

COMPLEMENTARY DESCRIPTION OF THE MIDDLE ORDOVICIAN TRILOBITE ASSOCIATIONS AT PRAHA-VOKOVICE

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Abstract: The temporarily exposed rocks of the Dobrotivá Formation (Middle Ordovician, upper Darriwilian) accessible, due to lower water levels, in Džbán water reservoir (Praha-Vokovice area) have produced common fauna. The newly obtained trilobite-dominated fossil associations enable a more detailed discussion of faunal changes in the lower and lower-middle portions of the Dobrotivá Formation – a transition from the *Placoparia* Association to the newly recognized *Degamella-Zeliszella* Association, dominated by mesopelagic forms.

Key words: Ordovician, trilobite associations, Dobrotivá Formation, Praha-Vokovice

INTRODUCTION

The area around Praha-Vokovice is a part of the long studied classical Barrandian area (see Chlupáč *et al.* 1999). It has been the subject of paleontological research for almost 150 years. Unfortunately, almost all of the classic paleontologic localities in the Dobrotivá Formation in this region are now inaccessible (Budil 1999a). Summaries of previous investigations of the Dobrotivá Formation in the area can be found in Budil (1999a) and Peršín & Budil (2005). Most of the classic localities produced fossiliferous nodules collected loose in the fields or from small excavations with only limited stratigraphic data.

The locality on the south bank of Džbán water reservoir in Vokovice is the only area periodically available (in winter, see below). When exposed only the lower to possibly middle portions of the Dobrotivá Formation are accessible; this is the only such locality in the eastern part of the Prague Basin. The locality was first described by Budil (in 1999a). At that time, the outcrop was accessible only in the winter, when water levels were lowered. Between 2006 to 2008, the reservoir was drained, cleaned and reconstructed. During this process all the mud was removed and bottom of the pond became accessible allowing more extensive collecting. The resulting data and collections allow further analysis of the fossil associations.

All specimens discussed herein are deposited either in the collections of the Czech Geological Survey (CGS PB and CGS MS), or in the collec-

tions of the National Museum (registered under cumulative number NM 16/92).

Complementary description of the locality

Budil (1999a) described a simplified stratigraphic section of the outcrop. The outcrop, more than 600 meters in length, exposed a total of 350 m of strata, characterized by the shale dominant section divided by relatively thin interbeds of quartzose sandstones which divide the section in to six intervals with differing lithologies. The shales are poorly fossiliferous. The rich fauna was collected almost exclusively from the siliceous and silty nodules (Budil 1999a, Peršín & Budil 2005). Each shale interval contains nodules with a distinctive fauna. Monotonously inclined quartzose sandstones yielded only scarce trace fossils (e.g. *Skolithos*). The shales are tightly folded and (on the bottom of the reservoir) dip NE between 30–45°, locally also 30–40° to the SE. A question as to whether a fault displaces the section remains unresolved. No fault has been observed directly and there is no recognized repetition of section at the reservoir, however Peršín & Budil (2005, p. 31) mentioned finding loose (none were found in situ) nodules typical for the underlying Šárka Formation (lower to middle Darriwilian) in the easternmost part of the outcrop. No stratigraphic contact of both formations was documented at Džbán and a stream transport of nodules by the Šárecký potok Brook could explain their shift as the shales

of the Šárka Formation are exposed about 2 km upstream where the Šárecký potok Brook crosses this formation.

Decription of the section

The subdivision of the section follows the concept of Budil (1999a). This author subdivided the section at Džbán into the six intervals I–VI (oldest to youngest). The intervals I–II correspond with the lowermost part of the Dobrotivá Formation represented by the Skalka Quartzite Facies (white to brownish quartzose sandstones). Total thickness of interval I (massive sandstones banks) is about 50 m. The thickness of interval II (thin-layered laminated sandstones) is about 8 m. Interval III is a grey silty shales about 40 m thick and contained rare nodules with a unique fauna. The fauna consists of two taxa, *Placoparia (P.) zippei*, represented by several cephala and *Archaeoconularia insignis* by one complete well preserved specimen (CGS PB 1501). Interval IV is a 15 m thick sequence of platy quartzose sandstones.

The majority of the fauna was collected from Intervals V and VI. Faunal differences in the associations allowed for more precise biostratigraphic subdivisions particularly in V (about 150 m thick).

