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Jurassic pebbles in the Cretaceous sandstones of the Bohemian Basin as a possible tool for reconstruction of the Late Jurassic and Late Cretaceous palaeogeography

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Key words: Bohemian Massif, Jurassic relics, Jurassic pebbles, Bohemian Cretaceous Basin, Late Jurassic and Late Cretaceous palaeogeography.

Abstract. A new find of pebbles of Jurassic silicites in the Coniacian sandstones of the Bohemian Cretaceous Basin in N Bohemia has permitted analysis of the stratigraphic extent of Jurassic sediments in the NW part of the Bohemian Massif. The studied silicites are dominated by the rhax microfacies, while bioclastic and oolitic microfacies are less common. The thickest section of Jurassic sediments in the NW part of the Bohemian Massif has been obtained from the Doubice borehole. It is represented by basal clastics overlain by a 70 m thick succession of silicite-free carbonate rocks which range in age from Callovian to Lower Kimmeridgian. These deposits are dominated by the bioclastic microfacies whereas the rhax and oolitic microfacies are missing. The studied silicite-bearing sequence is younger than the carbonate rocks in Doubice borehole and was deposited mostly in a deeper zone probably during the Late Kimmeridgian transgression, much like in the Upper Frankenalb in SE Germany. The extensive Jurassic basin in the Bohemian Massif was connected with the S part of the Polish and German basins and – *via* the Hessian (Saxonian) Seaway – with the Jurassic basin in SE Germany. The Jurassic sediments were mostly eroded from the Bohemian Massif during the Early Cretaceous with the exception of small relics. The remnant of the Jurassic deposits preserved in the area of the West Sudetic Island supplied coarse debris during Late Cretaceous to the Bohemian Cretaceous Basin.

INTRODUCTION

On the surface of the Bohemian Massif, platform Jurassic sediments have been preserved in only a few relics along the Lusatian Fault in N Bohemia and Saxony, and in the Brno area (Figs. 1, 2). The latter cover a vast area on the SE slopes of the Bohemian Massif, being buried beneath the Outer Carpathian nappes and Carpathian Foredeep sediments (Fig. 2). Surficial relics of the Jurassic have a stratigraphic range between the Upper Callovian and the Kimmeridgian in N Bohemia and Saxony, whereas those on the SE slopes of the Bohemian Massif are ranked from the Middle Jurassic (Upper Bajocian to Bathonian) to the Tithonian (Eliáš, 1981; Eliáš, Wessely, 1990; Adámek, 2002, 2005; Pieńkowski *et al.*, 2008; Tröger, 2011a; Hrbek, 2014).

The Jurassic sediments preserved in tectonic blocks along the Lusatian Fault, which separates the Bohemian (or Saxonian-Bohemian) Cretaceous Basin from the granitic rocks of the Lusatian pluton, have attracted attention since the first half of the 19th century (Cotta, 1838; Lenz, 1870; Geinitz, 1872; Bruder, 1882, 1886, 1887, 1888; Beck, 1893, 1895, Herrmann, Beck, 1897, a.o.). These include eight occurrences, mostly exposed by quarrying in the past (I–VIII in Fig. 2). Two additional outcrops of limestones, small and fragmentary, were found near Brtníky and Kyjov in N Bohemia by Fediuk *et al.* (1958). In some blocks, the Jurassic

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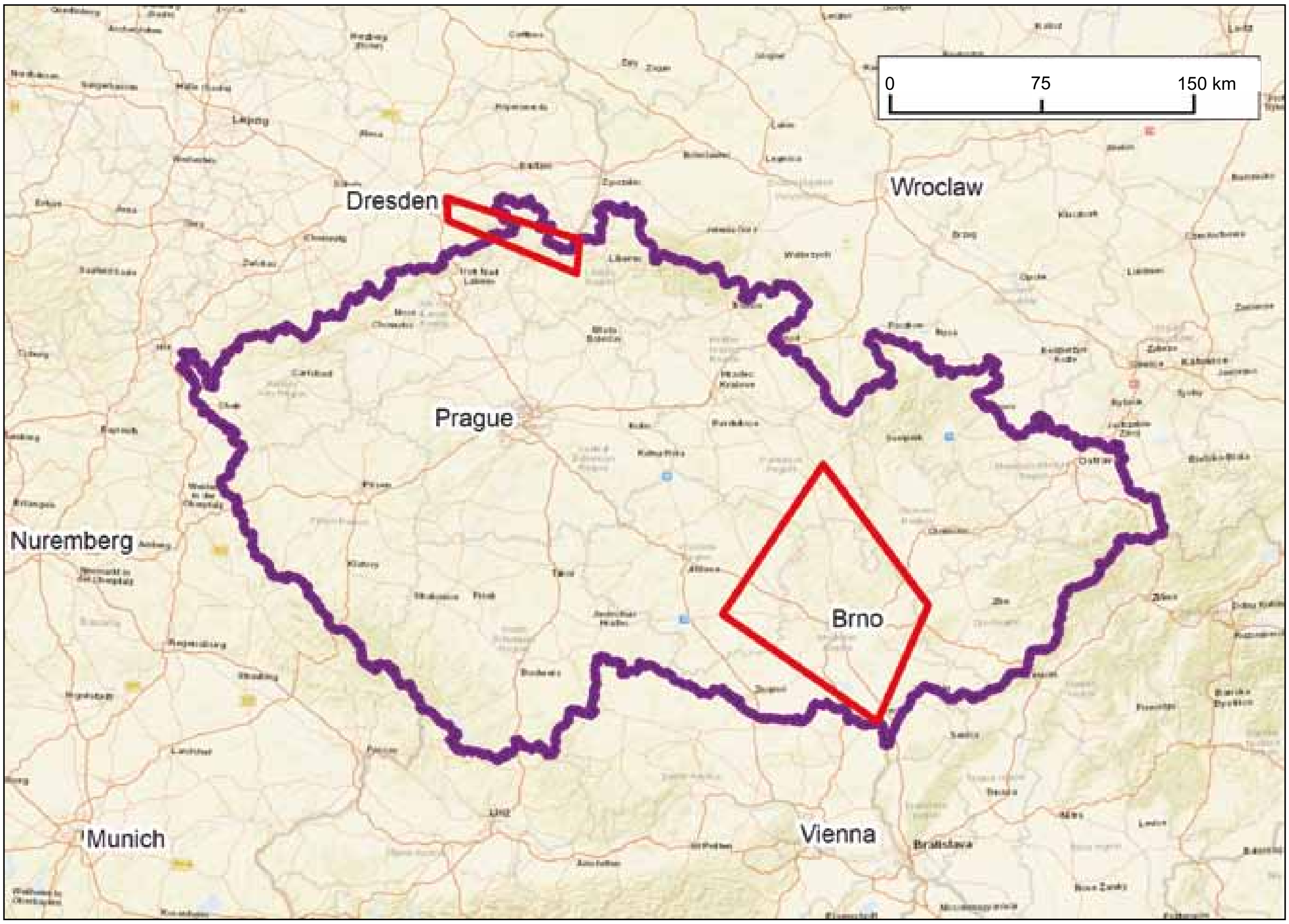

Fig. 1. Positions of areas with sites discussed in the text

rocks are accompanied by Permian sediments and volcanics (Opletal *et al.*, 2006; Valečka *et al.*, 2006). The Jurassic rocks are represented by limestones and dolomites with occasional marlstone intercalations. Basal clastics have been preserved at the sites of Hohnstein and Doubice. As for their microfacies, the Jurassic sediments from the Lusatian Fault zone have not been analysed yet with the exception of the section of borehole D-1 at the Doubice site (Eliáš, 1981).

Ten sites with pebbles of Jurassic carbonates and silicites have been reported from the Bohemian Cretaceous Basin (1–10 in Fig. 2). These pebbles are considered to be of Jurassic age based on their macroscopic similarity with the Jurassic rocks in outcrops. Their pertinence to the Jurassic was also based on the presence of redeposited fragments of Jurassic ammonites (Cotta, 1838) or the presence of oolites at several sites (Seifert, 1937; Voigt, 2009). The platform Jurassic rocks in the SE part of the Bohemian Massif have been subjected to a microfacies analysis. Surficial relics of the Jurassic deposis near Brno were studied by Hanzlíková and Bosák (1977), Bosák (1978) and Eliáš (1981). The microfacies of the Bajocian to Tithonian rocks beneath the Carpathian nappes and the Carpathian Foredeep were studied by Eliáš (1974, 1981), and this holds also for pebbles of Jurassic silicites and carbonates contained in several geological units in the SE part of the Bohemian Massif (Eliáš, 1981; 11–14 in Fig. 2). Their age at the Rudice site has been evidenced by the Jurassic fauna (Uhlig, 1881).

Microfacies analysis of the Jurassic rocks cropping out along the Lusatian Fault and of pebbles of the Jurassic rocks in the Bohemian Cretaceous Basin is complicated by the fact that nowadays most of the outcrops are partly or totally destroyed, and the sites with pebbles are sometimes difficult to trace. In N Bohemia, the site of Kyjov bears no outcrops, the site of Brtníky displays only a negligible outcrop of do-

