimes boudinous. Marginal parts of a powerful body of metabasites, which absorbs zsz. – vjv Shortening of rocks of the clay zone. Location dtto photo 6.

Location 5: Rocks at the outlet of the left-hand tributary of the Vltava in the cottage settlement of Fáberka. Agglomerate tuffs of rhyodacite composition alternate with sandy crystal clastic tuffs of the same composition.

In the place where the hiking trail bends towards the west into a small bay at the mouth of the left-hand tributary of the Vltava, close to the border with the metabasite body, it is possible to observe different grain types of intermediate to acidic tuffs, or in the direction of the Štěchovické dam, also tuffitic clasts. Coarse-grained agglomerate tuffs (Photo 8) of rhyodacite composition stand out directly at the bend of the hiking trail on the rocky promontory above the bay of the Štěchovice dam. They are composed of irregularly arranged clasts of cm up to 10 cm in size, which mostly do not touch each other and are scattered in the supporting mass of sand tuff. In contrast to strongly deformed metabasites, steep clay cleavage is not developed in these rocks, because these outcrops are already far away from the Central Bohemian pluton, and therefore there was not enough heating, necessary for the recrystallization of rocks and the creation of a new foliation system .

Photo 8: Agglomerate unsorted tuffs of rhyodacite composition. Rocks at the outlet of a side valley into the Vltava valley in the cottage settlement of Fáberka. Note that unlike metabasites, tuffs are not ductile deformed and retain primary textures formed by volcanic explosions. Site No. 5 in Fig. 2 and 3.

Photo 8: Agglomerate unsorted tuffs of rhyodacite composition. Rocks at the outlet of a side valley into the Vltava valley in the cottage settlement of Fáberka. Note that unlike metabasites, tuffs are not ductile deformed and retain primary textures formed by volcanic explosions. Site No. 5 in Fig. 2 and 3.

At the outcrops of sandy crystalloclastic rhyodacite and rhyolite tuffs, ash tuffs and, towards Štěchovice, also finer-grained ash tuffs, tuffitic slates and tuffitic cherts, we usually observe a slightly to moderately inclined primary stratification. In the transverse valley in the cottage settlement of Fáberka, it is folded, it slopes both to the SE (Photo 9) and to the NW at approximately NNW. –SSE direction of the rock bands. The same medium bows and very weak metamorphic damage can be observed on the outcrops scattered along the trail up to the Štěchovicka power plant. The folding of the uppermost positions of the tuffs of the clay belt, which, due to its composition, is clearly visible from the viewpoints near the power plant on the right bank of the Štěchovice dam. On these outcrops, it is possible to document the superposition of tuffs of the Davle Formation of the Jílov Belt and the Lečice member, which lie in the overlying NW flank of the anticlinal structure of the Jílové belt.

Tasks for students: 1. Take samples of different types of tuffs of the Davel Formation. 2. On suitable outcrops, try to measure the primary layering of tuffs and take the measurements to the geological map. 3. Document the selected outcrop where tuff stratification is evident. 4. On the basis of the measurements taken, try to draw a geological section through the Jílové belt in the direction from NNW to SE (roughly between Štěchovice and the dam of the Slapská přehrady. 5. From all the samples you brought back from the excursion, you can compile an exhibition of the main rock types of the southeastern wings of the Barrandien Neoproterozoic and put them in the school collections.It is also possible to photograph the samples, describe them in more detail and create an internet catalog of the Neoproterozoic rocks in the southeast area of Prague.

Doporučená literatura k tématu:

Drost, K., Gerdes, A., Jeffries, T., Linnemann, U. and Storey, C., Provenance of Neoproterozoic and early Paleozoic siliciclastic rocks of the Teplá-Barrandian unit (Bohemian Massif): Evidence from U-Pb detrital zircon ages. Gondwana Research, 19(1): 213-231.

Drost, K., Linnemann, U., McNaughton, N., Fatka, O., Kraft, P., Gehmlich, M., Tonk, C. & Marek, J., 2004. New data on the Neoproterozoic - Cambrian geotectonic setting of the Teplá-Barrandian volcano-sedimentary successions: geochemistry, U-Pb zircon ages, and provenance (Bohemian Massif, Czech Republic). International Journal of Earth Sciences, 93(5), 742-757.

Fiala, F., 1948. Algonkické slepence ve středních Čechách. Sbor. Stát. geol. Úst., 15(399-612).

Hajna, J., Zak, J. and Kachlik, V., 2011. Structure and stratigraphy of the Tepla-Barrandian Neoproterozoic, Bohemian Massif: A new plate-tectonic reinterpretation. Gondwana Research, 19(2): 495-508.

Chlupáč, I., 1999. Vycházky za geologickou minulostí Prahy a okolí. Academia Praha.

Kachlík, V.,2005. Geologický vývoj území České republiky (Doplněk k publikaci "Příprava hlubinného úložiště radioaktivního odpadu a vyhořelého jaderného paliva". web.natur.cuni.cz/ugp/kachlik/RegionalniGeologie/

Morávek, P. and Röhlich, P., 1971. Geology of the northern part of the Jílové Zone. Sbor. geol. Věd., Geol., 20: 101-145.

Röhlich, P., 1964. Podmořské skluzy a bahnotoky v nejmladším středočeském algonkiu. Sbor. geol. Věd, řada G, 6: 89-121.

Santolík, V., Ackerman, L., Kachlík, V., Sláma, J., Mészárosová, N., 2022. Petrogenesis of low-pressure intra-oceanic arc granitoids: Insights from the late Neoproterozoic Avalonian–Cadomian orogen, Bohemian Massif. Lithos 428-429, 106808.

Santolík, V., Ackerman, L., Kachlík, V., Žák, J., Sláma, J., Strnad, L., Trubač, J., 2024. Geochemical fingerprinting of continental crust trapped in Cadomian volcanic arcs along northern Gondwana. Gondwana Research 131, 91-114.

Sláma, J., Dunkley, D.J., Kachlik, V. and Kusiak, M.A., 2008. Transition from island-arc to passive setting on the continental margin of Gondwana: U-Pb zircon dating of Neoproterozoic metaconglomerates from the SE margin of the Tepla-Barrandian Unit, Bohemian Massif. Tectonophysics, 461(1-4): 44-59.

Waldhausrová, J., 1984. Proterozoic volcanics and intrusive rocks of the Jílové Zone in Central Bohemia. Krystalinikum, 17: 77-97.

Žák, J., Holub, F. & Verner, K., 2005. Tectonic evolution of a continental magmatic arc from transpression in the upper crust to exhumation of mid-crustal orogenic root recorded by episodically emplaced plutons: the Central Bohemian Plutonic Complex (Bohemian Massif). International Journal of Earth Sciences, 94(3), 385-400.