Interval V: The lowest part (V.1) is a black clayey shale with dark grey to black, 4 to 10 cm dia. siliceous nodules containing abundant fossils. Their internal molds are often leached out by water and most of these molds are yellow to orange in color. The fossiliferous nodules are not limited to a single bedding surface but are randomly dispersed within the section. The fauna is dominated by benthic forms. The most common being ubiquitous *Placoparia (P.) zippei* with tens of minute specimens forming accumulations of entire or almost entire exoskeletons in some nodules (see specimens CGS PB 497–498, NM 16/92). Other species are less frequent but are also represented by complete or slightly disarticulated exoskeletons. Dalmanitid trilobites are represented by *Ormathops novaki* (NM 16/92) and *Zeliszella oriens*, including “morphotype” corresponding to invalid (see Budil 1999b) subspecies of M. Šnajdr (1987) – *Z. o. egesta*, the former slightly more numerous than the later. Illaenid trilobites are rare with *Ectillaenus benignensis* represented by disarticulated cephala and pygidia. Other taxa are represented by single specimens or by single nodules

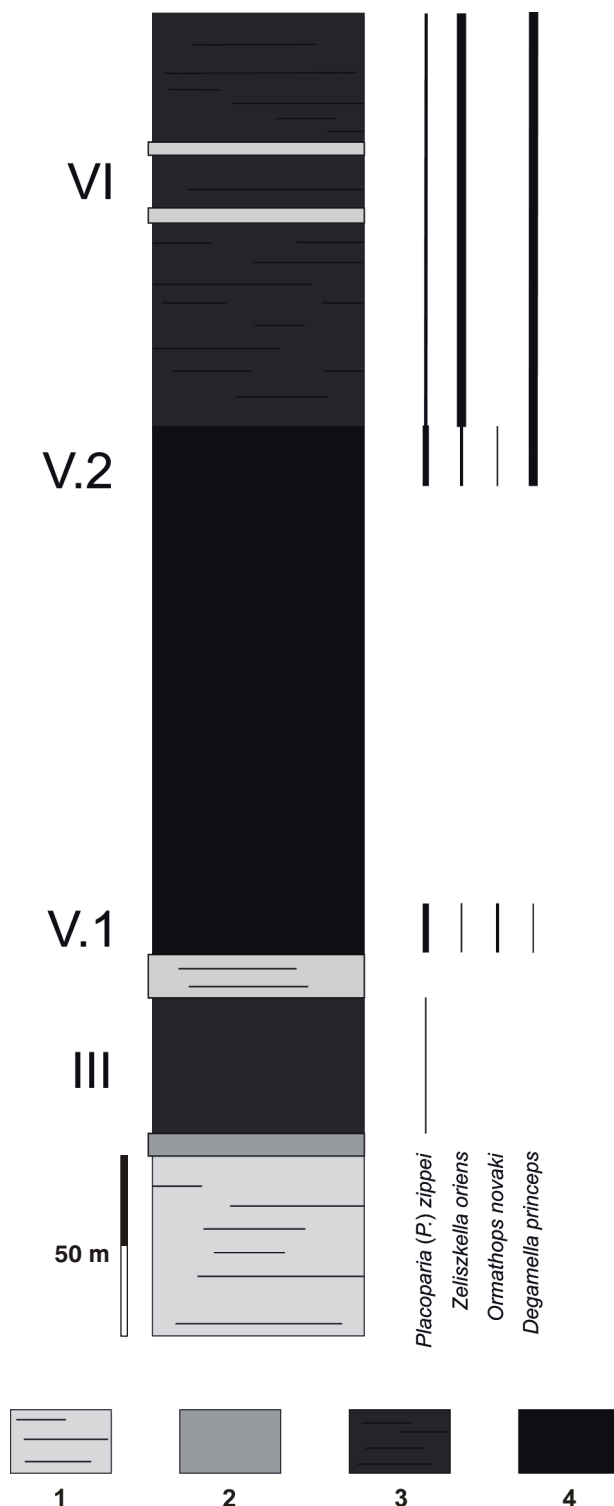


Figure 1. A schematic subdivision of the Džbán water reservoir section with marked ranges and relative abundances of the most important trilobite species forming somewhat different associations in its lower and upper part. 1 – quartz sandstone; 2 – platy quartz sandstone and siltstone; 3 – silty shale; 4 – black clayey shale (after Budil 1999a).