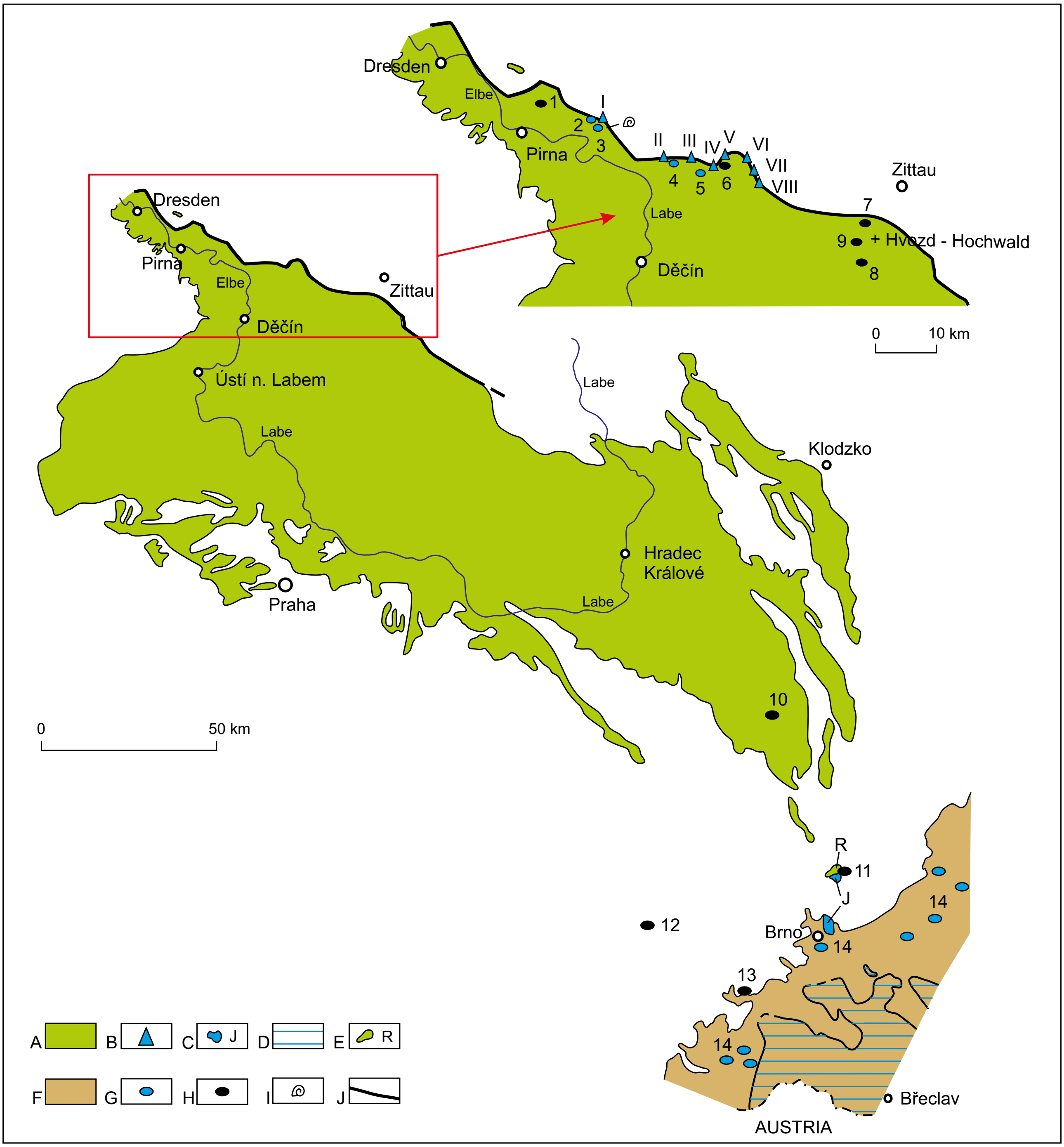

Fig. 2. Jurassic platform sediments and occurrences of Jurassic pebbles in the Bohemian Massif

A – Bohemian Cretaceous Basin, **B** – tectonically bounded blocks of Jurassic rocks along the Lusatian Fault, **localities**: I – Hohnstein, II – Lichtenhainer Mühle, III – Saupsdorf, IV – Hinterhermsdorf, V – Bílý potok (Weissbach), VI – Brtníky (Sternberg), VII – Kyjov and Peškova stráň Hill, VIII – Doubice, **C** – Jurassic relics near Brno and Olomučany, **D** – Jurassic covered with sediments of Carpathian Foredeep and Outer Carpathians nappes, **E** – Rudice sequence near Olomučany, **F** – area of Carpathian Foredeep and Outer Carpathians nappes, **G** – Jurassic carbonate pebbles, **localities**: 2 – Zeschnig, 3 – Hohnstein – Polenztal, 4 – Křinice River valley between Hausberg (elev. 396 m) and Großstein (elev. 360 m), 5 – Hinterhermsdorf (Heidelbachtal), 14 – sediments of Carpathian Foredeep, **H** – Jurassic silicite pebbles, **localities**: 1 – Kohlberg (elev. 303 m) near Wünschendorf, 6 – Benediktstein (elev. 416 m), 7 – vicinity of the town of Žitava (Zittau), 8 – Jezevčí vrch (Limberg) Hill (elev. 665 m), 9 – Hvozd (Hochwald) Hill (elev. 749 m), 10 – Svitavy, 11 – Rudice, 12 – Třebíč, 13 – Moravský Krumlov, **I** – fragments of Jurassic ammonites in Cretaceous sandstones near Hohnstein, **J** – Lusatian Fault lomite, and the site of Bílý Potok provides only scarce finds of dolomite fragments. Another important site is Peškova Stráň Hill near Kyjov, specifically the stream at the foot of the hill. Various lithotypes including micritic limestones and sparitic limestones with silicites and a silicified fauna can be found in the stream. It is important that the occurrences of Jurassic rocks in N Bohemia and the Jurassic pebbles in the Bohemian Cretaceous Basin are subjected to new palaeontological research and microfacies study for comparison with Jurassic rocks in other parts of the Bohemian Massif and its surroundings. Conglomerate beds with silicite pebbles were found by the author in an abandoned quarry in Cretaceous sandstones on the SW slopes of Hvozd Hill (Hochwald, elev. 749 m) in the eastern part of the Lusatian Mountains (Figs. 2–4). A description of this site, including the microfacies characteristics of the pebbles, and a review of the occurrences of Jurassic pebbles on the Bohemian Massif gives the route to palaeogeographic considerations for both Late Jurassic and Late Cretaceous times.

THE JURASSIC PEBBLES FROM HVOZD HILL

MATERIAL AND METHODS

Seventeen pebbles continuously numbered from 1 to 17 were acquired from the conglomerate beds. Sixteen pebbles were mounted as thin sections for microfacies analysis. For comparison, 17 samples were collected from the sites of Doubice, Brtníky and Bílý Potok for thin section and carbonate/sandstone analyses. The thin sections are deposited at the Czech Geological Survey as the collection of the author. Pebble No 17 was subjected to X-ray analysis using a Bruker D8 Advance diffractometer, and the recordings were evaluated using the Diffrac EVA 2015 software (Bruker AXS 2015) and the PDF2 database (ICDD 2002). Photomicrographs were taken in the NIS-elements AR 21, 30 program.

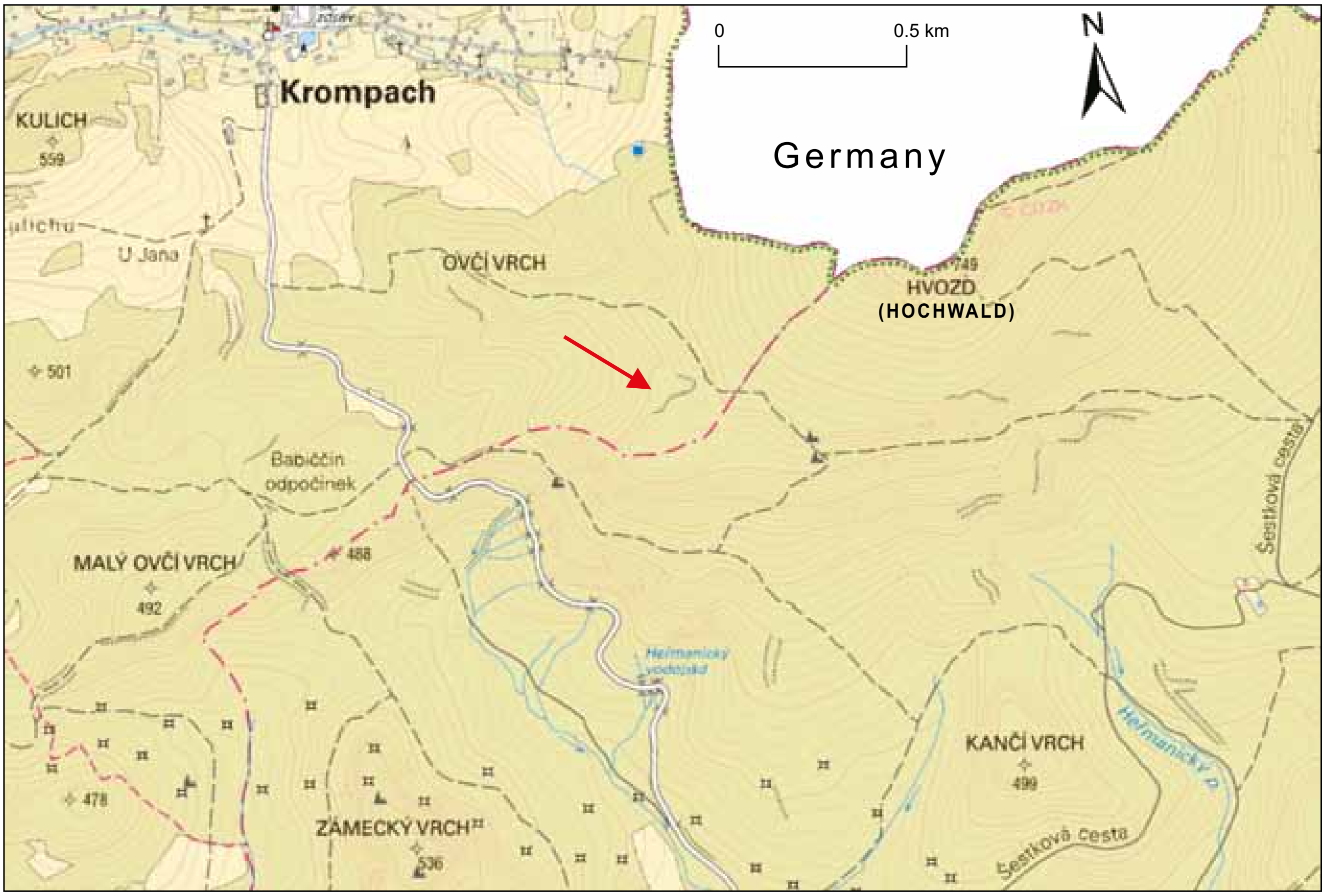

Fig. 3. Situation of the studied quarry (indicated by an arrow) on the southwestern slope of Hvozd (Hochwald) Hill (elev. 749 m)