usually with monospecific accumulations of exoskeletal parts: *Dindymene plasi*, *Zbirovia arata*, *Areia fritschi*, *Selenopeltis macrophtalma*, *Dionide jubata* and *Nobiliasaphus repulsus* (partially stored at NM 16/92). *Colpocoryphe adisol* is represented by a single well preserved specimen (Fig. 2, CGS PB501). Mesopelagic elements are represented by a few *Pricyclopyge binodosa longicephala* and rare *Degamella princeps* specimens (NM 16/92). Sessile benthic invertebrates are rare, represented by crinoids *Cheirocrinus* sp. (disarticulated plates and incomplete thecae) and unidentified columnals; rare conulariids *Metaconularia imperialis*, rare brachiopods *Benignites primulus*, monoplacophoran *Archinacella* sp. and by rare small hyolithids.

Upper part of this sequence, V.2, is separated from the lower, V.1, by about 90 m thick layer of black shale with rare nodules. No fauna was found in this interlayer.

Interval V.2 consists of black clayey to silty shales, is siltier than in lower units of the section, often outcropping as a muddy residuum containing a few shale fragments but very abundant nodules. It is the most fossiliferous part of the entire sequence at Džbán. Fauna occurs in 3–5 cm dia. nodules. The fossils are characteristically black colored and are often damaged by weathering.

The V.2 association is dominated by trilobites; all other groups are very rare. Occurrence of complete trilobite specimens is less frequent than in lower parts of the section. The mesopelagic *Degamella princeps* and the benthic *Placoparia (P) zippei* are co-dominant. The dalmanitid trilobites are less frequent, with *Zeliszella oriens* more numerous than the rare *Ormathops novaki*; both usually occurring as rare accumulations of complete or slightly disarticulated specimens (some specimens are most likely exuviae). The harpetid *Eoharpes benignensis*, the illaenid *Ectillaenus benignensis* and cyclopygid *Pricyclopyge binodosa longicephala* are rare. Agnostids are rare, being represented by two specimens of *Corrugatagnostus morea*, only one pygidium and one enrolled specimen were recovered (CGS PB 1502). Two gastropod species, *Sarkanella vokovicensis* and *Cimbularia klouceki* are present but rare. Carapaces of phyllocarid crustacean *Caryocaris* sp. are abundant but indeterminate due to longitudinal enrolling (see Chlupáč 1970). Brachiopods are less common,

being represented by *Benignites primulus*, *Brandyia benigna*, and *Paterula circina*. Conulariids are represented by one poorly preserved specimen of *Metaconularia* sp. (taxa discussed above are partially stored under cumulative No. NM 16/92)

The easternmost and stratigraphically highest interval of the section, interval VI, possesses several notable differences: the lithology of the shale as well as the shape, size, and lithology of the siliceous nodules. The silty shale is softer, greyish to yellow nodules much smaller, flattened and softer than in the underlying part of the section. The included fossils are often damaged or destroyed by weathering. Despite this, identifiable fossils are abundant. Planktonic or nektobenthic forms are dominant, benthic forms are rarer. Complete specimens of trilobites are uncommon; most frequently found are their cranidia. *Degamella princeps* and *Zeliszella oriens* are co-dominant, *Cyclopyge umbonata bohémica* and *Parabarrandia crassa* are infrequent (the latter represented mostly by juvenile specimens), *Pricyclopyge binodosa longicephala* is rare. *Placoparia (P) zippei* is much less frequent than in previously described intervals in the section. *Emmrichops planicephalus* is rare but in comparison with other localities in the Prague Basin it is abundant here (eight specimens have been found). A few poorly preserved fragments of larger trilobites belonging to *Nobiliasaphus repulsus*, *Parabarrandia crassa* and *Ectillaenus benignensis* are present in the collections. The non-trilobite fauna was represented by a common phyllocarid crustacean *Caryocaris* sp. (CGS PB 521), and numerous brachiopod specimens attributed to *Paterula circina* and *Rafanoglossa impar* (NM 16/92).