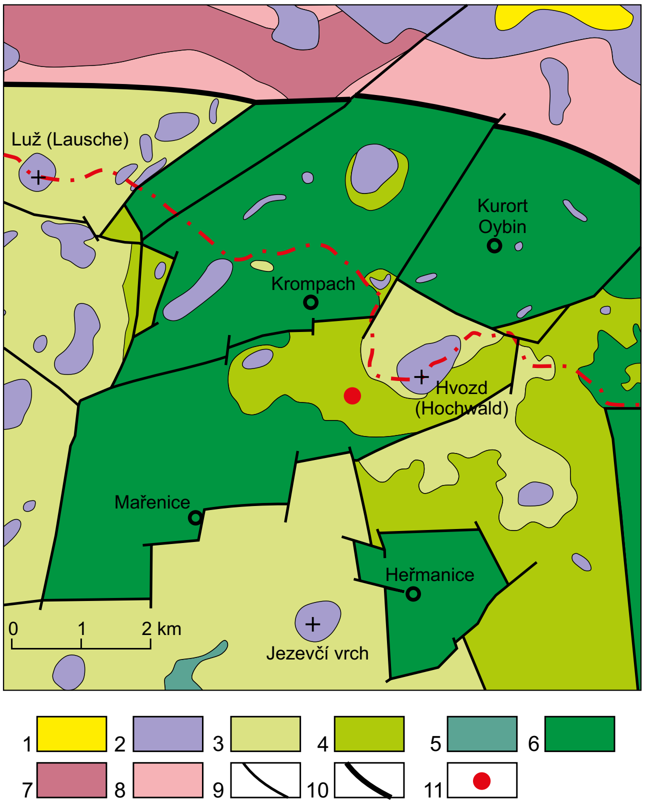

Fig. 4. Geological map in the vicinity of the studied locality

1 – Žitava (Zittau) Basin (Oligocene–Miocene): sands, clays, coal, 2 – neovolcanic rocks (basaltic rocks, trachytes, phonolites); Bohemian Cretaceous Basin: 3 – sandstones of the Březno Formation (Coniacian), 4 – sandstones of the Teplice Formation and Rohatce Member (Upper Turonian–Lower Coniacian), 5 – calcareous mudstones of the Teplice Formation (Upper Turonian–Lower Coniacian), 6 – sandstones of the Bílá Hora and Jizera Formations (Lower to Upper Turonian); Lusatian pluton: 7 – biotite monzogranite, Rumburk type, 8 – biotite monzogranite, Brtníky and Václavice types, 9 – faults, 10 – Lusatian Fault, 11 – studied locality

GEOLOGICAL SETTING

The studied site, an abandoned quarry, lies near the NNW margin of the Bohemian Cretaceous Basin, 0.7 km SW from the top of Hvozd Hill (elev. 749 m) near the Czech–German border (Fig. 3). The quarry is probably identical with that reported by Andert (1929, page 121) from an analogous position. In this quarry, Andert described fine- to medium-grained sandstones with thin beds containing quartz pebbles; no silicite occurrences were, however, mentioned. The site is located 5 km from the Lusatian Fault, which separates the Bohemian Cretaceous Basin from granitic rocks of the Lusatian pluton (Fig. 4). The Cretaceous sediments preserved in this area are of max. *ca.* 800 m in thickness, pertaining to the Peruc-Korycany to Březno formations of Cenomanian to Coniacian age (Čech *et al.*, 1980). The Cretaceous sediments as well as granitic rocks are penetrated by many neovolcanic bodies of the Ohře Rift. The Cretaceous sediments at this site are dominated by psammites in all formations, a typical feature of the near-source Lusatian lithofacies development of the NNW part of the Bohemian Cretaceous Basin. The sandstones in the quarry belong to a sequence of fine- to medium-grained, well sorted, weakly clayey to quartzose sandstones, sharply overlying the Middle to Upper Turonian Jizera Formation. The quarry is placed 90–100 m above the base of the sequence. As indicated by the presence of *Cremnoceramus crassus crassus*, which was found by S. Čech (pers. comm.) *ca.* 15 m above the quarry section, the sandstones can be attributed to the lower part of the Lower Coniacian. They correspond to the Rohatce Member in the lithostratigraphy of Čech *et al.* (1980), and to unit Con 1 in the sequence stratigraphy of Uličný *et al.* (2009). The section of the quarry face, max. 9.2 m high, contains an erosional boundary separating massive sandstones from thinly bedded sandstones (Fig. 5, level 0.00 in Fig. 6). This boundary is overlain by four beds of coarse-grained sandstone with pebbles, each of them composed of smaller layers, 5–20 cm thick, mostly with positive grading. The bases of the beds are erosional, their tops are sharp or represented by a lithological transition. The basal surfaces are covered with a dense network of crawling traces (repichnia), preserved in positive relief (hypichnia). The pebbles vary between 2 mm and 4 cm, with quartz pebbles attaining max. 10 cm in size in the bed whose base is positioned at 2.4 m. Besides quartz, cm-sized pebbles of hard, whitish grey to white silicites are present in the beds with bases at 2.4 and 2.6 m above level 0.00, showing homogeneous, macroscopically silty texture (Figs. 6, 7).

DISTRIBUTION, SIZE AND SHAPE OF THE SILICITE PEBBLES

The silicite pebbles concentrate near the bases of coarse-grained beds, with almost no mutual contacts (Fig. 7). Their maximum size (c-axis) lies in a narrow range of 1.9–3.9 cm, unlike the maximum size of quartz pebbles which ranges between 0.2 and 10.0 cm. In the grain size category of 1–10 cm, the silicite pebbles dominate over the quartz pebbles. The dimensions of the axes of 12 silicite pebbles have been measured and overall shapes could be determined (Table 1). Equant (spherical) pebbles predominate, while prolate (rod-shaped) and oblate (blade-shaped) pebbles are rare, and a single disc-shaped pebble was encountered.

Fig. 5. Southwestern part of the studied quarry

A boundary between massive sandstones and thickly bedded sandstones indicated by an arrow. Photo by J. Valečka 2018

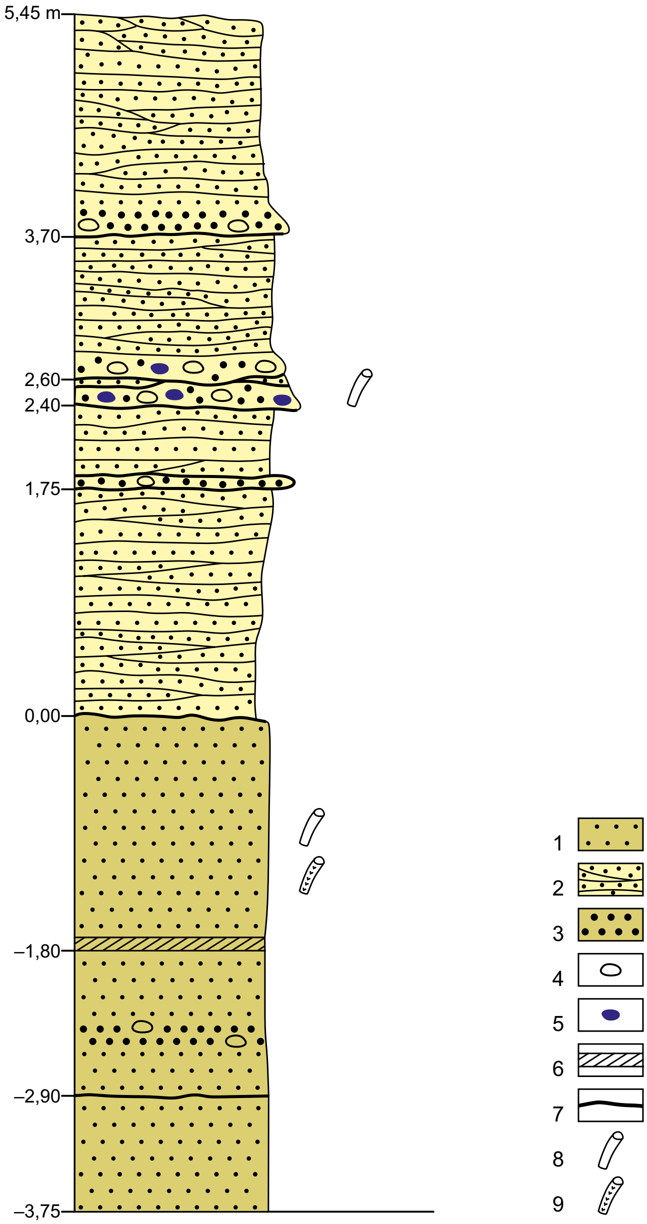

Fig. 6. Lithological section in the central part of the studied quarry

1 – massive, fine- to medium-grained, well sorted sandstones, 2 – thinly bedded, fine-to medium-grained, well sorted sandstones, 3 – coarse-grained sandstones with gravel, 4 – quartz pebbles, 5 – Jurassic silicite pebbles, 6 – cross-bedding, 7 – erosive boundary, 8 – ichnogenus Planolites, 9 – ichnogenus Ophiomorpha

SEDIMENTARY ENVIRONMENT OF SANDSTONES WITH SILICITE PEBBLES

The Upper Cretaceous sandstones belong to a succession of fine- to medium-grained sandstones several tens to 100 m thick, with thin intercalations of coarse-grained gravelly sandstones. This succession stretches across an extensive belt along the Lusatian Fault, several kilometres to over 10–12 km in width. The sandstones were deposited several kilometres to more than 10 km from the sedimentary basin margin, in an offshore zone of a shallow, open sea with the presence of shallow-water ichnogenera of *Planolites* and *Ophiomorpha*. The basin margin was adjacent to a rather small but tectonically active source area of sand-sized debris, known as the West Sudetic Island (*e.g.*, Tröger, 1969, 2011b; Klein *et al.*, 1979; Skoček, Valečka 1983; Voigt *et al.*, 2008). The good sorting of sandstones points to deposition in a nearshore zone with intensive sorting processes. The zone included areas with elevated contents of quartz gravel, less commonly also silicite gravel, transported by rivers or

Fig. 7. A coarse bed with quartz and silicite pebbles, basal bed boundary at the level of 2.40 m in Fig. 6.

Silicite pebbles indicated by arrows, erosive boundary near the mobile phone. Photo by J. Valečka, 2018

abraded from a rocky coast. The prevalence of spherical pebbles (Table 1) documents the prolonged resting of the gravel in the dynamic nearshore zone before its deposition farther offshore. Gravel deposition far from the shoreline was induced by extreme storms, in the form of coarse tempestites.