DISCUSSION

Fossil associations of the Dobrotivá Formation were discussed previously by Havlíček (1982), and by Havlíček & Vaněk (1990). The upper part of the formation and its contact with the overlying Libeň Formation has been thoroughly studied by Havlíček & Vaněk (1996). In their concept of the fossil associations in the Dobrotivá Formation, the *Placoparia* Trilobite Community (see Havlíček & Vaněk 1990, 1996) is confined to the lower part of the formation, typically associated with an abundant benthic biota. In their treatment of the rich

trilobite record in the Middle Ordovician Šárka and Dobrotivá formations Mergl *et al.* (2008) preferred the name *Placoparia* Association that they understand as continuing (with the faunal changes often on a species level only) from the underlying Šárka Formation. The trilobites of the Šárka and Dobrotivá formations were assigned to the atheloptic associations and the cyclopygid biofacies of deeper outer shelf by Fatka & Mergl (2009). *Placoparia* (*P.*) *zippei*, *Ormathops novaki*, *Eoharpes benignensis* and *Pricyclopyge binodosa longicephala* as well as the brachiopod *Benignites primulus* are typical elements of the *Placoparia* Association in Dobrotivá Formation (Havlíček & Vaněk 1990 and Mergl *et al.* 2008), confined to the lower part of the formation belonging to *Hustedograptus tertiusculus* Biozone (Havlíček & Vaněk 1990). In the middle part of the Dobrotivá Formation, the deeper-water trilobite association corresponding to the younger *Cryptograptus tricornis* Biozone gradually substitutes the typical *Placoparia* Association. This new association is characterized by dominance of *Cyclopyge umbonata bohémica* and *Zeliskella oriens*; *Placoparia* (*P.*) *zippei* is uncommon. The “lower upper” part of the Dobrotivá Formation (absent at the Džbán section) is considered to present (following Havlíček & Vaněk 1990, 1996) a deepest-water facies and is characterized by a low diversity *Paterula* Community *sensu* Havlíček (1982) with the infrequent benthic trilobite *Mytocephala mytoensis* and rare cyclopygids *Heterocyclopyge nigra*, *Degamella princeps* and *Cyclopyge umbonata bohémica* (Havlíček & Vaněk 1990, 1996). In our opinion, this association can reflect rather increasing, spreading dysoxia than the deepening of the basin. The uppermost layers of the Dobrotivá Formation have yet another association dominated by *Placoparia* (*Coplacoparia*) *borni*, frequent *Pragolithus praecedens*, and sparse non-trilobite benthic fauna with some rare pelagic forms (see Havlíček & Vaněk 1996 and Mergl *et al.* 2008).

***Degamella princeps-Zeliskella oriens* Trilobite Association**

Definition: Trilobite association confined to the lower-middle part of the Dobrotivá Formation characterized by the dominance of the cyclopygid *Degamella princeps* and dalmanitid *Zeliskella oriens*.

Type locality: Džbán water reservoir section, intervals V.2 and VI

Other localities: Praha-Liboc (Veleslavín), see Havlíček & Vaněk (1990, 1996) and Havlíček *et al.* (1993).

Characterization: Nectobenthic (mostly cyclopygid) trilobites, especially eponymous *Degamella princeps* dominate. *Pricyclopyge binodosa longicephala* and *Cyclopyge umbonata bohémica* are rare. *Emmrichops planicephala* is also rare but characteristic, the nileid *Parabarrandia bohémica* is common, agnostoid *Corrugatagnostus morea* is distinctive. Among benthic forms, the dalmanitid *Zeliskella oriens* dominate meanwhile the pliomerid *Placoparia* (*P.*) *zippei* is generally infrequent. The illaenids (*Ectillaenus benignensis*), harpetids (*Eoharpes benignensis*), asaphids (*Nobiliasaphus repulsus*) and trinucleoids (*Pragolithus praecedens*) are rare.

Discussion: Lower part of the section at Džbán (intervals III–V.1) belongs to the *Placoparia* Association *sensu* Mergl *et al.* (2008) and corresponds to the lower part of the Dobrotivá Formation. The association from Džbán is, however, slightly different from the typical *Placoparia* Association *sensu* Mergl *et al.* (2008) and Havlíček & Vaněk (1990, 1996), known from Malé Přílepy, Mýto and Strašice. At Džbán, in interval V.1, *Ormathops novaki* and *Pricyclopyge binodosa* are not common and *Eoharpes benignensis*, relatively common at some other localities distant from Džbán, was rare. Brachiopods are not common, *Benignites primulus* being the dominant taxon. Significant is a rare occurrence of *Cheirocrinus* sp. Conversely taxa common in the *Placoparia* Association at other localities, the styloporans *Mitrocystites*, *Mitrocystella*, *Lagynocystites*, and polyplacophoran *Helminthochiton equivocata*, are missing at Džbán. This depauperate fauna may indicate unfavorable bottom conditions, perhaps dysoxia; this possibility may also explain the near lack of ichnofossils in the Džbán section.