MICROFACIES CHARACTER OF SILICITES AND SEDIMENTOLOGICAL INTERPRETATION OF MICROFACIES

The microfacies analysis of the silicites aimed at a comparison with the Jurassic microfacies in the Bohemian Massif, determination of the depositional environment and a comparison with the Jurassic rocks exposed along the Lusatian Fault. Three essential components can be distinguished in the pebbles: the matrix, the clasts (allochems *sensu* Folk, 1959, 1962 or grains *sensu* Dunham, 1962) and the

Table 1

Pebble axis dimensions (in cm) and pebble shapes

Pebble number	Axis a	Axis b	Axis c	b/a	c/b	Zingg shape classes	Pebble shape
1	3.9	3.2	2.2	> 2/3	> 2/3	II	spherical
2	2.3	2.1	2.1	> 2/3	> 2/3	II	spherical
4	2.2	2.0	1.4	> 2/3	> 2/3	II	spherical
6	2.4	1.7	1.4	> 2/3	> 2/3	II	spherical
7	3.6	3.0	2.1	> 2/3	> 2/3	II	spherical
8	3.6	1.4	1.3	< 2/3	> 2/3	IV	rod-shaped
9	3.0	1.5	1.2	< 2/3	> 2/3	IV	rod-shaped
11	3.8	1.8	1.0	< 2/3	< 2/3	III	bladed
12	1.9	1.2	0.2	< 2/3	< 2/3	III	bladed
13	3.2	2.2	1.8	> 2/3	> 2/3	II	spherical
14	2.3	1.6	1.1	> 2/3	> 2/3	II	spherical
15	3.5	2.4	1.4	> 2/3	< 2/3	I	discoidal

terrigenous admixture. In all the pebbles, the matrix is formed by an aggregate of fine quartz grains, with sporadic fibrous chalcedony. The grains are mostly totally silicified including echinoderm fragments and prismatic layers of mollusc shells. Their content exceed 10%. The terrigenous components are represented by dispersed quartz grains and by clay admixture (analytical determination). High SiO_2 content was also proved by orientation X-ray quantitative phase analysis, which showed SiO_2 content of ca. 85 wt.% and detected kaolinite (15 wt.%) as the second phase. The matrix was pervaded by Fe oxyhydroxides in one pebble. Based on the character of the dominant grains, three microfacies can be distinguished in the silicites: 1) rhax microfacies, 2) bioclastic microfacies, and 3) oolitic microfacies.

The **rhax microfacies** is the most common one: it was found in 12 pebbles (Nos. 1, 3–6, 9–13, 15 and 16). Bioclasts are dominated by rhaxes, which constitute 10–30%, in some portions as much as 35% of the rock (Pl. 1: 1, 4, 5). The rhaxes are visible in circular, slightly elliptical and in typical bean- and kidney-shaped cross sections (Pl. 1: 2, 3, 5–7). The cross sections range between 0.09 and 0.16 mm in diameter, most commonly between 0.12 and 0.14 mm. The rhaxes occasionally show preserved cavities, but mostly they are filled with quartz of coarser grain than that of the walls (Pl. 1: 1, 3, 4). Other bioclasts include elongated sponge spicules in amounts below 1% to below 5%. Monaxon spicules prevail, while polyaxons (triaxons, calthrops and also dichocalthrops) are less frequent (Pl. 1: 5–7). An area with subparallel-aligned monaxons was found in one pebble (Pl. 1: 5). The canals of the spicules have mostly disappeared during silicification, being filled with quartz. A glauconite fill of a triaxon canal was occasionally encountered. Bivalve shell fragments are rare (below 1%), often formed of prismatic layers. Foraminifers were found in two sections from a single pebble, and echinoderm fragments are very rare. Minute undeterminable bioclasts are accessory. The content of terrigenous quartz grains in silt to fine sand fractions (max. 0.25 mm) is 1–5%. The glauconite grains are rare, max. 0.1 mm in size, and muscovite flakes are exceptional. Bioturbation structures were observed, forming darker cross sections of small bioclast-free burrows lined with accumulated rhaxes (Pl. 1: 1).

The **bioclastic microfacies** was found in only three pebbles (Nos. 2, 7 and 8). This microfacies represents silicites with 15–25% of bioclasts. Most bioclasts cannot be determined. The determined bioclasts are variable, with rhaxes (2–5%), elongated sponge spicules – almost exclusively monaxons (<3%), and with rare elongated, wavy shells of thin-walled bivalves (Pl. 1: 8). Accessory foraminifers and echinoderm fragments were found in pebble No. 2 (Pl. 2: 1). The content of terrigenous quartz in coarse silt to fine sand fractions reaches max. 3%. Similar bioclastic microfacies with various bioclasts (sponge spicules, bryozoans, brachiopods, bivalves and scarce foraminiferas and rhaxes) were described by Hrbek (2014, fig. 3).

The oolitic microfacies with oncoid admixture was identified in a single pebble (No. 14). The ooids are 0.4 mm in size on average, ranging between 0.22 and 0.95 mm in size. Some ooids show concentric texture, while some others are simple ooids with no clear concentric fabric (Pl. 2: 2, 3). It cannot be excluded that their concentric fabric was obscured by silicification. In addition, rare particles of elongate to irregular shapes with concentric fabric were found, sometimes with coarser-grained aggregate of quartz in the core. These particles are herein interpreted as oncoids (Pl. 2: 4). The content of terrigenous quartz in the coarse silt to fine sand fractions reaches 2% of the rock.

The identified microfacies can be compared with the standard microfacies (SMF) of Flügel (2004) with the assumption that the matrix was micritic both in the rhax and bioclastic microfacies. The **oolitic microfacies** with oncoid admixture corresponds to SMF 15 (ooid grainstone) formed in shallow, mobile environments, on shallows, beaches or possibly even on tidal flats, above the fair weather wave base. A shallow-water to intertidal environment is evidenced by the presence of oncoids. The **bioclastic microfacies** without shallow-water elements (algae, ooids, a.o.) is comparable with SMF 9 (bioclastic wackestone), deposited in a deeper zone of open shallow sea, below the fair weather wave base, with good circulation. The **rhax microfacies** is an analogue of SMF 1 (spiculite wackestone, or spiculitic packstone), characterizing a deeper zone of the shelf with low rates of deposition. The occasional effect of bottom currents is evidenced by the alignment of monaxial spicules (Pl. 1: 5). Bioturbation structures, attributable to fodinichnia or pascichnia (Pl. 1: 1), document a non-anoxic environment. The rhax microfacies in the North German Basin were placed to a deeper shelf, below the storm wave base by, *e.g.*, Bai *et al.* (2017).

THE OCCURRENCE OF MICROFACIES AND SILICITES IN OTHER JURASSIC SEDIMENTS IN THE BOHEMIAN MASSIF

The microfacies encountered in silicite pebbles at the studied site at Hvozd Hill find their equivalents among Jurassic rocks cropping out in the Brno area and on the SE slopes of the Bohemian Massif (Figs. 1, 2). The **rhax microfacies** are common in carbonate rocks near Olomučany and Brno, dating from Oxfordian to Kimmeridgian (Eliáš, 1974, 1981; Adámek, 2005). These microfacies contain 10–40% rhaxes, and a local admixture of elongated sponge spicules (2–10%). Rhaxes are also frequent in Jurassic rocks on the SE slopes of the Bohemian Massif, especially in the Vranovice and Nové Sedlo limestones and dolomites of Eliáš (1974, 1981), *i.e.*, in the Vranovice and Mikulov Formations of Adámek (2005) of Oxfordian to Lower Tithonian age. Rhaxes constitute 10–20% of the rock, being equally abundant as elongated sponge spicules (sponge-rhax biomicrites) or less abundant than the spicules. The **bioclastic microfacies** with variable contents and compositions of bioclasts were reported by Eliáš (1974, 1981) from a site near Olomučany N of Brno as well as from the Stránská Skála site on the E edge of Brno (Fig. 2). Bioclasts constitute 5–20% of the rock, being represented by foraminifer fragments, elongated sponge spicules, rhaxes, bivalves and echinoderms. The same microfacies can be found in the Callovian to Lower Tithonian carbonate rocks and marlstones on the SE slopes of the Bohemian Massif (Eliáš, 1974, 1981; Eliáš, Wessely, 1990). The microfacies contains also fragments of elongated sponge spicules, rhaxes, molluscs, echinoderms and others constituting 5–25% of the rock. The **oolitic microfacies** are common on the SE slopes of the Bohemian Massif in the Hrušovany and Vranovice limestones and dolomites (Eliáš, 1981; Eliáš, Wessely, 1990), *i.e.*, in the Oxfordian Vranovice Formation of Adámek (2002, 2005). Oosparitic limestones are equally common in the Tithonian, as reported by Eliáš (1981) and Adámek (2002, 2005). Eliáš (1981) reported them from the Kobylí limestones, which are an equivalent of the upper part of the Kurdějov Formation of Adámek (2005). These microfacies contain 40–80% oolites, and bioclasts are usually present in a small admixture.

Microfacies analysis of Jurassic relics along the Lusatian Fault has been realized only in borehole D-1 near an abandoned quarry at the Doubice site (site VIII in Fig. 2). This exploratory borehole (Chrt, 1958) provided the most complete section of the Jurassic sediments in the Lusatian Fault area (Fig. 8). The microfacies were evaluated by Eliáš (1981). The basal clastics, developed as coarse-grained sandstones with conglomerate beds 20 m thick, were designated as the Brtníky Formation, whereas the overlying 70 m thick succession of dolomites and dolomitic limestones was called the Doubice Formation by Eliáš (1981). The carbonate rocks of the latter unit are sandy at the base, with 10–40% of terrigenous quartz. Higher up, the content of quartz grains decreases to 1–8%. According to Eliáš (1981), the section is dominated by dolosparites with an admixture (max. 7%) of fragments of elongated sponge spicules, foraminifers and echinoderms. Intradolosparites with max. 25% intraclasts and pelodolosparites with max. 20% pellets were found in two thin intervals (Fig. 8). The present microscopic study of rocks from the nearby Doubice quarries confirms the conclusions of Eliáš (1981). The basal sandstones, exposed in a thickness of several metres, are mineralogically highly mature, with 85–95% quartz grains and granules. The rest of the rock volume is formed by clay. Quartz clasts display fragmentation due to pressure induced by movements along the Lusatian Fault (Pl. 2: 5). Thickly bedded carbonate rocks are exposed in a thickness of 8.5 m (Fig. 9). They are dominated by dolomitic limestones with $CaCO_3$ contents between 56.4 and 52.1%, occasionally only 36.48%. The contents of $MgCO_3$ range between 37.24 and 24.89%. Dolomites with 36.09% $MgCO_3$ and 32.93% $CaCO_3$ are subordinate. In their microfacies, the carbonate rocks corre-