Intervals V.2 and VI contain different (see Fig. 1) associations dominated by *Degamella princeps* and *Zeliskella oriens*. These associations represent here the newly defined local *Degamella princeps-Zeliskella oriens* Trilobite Association and the outcrop at Džbán is designated its type locality. *Placoparia* (*P.*) *zippei* is still present but not dominant. Benthic forms are rare and the sessile benthos is missing.

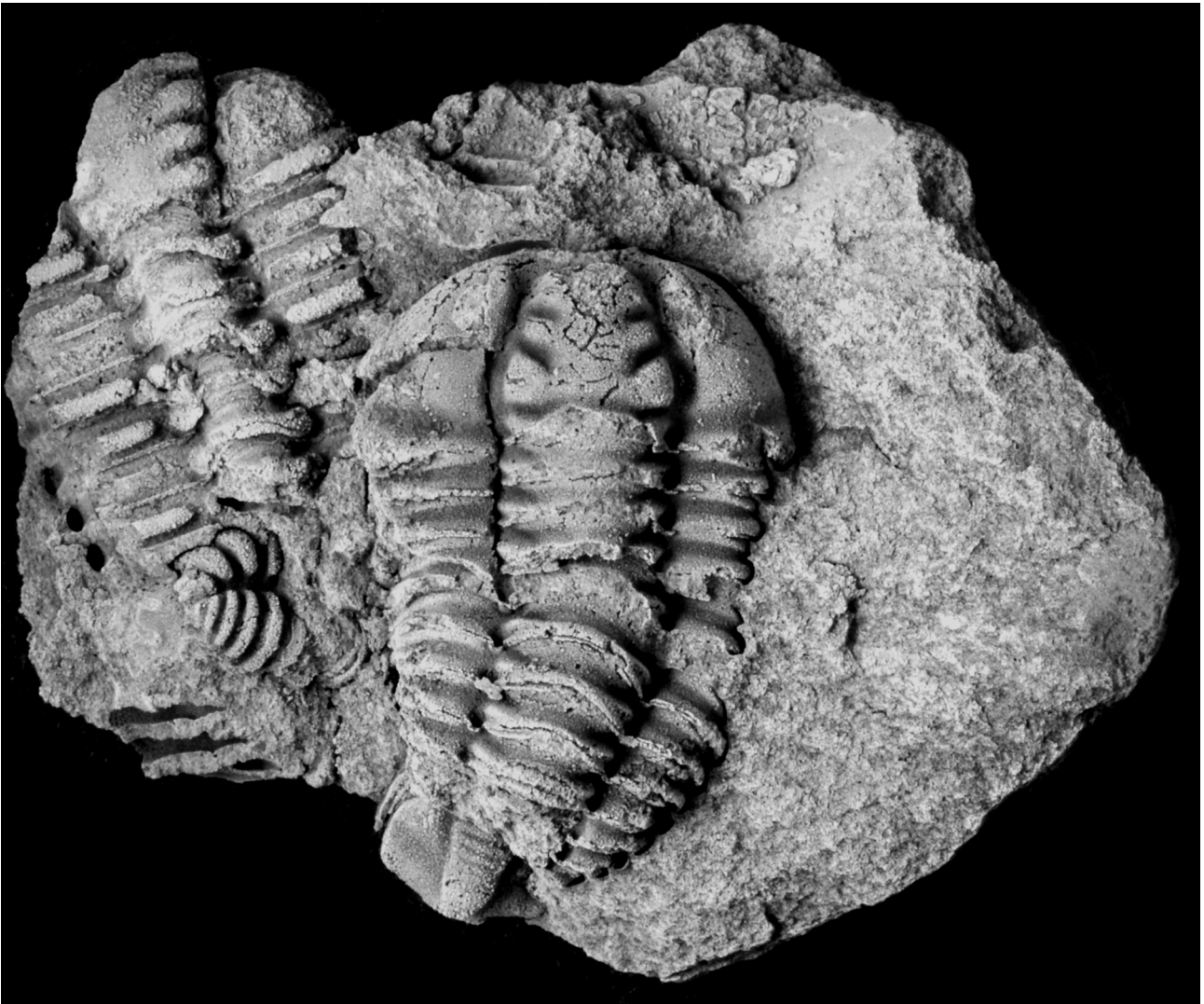


Figure 2. *Colpocoryphe adisol*, rarely occurring in the part of the section numbered as V. 1. The sagittal length of partially disarticulated trilobite attains 25 mm; the specimen is housed in the Czech Geological Survey collections under No. PB 501.