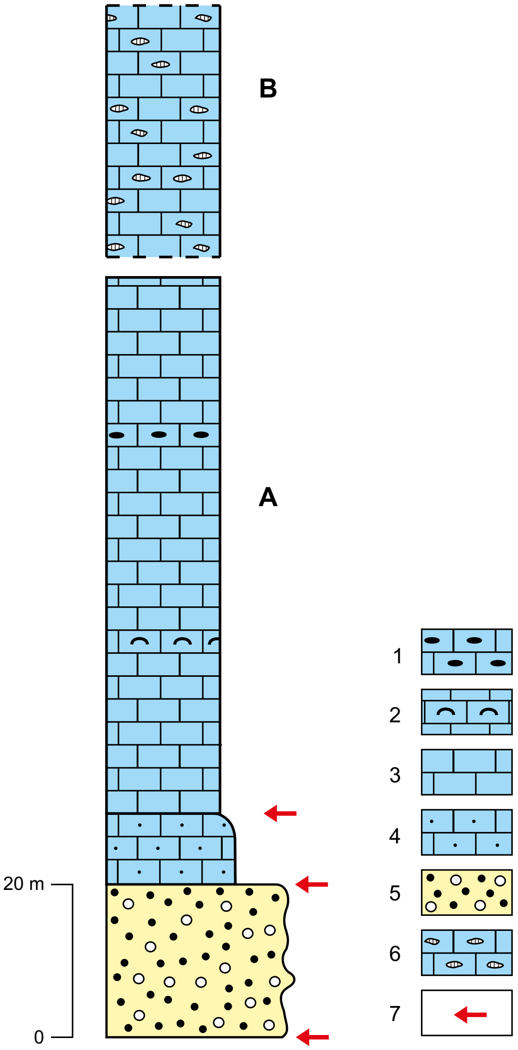

Fig. 8. A. Jurassic section in borehole D-1 near Doubice (adapted after Eliáš, 1981); B. Supposed position of carbonates with silicites

Borehole D-1 section: 1 – pelmicritic dolomites, 2 – intraclastic dolosparites, 3 – dolosparites and sparitic limestones with bioclastic admixture, subordinate marlstone layers, 4 – sandy dolomites and dolomitic limestones with bioclastic admixture, 5 – quartzose sandstones with gravel admixture; 6 – sequence of carbonates with silicites, 7 – transgressive boundaries

Fig. 9. An outcrop of dolomitic limestones and dolomites in an abandoned quarry near Doubice. Photo by J. Valečka 2018

spond to dolosparites with bioclast admixture, referred to as SMF 9 by Eliáš (1981). The sparitic matrix contains dispersed bioclasts (3–5%) with a prevalence of echinoderms. The content of terrigenous quartz grains reaches 1–5% (Pl. 2: 6).

Silicites (cherts) with SiO_2 content between 96.65 and 99.37% are common in the Olomučany area N of Brno (Hanzlíková, Bosák, 1977; Bosák, 1978; Eliáš, 1981; Adámek, 2005). Silicites (cherts) have been also reported by Adámek (2005) from carbonate rocks of the Altenmarkt Group (Kimmeridgian) on the SE slopes of the Bohemian Massif. The silicite-bearing carbonates were possibly visible at the almost destroyed sites of Brtníky and Kyjov in N Bohemia (sites VI and VII in Fig. 2): this is where Bruder (1886, 1887, 1888) reported siliceous concretions ("*kieseligen Concretionen*"). Any presence of silicites cannot be verified at these sites nowadays except the locality of Peškova Stráň Hill.

Based on the above data, the silicite pebbles from Hvozd Hill as discussed herein can be considered as certainly being of Jurassic age. Of the microfacies found in the pebbles, only the bioclastic microfacies has been reported from Jurassic relics in the proximity of the Lusatian Fault (Eliáš 1981, see above). Oolitic limestones have been described only from Jurassic pebbles contained in Cretaceous sandstones from three sites in Saxony (sites 1, 2 and 5 in Fig. 2). Oolitic limestones and silicified oolites have been reported from these sites by Geinitz (1872), Seifert (1937) and Voigt (2009). The rhax microfacies has not been known from either Jurassic relicts or from the Jurassic pebbles.

The carbonate rocks of the Doubice Formation contain neither the silicites nor the rhax and oolitic microfacies which were found in pebbles at the Hvozd Hill site. At the time of the deposition of Coniacian sandstones, a Jurassic carbonate succession with silicites younger than the Doubice dolomites defined by Eliáš (1981) must have been located on the West Sudetic Island. This succession, at least several tens of metres thick and dominated by the rhax microfacies, was deposited in a deeper environment than the Doubice Formation. Subsequent shallowing is indicated by the presence of the bioclastic and oolitic microfacies. The oolitic microfacies may indicate the end of the regressive phase but it may equally result from the formation of a local shallow.

The presumed position of the formation with silicites is shown in Fig. 8, overlying the Doubice Formation. The Jurassic sediments in the tectonic blocks along the Lusatian Fault range in age from the uppermost Callovian to the Lower Kimmeridgian. The basal clastics are considered to be Callovian in age while the overlying carbonate rocks with occasional marlstone interbeds are allocated to the Oxfordian and the Lower Kimmeridgian (Dvořák, 1964; Pietzsch, 1962; Eliáš, 1981; Pieńkowski *et al*., 2008; Tröger, 2011a). This stratigraphic range (*i.e.* Platynota Zone) was also confirmed by Hrbek (2014) after a revision of older collections of ammonite faunas from sites in northern Bohemia and from the site of Hohnstein in Saxony. New micropalaeontological studies do not exclude the Tithonian age of the northern Bohemian occurrences either (Holcová, Holcová, 2016). The formation of deposits with silicites could have reached stratigraphically to the Upper Kimmeridgian or even to the Tithonian.

THE PEBBLES OF THE JURASSIC ROCKS IN THE CRETACEOUS AND TERTIARY SEDIMENTS OF THE BOHEMIAN MASSIF

The newly described locality at Hvozd (Hochwald) Hill extends the number of sites from which Jurassic pebbles have been reported since the 1830s (Fig. 2). A register of sites dispersed in geological formations of different ages in different areas may contribute to the assessment of the extent of Jurassic deposition in the Bohemian Massif.

The highest number of sites have been reported from sandstones and conglomerates of Cenomanian, Turonian and Coniacian age of the Bohemian Cretaceous Basin. Nine of these sites are located close to the Lusatian Fault between Pirna in Saxony and Hvozd / Hochwald Hill (elev. 749 m) on the Czech–German border (sites 1–9 in Fig. 2). The first significant paper was published by Cotta (1838), who reported pebbles of Jurassic limestones together with fragments of the Jurassic ammonites *Ammonites polygratus* and *A. goverianus* from Hohnstein. Pebbles of Jurassic limestones from the Hohnstein area were also described by Beck (1893), Häntzschel (1928) and Seifert (1932). Geinitz (1872) found fragments of Jurassic limestones and fine-grained oolites in the Cenomanian conglomerates at Zeschnig near Hohnstein. Pebbles of Jurassic limestones from outcrops and galleries near Hohnstein were also mentioned by Beck (1893). A conglomerate bed with "fragments of sponges from whitish siliceous matter" was described by Zahálka (1916) from the NE foot of Limberg Hill (now Jezevčí vrch, elev. 665 m). Though this find has not been verified in the field, it is clearly of Jurassic age. Chert pebbles were found by Fischer (1934) at Kohlberg Hill (elev. 313 m) near Wünschendorf. Seifert (1937) reviewed the already published finds of Jurassic pebbles and other exotic rocks; in addition, he identified oolite grains and sponge spicules in cherts at the site of Kohlberg Hill (elev. 313 m). He also discovered other sites with Jurassic pebbles in the Turonian sandstones in the Křinice River valley S of Sebnitz between the hills of Hausberg (elev. 396 m) and Großstein (elev. 360 m) and on the elevation of Benediktstein (elev. 416 m). The presence of pebbles of Jurassic limestones in the Turonian sandstones in the Zittau area was mentioned by Petrascheck (1944) with no closer specification of the site. Voigt (2009) analysed exotic pebbles at a few sites along the Lusatian Fault in Saxony. Besides quartz, ironstones, red siltstones, limonitized sandstones, etc., he also described limestone and marlstone pebbles and attributed them to the Jurassic, ranking them from the upper Middle Jurassic ("Upper Dogger") to the Upper Jurassic ("Malm"). According to Voigt, marlstones comprise 3% of the pebbles at Zeschnig, the site of Hohnstein is dominated by limestone pebbles (95%), and the borehole of Hohnstein 101 comprises 12% limestone pebbles and 2% marlstone pebbles. In the Turonian conglomerates at Hinterhermsdorf (Heidelbachtal), Voigt determined 5% of pebbles of silicified oolitic limestones and silicified "sponge limestones". The Cretaceous sandstones in the proximity of the Lusatian Fault contain planar fragments as well as ironstone and ferruginous sandstone pebbles, considered to be of Jurassic, specifically "Dogger" age (Hermann, Beck 1897; Siegert, 1897; Zahálka, 1916; Häntzschel, 1928; Seifert, 1937, 1955; Voigt, 2009). The genesis of the ironstones and the ferruginous sandstones was studied by Valečka (2002). Based on the fact that deep boreholes along the Lusatian Fault contain fragments and pebbles of ironstones and ferruginous sandstone only in the Jizera Formation (Middle to Upper Turonian), he interpreted them as a product of arid climatic phases of the Turonian. Under these climates, the ferricrete was formed on different types of rocks in the source area. During the subsequent erosion, fragments of the ferricrete were transported to the Cretaceous Basin.

As suggested by the positions of sites with pebbles of Jurassic carbonate rocks and silicites along the Lusatian Fault (sites 1–9 in Fig. 2), the pebbles were deposited in sandstones and conglomerates along the NE Bohemian Cretaceous Basin margin and were derived from the West Sudetic Island (see Fig. 10). Another source area located to the SW of the SW basin margin supplied material to the E part of the Bohemian Cretaceous Basin for the sites in the Svitavy area, at Javorník and Moravský Lačnov (site 10 in Fig. 2). This is where Soukup (1952, 1962) reported pebbles of Jurassic cherts with occasional faunal remains, together with pebbles of granites, metalydites, quartzites and porphyries. The pebbles are found in conglomerate beds within the Middle Coniacian sandstones (Čech *et al.*, 2011). Other occurrences of pebbles are concentrated on the SE margin of the Bohemian Massif. Abundant pebbles and angular chert fragments are found in relicts of continental sands and clays of the Rudice Member, filling karst depressions in the Devonian limestones near Rudice and Olomučany N of Brno (site 11 in Fig. 2). The cherts were found to contain a rich fauna of bivalves, brachiopods, echinoids, corals, sponges etc. by Uhlig (1881). This author also described fragments of ammonites of the genera *Peltoceras* and "*Harpoceras*" and proposed that the Rudice Member belonged to the Jurassic.

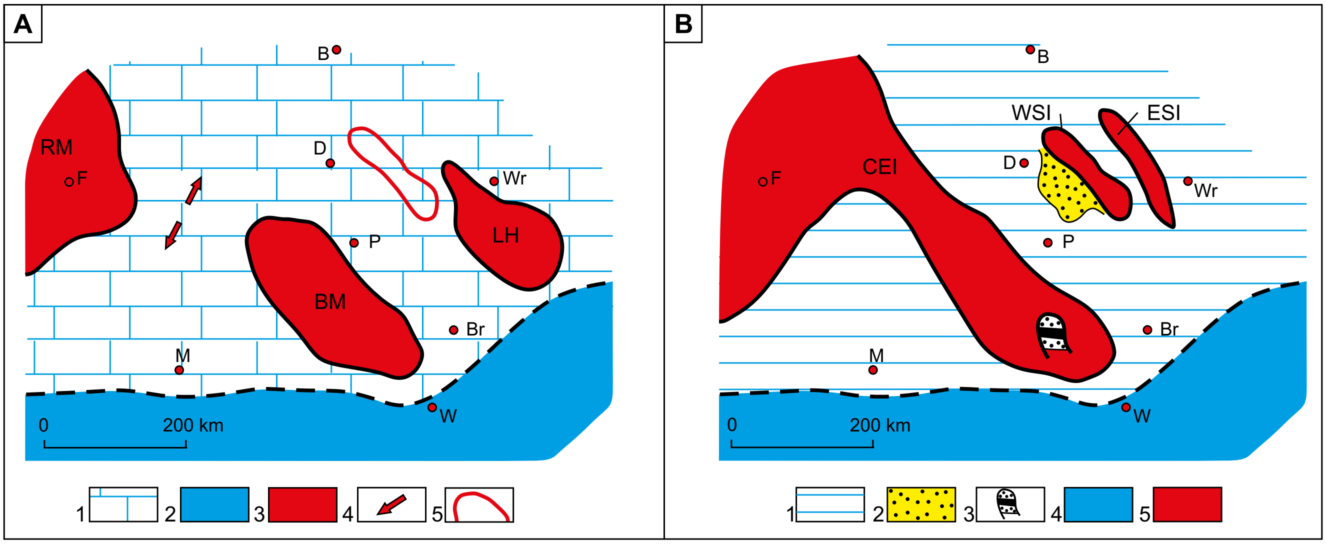

Fig. 10. Late Jurassic and Late Cretaceous paleogeography of the Bohemian Massif and adjacent areas (combined and modified after Klein *et al.*, 1979; Skoček, Valečka, 1983; Meyer, Schmidt-Kaler, 1989; Ziegler, 1990; Picha *et al.*, 2006; Pieńkowski *et al.*, 2008)

A. Kimmeridgian: 1 – platform area with carbonate sedimentation, 2 – Tethys area, 3 – source areas (BM – Bohemian Massif, RM – Rhenish Massif, LH – Lusatian high), 4 – Hessian/Saxonian Seaway, 5 – West Sudetic Island in the Late Cretaceous. **B.** Upper Turonian to Coniacian: 1 – platform area with marlstone, siltstone and subordinate sandstone and carbonate sedimentation, 2 – platform area with thick medium- to coarse-grained sandstones bodies, 3 – fluviatile and lacustrine sediments in South Bohemian Basins, 4 – Tethys area, 5 – source areas (WSI – West Sudetic Island, ESI – East Sudetic Island, CEI – Central European Island)

B – Berlin, F – Frankfurt, M – Munich, D – Dresden, P – Prague, Wr – Wrocław, Br – Brno, W– Vienna

Based on a sedimentological analysis and its geological position, the Rudice Member should be placed in the uppermost Lower Cretaceous and in the Lower Cenomanian. The cherts represent redeposited residue after the denudation of a thick Jurassic cover (Dvořák, 1964; Krystek, 1974; Peloušková *et al.*, 1985; Müller, Novák, 2000). Also the cherts found W and SW of Brno (sites 12 and 13 in Fig. 2) have their source in the Jurassic deposits of the Bohemian Massif. These cherts were found in relict Neogene gravels near Třebíč by Zapletal (1925). Striated boulders and smaller nodules of cherts and chert breccias at the base of the Miocene sediments, or free-lying on the surface were reported from the Moravský Krumlov area by Dvořák (1956). The cherts from the two sites were correlated with the silicites and the Jurassic sponge-rhax microfacies from Olomučany by Eliáš (1981) based on the high contents of rhaxes and elongated sponge spicules. In the Carpathian Foredeep SW and NE of Brno, pebbles of Jurassic carbonate rocks can be found in beds of polymict conglomerates in the Lower Badenian (Moravian) sands and clays, as reported by Krystek (1974) (site 14 in Fig. 2). These pebbles were studied by Eliáš (1981) and, with respect to the presence of rhaxes (up to 7%) and ooids (up to 10–15%), compared with the Jurassic deposits of the Bohemian Massif.

AN OUTLINE OF THE JURASSIC PALAEOGEOGRAPHY IN THE BOHEMIAN MASSIF

The first palaeogeographic concept of Jurassic deposition in the Bohemian Massif comes from Bruder (1886). He presumed the existence of a NW–SE-directed seaway (“Bohemian basin”) connecting the sedimentary basin in NW Europe with the “Moravian basin” in SE Moravia. The seaway was separated from the basin in S Germany as well as from the basin in Poland. A narrow island was situated between the basin in Poland and the “Bohemian basin” on the NE margin of the Bohemian Massif, strongly resembling the West Sudetic Island (Fig. 10) near the NE margin of the Bohemian Massif in its position. This idea of Bruder has been adopted by Dvořák (1964), Ziegler (1990), Matyszkiewicz (1997) and Bai *et al.* (2017). A different opinion was presented by Walter (1995), who assumed that the Bohemian Massif formed an extensive elevation in the Late Jurassic times and the sea covered only the NW margin of the Bohemian Massif and its SE slopes. In contrast, Matyja and Wierzbowski (1995) included the whole Bohemian Massif into the Middle Oxfordian depositional area. The idea of an extensive Late Jurassic depositional area, also covering the future West Sudetic Island, was presented by Voigt (2009). Hrbek (2014) presumed an interconnection of the Polish Basin and the South German Basin across the Bohemian Massif because the Jurassic sediments in the Bohemian Massif include ammonite taxa typical of Boreal or Subboreal zones, much like the Jurassic rocks in the Polish Jura Chain (Central Poland) and in southern Germany.

Jurassic sedimentation in the Bohemian Massif started on its SE slopes in the Late Bajocian to Bathonian, when the fluvial, deltaic and nearshore clastics of the Gresten Formation were deposited (Adámek, 2005; Nehyba, Opletal, 2016). The marine clastics of the Nikolčice Formation were deposited during the next transgression (Nehyba, Opletal, 2017). The subsequent transgression at the end of the Callovian led to the replacement of the clastics on the SE slopes of the Bohemian Massif by the platform carbonate sediments of a passive continental margin (Nehyba, Opletal, 2016). At the same time, the depositional area propagated to topographically higher portions of the Bohemian Massif, where sedimentation started not only in the Brno area (Adámek, 2005) but also in N Bohemia and in Saxony. In all these areas, the base of the Jurassic is locally overlain by clastics of small thicknesses (Hanzlíková, Bosák, 1977; Bosák, 1978; Eliáš, 1981). These clastics which are referred to the Callovian are followed by carbonate rocks with maximum preserved thicknesses recorded in borehole S-1 Slatina near Brno (130 m) and in borehole D-1 Doubice (70 m) in N Bohemia and Saxony. These carbonate rocks are referred to the Oxfordian and the Lower Kimmeridgian (Eliáš, 1981; Adámek, 2005; Hrbek, 2014). The section in borehole D-1 can be evaluated as a record of three transgressive phases: 1. the onset of clastic deposition, 2. the onset of the deposition of sandy carbonate rocks with up to 40% of terrigenous sand component, and 3. the deposition of carbonate rocks with a negligible terrigenous sand component (Fig. 8). As already the deposition of basal clastics extended to the area NE of the Lusatian Fault, the subsequent transgressions led to the expansion of the platform Jurassic sea across a large part of the Bohemian Massif and to the interconnection of depositional areas in its SE part and in N Bohemia and Saxony. The origin of a vast depositional area with a thick succession of Jurassic sediments is evidenced by: 1) a similar development of the Oxfordian to Kimmeridgian carbonate rocks with no terrigenous clastic intervals, 2) the occurrence of identical microfacies, and 3) the wide areal distribution of the Jurassic pebbles, found in several geological formations from the Cenomanian (or the topmost Lower Cretaceous) to the Neogene (Fig. 2).

After several transgressive phases between the Callovian and the Early Kimmeridgian, yet another transgression can be presumed, which started the deposition of the succession with the silicites (Fig. 8). This assumption is supported by the prolonged transgression history on the SE slopes of the Bohemian Massif, where the “basinal” marlstone facies of the Mikulov Formation shifted towards the NW, to the centre of the Bohemian Massif, from the Oxfordian to the Kimmeridgian/Tithonian boundary (Adámek, 2005; Picha *et al.*, 2006). Similarly, a transgression occurred in the platform Jurassic deposition in the Frankenalb area, Bavaria, in the Late Kimmeridgian; this was followed by the sedimentation of carbonate rocks with silicites, giving rise to the Torleite Formation and the overlying formations (Bloos *et al.*, 2005; Niebuhr, Pürner, 2014; Mönnig *et al.*, 2018). Not later than after this transgression, the sedimentary basin on the Bohemian Massif united with the area of platform Jurassic deposition in southern Germany, in Frankenalb, across the Hessian (Saxonian) Seaway (Meyer, Schmidt-Kaler, 1989; Pieńkowski *et al.*, 2008). This seaway separated the emerged portions of the Bohemian and Rhenish massifs (Fig. 10a). The Lusatian High between the basin on the Bohemian Massif and the S part of the Polish Basin was of smaller areal extent than presumed, *e.g.*, by Ziegler (1990). The basin on the Bohemian Massif was connected with the S part of the Polish Basin in Lower Silesia as well as with the S part of the North German Basin SE of Berlin, in the East Brandenburg Basin area. Deposition on the central and northern parts of the Bohemian Massif could have extended perhaps into the Tithonian. This may be suggested by the presence of the oolitic microfacies in the Jurassic pebbles along the Lusatian Fault, which is related to the Tithonian regression on the SE slopes of the Bohemian Massif (Eliáš, 1981; Adámek, 2002, 2005), and by the composition of the nannoplankton (Holcová, Holcová, 2016).