The fauna discovered during excavation in the nearby Praha-Liboc in the 1990's (see Havlíček & Vaněk 1990, 1996; Havlíček *et al.* 1993 and Peršín & Budil 2005) can be also affiliated to this newly proposed *Degamella princeps-Zeliskella oriens* Trilobite Association. This locality at the Praha-Liboc, placed south of possibly synsedimentary (see Peršín and Budil 2009) Šárka Fault, was correlated by Havlíček & Vaněk (1996) to the B.A.4. life zone *sensu* Boucrot (1975). Havlíček *et al.* (1993) and Havlíček & Vaněk (1996) explicitly state that the association in the supposedly lower part of the Dobrotivá Formation, gathered at Praha-Liboc, represents a different, deeper-water

faunal association to compare with other associations at Praha-Vokovice, north of the Prague Fault ("The Liboc-Veleslavín area clearly differs from the Vokovice area, located north of the Šárka Fault in composition of the benthic and pelagic associations. Dobrotivá Series at Praha-Vokovice has yielded slope associations confined to a lateral transition of the quartzitic sequence into a deeper-water, black shale lithofacies" see Havlíček *et al.* 1993, p. 79). The "slope association" at Praha-Vokovice was affiliated to the B.A.3 life zone by Havlíček & Vaněk (1996), and was assigned to their *Placoparia* Trilobite Community. Neither Havlíček *et al.* (1993) nor Havlíček & Vaněk

(1996), however, knew the Džbán section (described later by Budil in 1999), where a superposition of the *Placoparia* (lower in the section) and the pelagic-dominated, newly defined *Degamella princeps-Zeliskella oriens* trilobite associations is present. In summa, surface and subsurface excavations at Praha-Liboc exposed black shales of the Dobrotivá Formation with abundant trilobite faunas corresponding well with the newly defined local *Degamella princeps-Zeliskella oriens* Trilobite Association. The association at Praha-Liboc consists mainly of mesopelagic *Degamella princeps* and *Parabarrandia crassa*. The benthic fauna includes *Zeliskella oriens* as the dominated taxon; thus it can be correlated with the upper part of the Džbán section. The Praha-Liboc locality produced rare graptolites including *Hustedograptus teretiusculus*, which indicates that the strata exposed there correspond to the lower part of the Dobrotivá Formation. The relatively common occurrence (nine specimens) of *Emmrichops planicephalus* would suggest a correlation with the upper part of Džbán section. The agnostid *Corrugatagnostus morea* is relatively common at Praha-Liboc supporting the correlation with the upper part of the Džbán section. At both Liboc and Džbán, *Placoparia (P.) zippei* often occurs in monospecific accumulations of nearly complete to complete specimens on some bedding planes, or (at Džbán) in nodules, but it was not the dominant taxon.

Whether the same faunal change from the typical *Placoparia* to the *Degamella-Zeliskella* Association happened also in the other parts of the Prague Basin or if it is confined to the Praha-Vokovice area only cannot be decided at current level of knowledge. Future excavations in lower parts of the Dobrotivá Formation may elucidate this question.

CONCLUSIONS

Džbán locality provides an excellent opportunity to trace the local faunal changes from the lowermost to lower-middle part of the Dobrotivá Formation (with reservation concerning a possible tectonic faulting of the section, see the Introduction). It has recorded a time-dependent environmental change rather than an evolutionarily driven transition from an association dominated by *Placoparia* to one dominated by mesopelagic forms with abundant *Degamella princeps* and benthic *Zeliskella*

oriens. The stratigraphy of the lower part of the Dobrotivá Formation, especially in the NW and NE part of the Prague Basin, is not well exposed and not fully understood. It is not known if the *Degamella princeps-Zeliskella oriens* Association, defined herein, is a lateral, deeper-water equivalent of the *Placoparia* Association or if it gradually replaces the later in the lower-middle part of the Dobrotivá Formation. The observations from the Džbán locality support the latter model. A study of the transformation of the benthic-dominated to the pelagic-dominated trilobite associations in the middle part of the Dobrotivá Formation is needed.

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