REMARKS ON THE PALAEOGEOGRAPHY OF THE BOHEMIAN CRETACEOUS BASIN

The Bohemian Cretaceous Basin occupied a similar region on the Bohemian Massif as the platform Jurassic sea (Fig. 10b). It was elongated in a NW–SE direction, connecting the epeiric sea in NW Europe with the Tethys. Unlike the Jurassic depositional area, the Bohemian Cretaceous Basin is characterized by bodies of medium- to coarse-grained quartzose sandstones. The most extensive sandstone bodies, as much as 500 m thick, stacked on one another, were adjacent to the tectonically active West Sudetic Island (Tröger, 1969, 2011b; Klein *et al.*, 1979; Skoček, Valečka, 1983; Uličný *et al.*, 2009; Voigt 2009; Fig. 10b herein). Based on the size, roundness and crystallinity of the quartz grains, Skoček and Valečka (1983) speculated that *ca.* 60% of the grains were derived from granitic rocks of the Lusatian pluton, 30% were derived from the Permo-Carboniferous sedimentary and volcanic rocks, or perhaps Triassic rocks, and 10% from the metamorphic rocks. Voigt (2009) and Hofmann *et al.* (2013) considered the Lower Cretaceous sediments as the main source of sand-sized detritus, and the basal Jurassic (Dogger) clastics as another important source.

Voigt (2009) presumed tectonic inversion in the area of the future West Sudetic Island, which functioned as a depositional area in Jurassic times. In his concept, this area turned into the separate Prignitz-Lausitz Basin in the Early Cretaceous, where thick clastic successions were deposited. A tectonic inversion occurred after the origin of the Bohemian Cretaceous Basin. The Prignitz-Lausitz Basin changed into the West Sudetic Island, and erosion of Lower Cretaceous, Jurassic and Permo-Triassic rocks supplied detrital material for the Cretaceous Basin. Not sooner than in the Turonian, granitoids of the Lusatian pluton and their metamorphic envelope became exposed. Hofmann *et al*. (2013, 2018) presumed that sand-sized material deposited prior to the Turonian was derived from the Lower Cretaceous sediments. After the erosion of the Lower Cretaceous rocks, from the Coniacian onwards, sand-sized material was presumed to be derived also from the redeposited basal Jurassic and Triassic clastics. To support their idea, the above authors presented a find of Proterozoic zircon in the Coniacian sandstones at the site of Schmilka in Saxony. This zircon, probably from Baltica in its origin, corresponds to zircons from sites of Jurassic clastics in Saxony and in S Germany (Bavaria). In a similar way, Nadaskay *et al.* (2019) interpreted the Baltica zircons as a trace of a completely eroded the Late Jurassic / Early Cretaceous basin situated on the top of the present-day Lusatian massif. While flooding of the area of the West Sudetic Island by the Jurassic sea is obvious from the palaeogeographic situation of the Bohemian Massif (Fig. 10a), the existence of an Early Cretaceous basin does not seem to by supported by any evidence. No Lower Cretaceous deposits have been preserved in basins in a broad area surrounding the West Sudetic Island. The sediments of the Bohemian Cretaceous Basin almost exclusively overlie the pre-Mesozoic basement and, in only a very small area in the E part of the basin, do they rest on Triassic rocks. The Pre-Mesozoic basement rocks are commonly covered by weathering profiles as much as tens of metres thick. Also, pre-Jurassic formations directly underlie the Upper Cretaceous sediments of the North Sudetic Basin near the NE margin of the West Sudetic Island (Milewicz, 1997; Voigt *et al*., 2008; Chrząstek, Wypych, 2018) and the Opole Basin situated farther SE (Voigt *et al*., 2008). No Lower Cretaceous sediments have been encountered either in the East Brandenburg Basin, forming the NW continuation of the North Sudetic Basin (Sine, 1968; Voigt *et al*., 2008).

Early Cretaceous times were marked by erosion and peneplanation in the Bohemian Massif. These processes removed the Jurassic deposits from the NW and central parts of the Bohemian Massif, with the exception of small relicts preserved mainly in tectonic blocks. More extensive stretches of the Jurassic rocks were preserved in the SE part of the Bohemian Massif during the Late Cretaceous and Tertiary. In the Cenomanian, supply of medium- and coarse-grained sand (gravel in nearshore settings) from the West Sudetic Island to the Bohemian Cretaceous Basin started, and lasted till the end of Cretaceous sedimentation. Sandstone successions *ca.* 1950 km^3 in volume (Skoček, Valečka, 1983) were formed in the proximity of the island (Fig. 10b). Coarse detrital material could not have been derived from the carbonate-dominated Jurassic sediments. The relatively thin, discontinuous Jurassic clastics could provide only a negligible contribution to sand-sized debris for the Upper Cretaceous sandstones hundreds of metres thick. The regressive Merboltice Formation sandstones (Santonian) were also supplied by material derived from emerged sandstones of older Upper Cretaceous formations.

CONCLUSIONS

The pebbles of the Jurassic silicites were found in conglomerate beds in Coniacian sandstones 5 km S of the Lusatian Fault on the slopes of Hvozd Hill (elev. 749 m) in the Lusatian Mountains in the NNW part of the Bohemian Cretaceous Basin. This site thus added to the several hitherto reported occurrences of Jurassic pebbles in sandstones of the Bohemian Cretaceous Basin. The pebbles from this site were subjected to microfacies analysis as the first of these sites. Three microfacies were identified in the pebbles: the dominant rhax microfacies, the less frequent bioclastic microfacies and the occasional oolitic microfacies. The microfacies can be paralleled with standard microfacies SMF 1 (spiculite wackestone), SMF 9 (bioclastic wackestone) and SMF 15 (ooid grainstone). These microfacies are common in the Jurassic carbonate rocks preserved in denudation relics near Brno and Olomučany in the SE part of the Bohemian Massif and beneath the Outer Carpathian nappes and sediments of the Carpathian Foredeep on the SE slopes of the massif.

In the NW part of the Bohemian Massif, the Jurassic platform carbonate rocks have been preserved only in several tectonic blocks along the Lusatian Fault. Their microfacies have been studied only in borehole D-1 at the site of Doubice. This borehole yielded the thickest Jurassic section in the NW part of the Bohemian Massif. The section, composed of deposits from the Callovian to the Lower Kimmeridgian, comprises basal terrigenous clastics 20 m thick and a carbonate succession 70 m thick. The carbonate rocks are dominated by bioclastic microfacies SMF 9, but the rhax and oolitic microfacies are missing and so are the silicites. The section shows a record of three transgressive phases, starting with the Late Callovian transgression. The carbonate succession with silicites, with dominant SMF 1, as described from the Hvozd Hill, is younger than the carbonate rocks found in the Doubice borehole; it was largely deposited in a deeper zone, after the next transgressive phase. This phase can be paralleled with the Late Kimmeridgian transgression, also recorded in the Upper Frankenalb area in SE Germany, where it was followed by deposition of silicite-bearing carbonate rocks. The pebbles of the Jurassic carbonate rocks and silicites are distributed over a vast area on the Bohemian Massif and in several geological formations ranging from the Cenomanian (or possibly the uppermost Lower Cretaceous) to the Neogene.

The Upper Jurassic basin on the Bohemian Massif was much more extensive than hitherto supposed. It was connected with the SW margin of the Polish Basin and with the SE margin of the North German Basin. It communicated with the area of platform Jurassic deposition in S Germany, in Frankenalb, *via* the Hessian (Saxonian) Seaway. The basin covered the area of the future West Sudetic Island, which supplied large amounts of sand-sized debris to the Bohemian Cretaceous Basin. During the Cretaceous sedimentation, the Jurassic sediments were eroded from the island with the exception of subtle relics. The Jurassic clastics yielded only a negligible proportion of detrital material for the thick, extensive bodies of Cretaceous sandstones.

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PLATE 1

Fig. 1	Pebble No. 5, typical rhax microfacies, strongly bioturbated central part contrasts with the nearly homogeneous right part. Crossed nicols
Fig. 2	Pebble No. 5, rhax microfacies, a close-up view, rhax cross sections exhibit bean-shaped, kidney-shaped and ellispoidal forms, scarce quartz grains. Parallel nicols
Fig. 3	Pebble No. 5, same as Fig. 2. Crossed nicols
Fig. 4	Pebble No. 4, rhax microfacies, majority of rhaxes exhibit quartz filling of holes. Crossed nicols
Fig. 5	Pebble No. 16, rhax microfacies, subordinate monaxial sponge spicules exhibit parallel alignment. Parallel nicols
Fig. 6	Pebble No. 13, rhax microfacies, rhaxes and subordinate multiaxial spicules, with canals filled with quartz. Crossed nicols
Fig. 7	Pebble No. 3, rhax microfacies, with multiaxial (triaxial) spicule in the upper part, canals filled with quartz. Crossed nicols
Fig. 8	Pebble No. 7, bioclastic microfacies, undeterminable bioclasts, a thin mollusc shell in the centre, scarce disseminated rhaxes, spicules and scarse quartz grains. Crosssed nicols

Photos by J. Valečka

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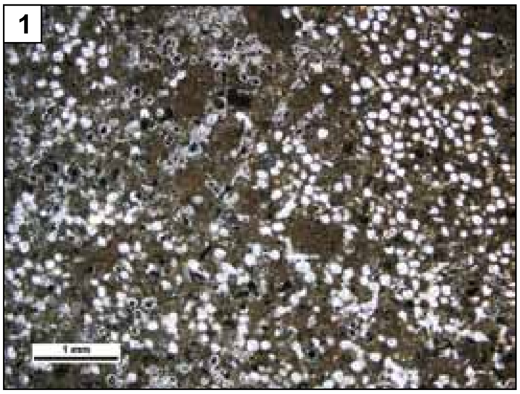

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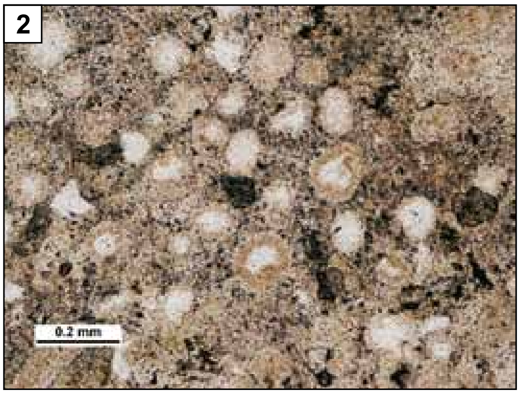

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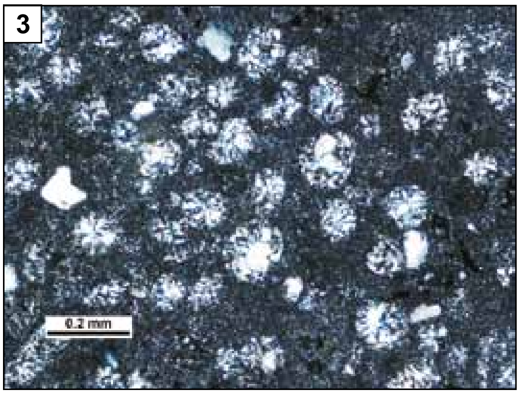

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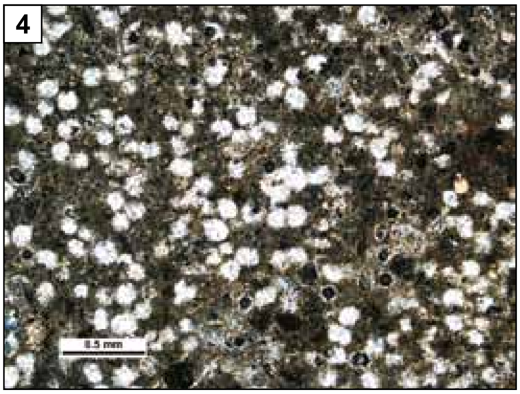

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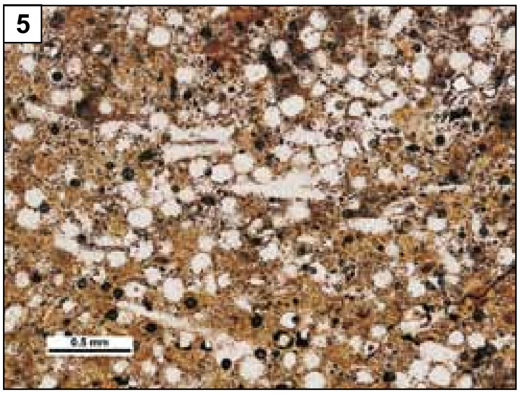

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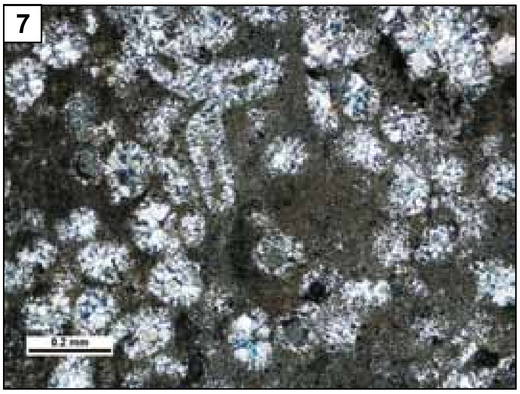

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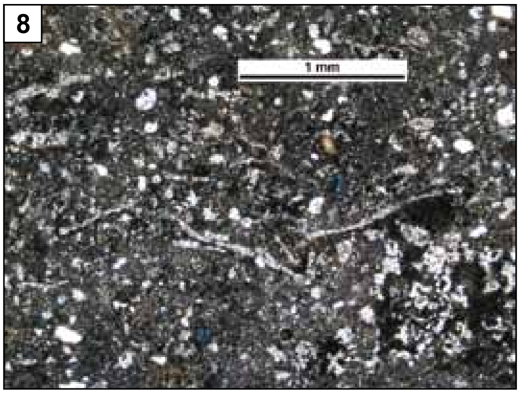

PLATE 2

Fig. 1 Pebble No. 2, bioclastic microfacies, a test of a foraminifera with cells filled with pyrite. Parallel nicols

Fig. 2 Pebble No. 14, oolitic microfacies, some ooids lack dictinct concentric structure, scarce quartz grains. Crossed nicols

Fig. 3 Pebble No. 14, oolitic microfacies, a close-up view of an ooid with concentric structure. Crossed nicols

Fig. 4 Pebble No. 14, oolitic microfacies, an oncoid with concentric structure, crossed nicols

Fig. 5 Coarse-grained, poorly sorted quartzose sandstone with gravel admixture, fine-grained in the central part, in a tectonically crushed zone. An outcrop in an abandoned quarry near Doubice. Crossed nicols

Fig. 6 Sparitic, dolomitic limestone with bioclast admixture, echinoderm fragments exhibiting thin discontinuous cement rim consisting of calcite crystals are indicated by arrows. An outcrop in an abandoned quarry near Doubice. Crossed nicols

Photos by J. Valečka

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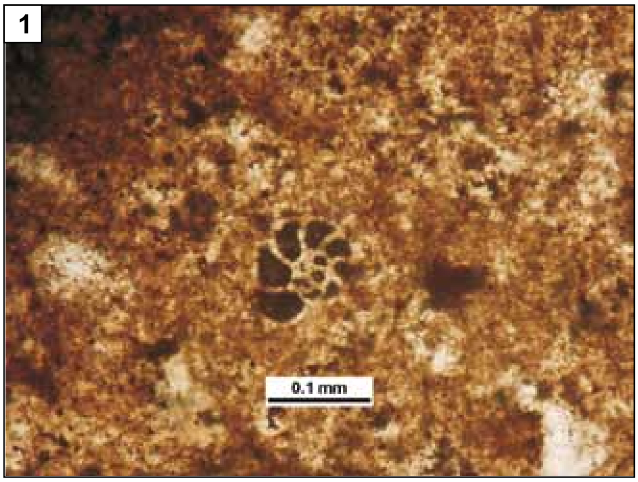

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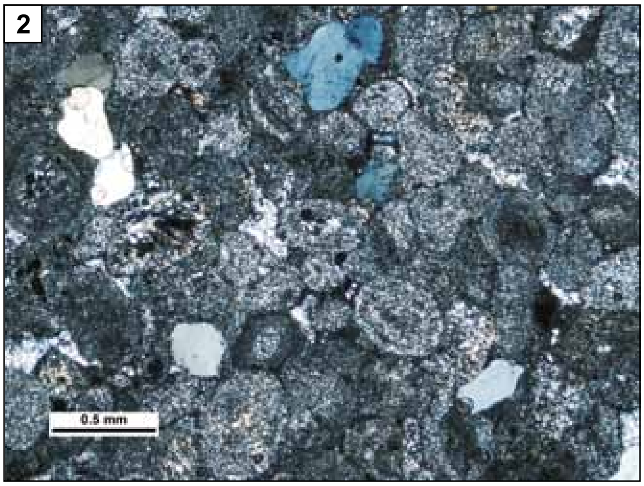

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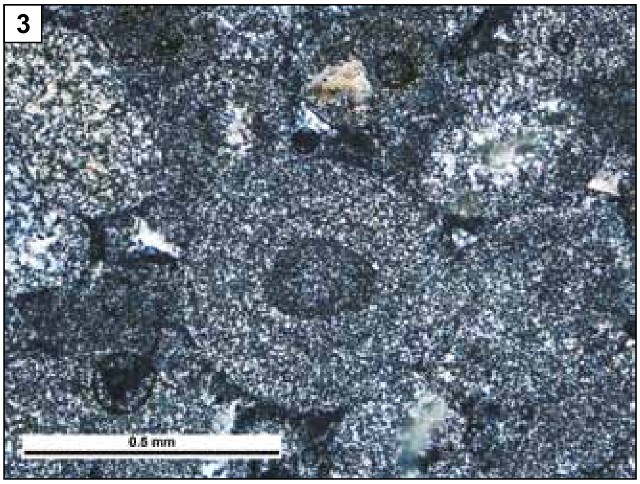

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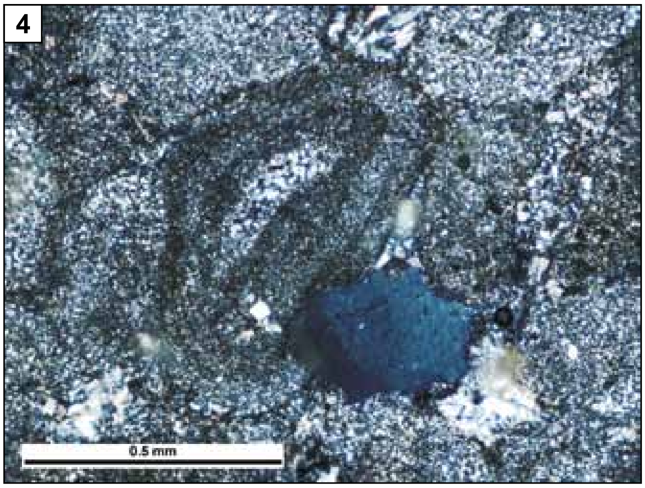

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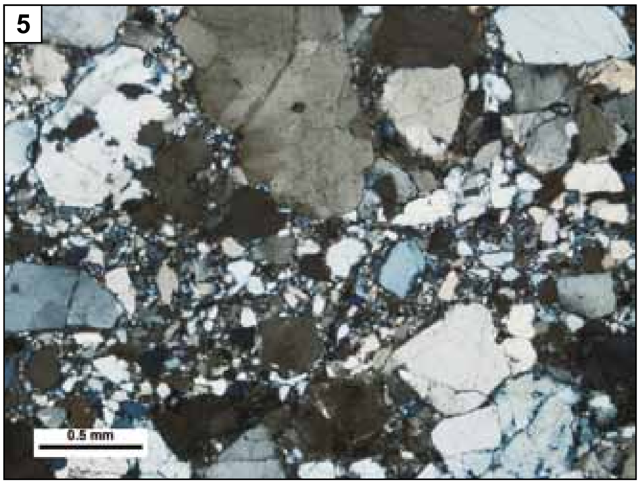

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