LOWER AND EARLY MIDDLE ORDOVICIAN TRILOBITE ASSOCIATIONS OF THE PRAGUE BASIN (PERUNICA, CZECH REPUBLIC)

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1 TREMADOCIAN

The earliest Ordovician trilobite fauna of the Prague Basin (Text-fig. 1) is definitely of early Tremadocian age. It is known from eight localities in the Tfenice and Milina fms, situated in the western part of the Prague Basin (Komárov area) and east of Prague (Uvaly area). Trilobites are already known for ninety years and have been recently revised by Pek (1977), Mergl (1984, 1994, 2006).

Trilobite exoskeletons are always preserved as internal and/or external moulds, or the original material is replaced by quartz in quartzitic hematites (Text-fig. 2: 1-7, 9). High taphonomic fragmentation, small-scale reworking and sorting suggest high to moderate energy depositional environments. Despite the above-mentioned factors combined with different lithology (trilobites are preserved in chert, greywacke, quartzitic haematite and quartzitic shale), trilobites could be referred to the Illaenid-Cheirurid and Nileid biofacies (sensu Fortey, 1975).

The Illaenid-Cheirurid Biofacies is represented by the Hemibarrandia-Parapilekia Association. This association is known from the southwestern part of the Prague Basin, being dominated by the cheirurid Parapilekia, the illaenimorph Hemibarrandia and a problematic (?) eurekiid Holubaspis. These three genera represent between 50 and 70 % of the trilobite fauna in our estimation. Associated early calymenaceans Holoubkocheilus and Parabathycheilus are less common, representing together about 10 %. This generally diverse benthic trilobite association is further
likely preferred shallower habitats, while Harpides, Celdometopus, Dikelokephalina, Orometopus and Pricyclopyge preferred deeper conditions. Parapilekia and Parabathycheilus were generally eurytopic. In total, 29 trilobite species (12 species in the Třenice Fm. and 19 species in the Milina Fm.) have been recognized within the Hemibarrandia-Parapilekia Association. There are only tiny morphological differences between several taxa occurring in the Třenice Fm. and Milina Fm., which are interpreted as separate species. This could be interpreted as evolutionary continuity within the basin.

The high level of morphological disparity of trilobite fauna indicates differentiated benthic life strategies, influenced by direct substrate relationship and various food sources. This is evidenced also by variable cuticle thickness, ranging from thin (Apatokephalus) to thick (Hemibarrandia, Holubaspis). Semi-infaunal, subvertical, subvertical life position in the sediment can be supposed for the illaenimorph Hemibarrandia and also for the smaller Ottenbyaspis. Upward stretched pleural spines of large Parapilekia indicates a mobile scavenger or even predator; Anacheirurus probably fed on similar smaller prey. Large and flat exoskeletons of Dikelokephalina, Platypeltoides, and Harpides indicate less mobile, slowly moving benthic scavengers. Tuberculate surfaces of Holoubkocheilus, Parabathycheilus and Holubaspis suggest a semi-infaunal life habit comparable to their Middle Ordovician descendents, known from the Neseoretus fauna. Small orometopid Celdometopus was probably epibenthic, while the remopleuridid Apatokephalus was an active nectobenthic swimmer.

Composition of the trilobite assemblage slightly differs in the Uvaly area with a clear deficiency of cheirurids, illaenimorphs and calymenids. The same species also occur in the Milina Fm. of the Komárov area, but Parapilekia and Holubaspis are less common; Hemibarrandia, Parabathycheilus, Agerina and Apatokephalus are rare, whereas Holoubkova and Celdometopus are unknown. The commonest trilobite is Proteuloma, followed by less abundant Ceratopyge, Geragnostus and Platypeltoides. A cyclopygid Pricyclopyge is known but uncommon. Less fragmental exoskeletons indicate deeper sea, however complete
specimens are rare. This Proteuloma Association is more comparable with the Nileid Biofacies, indicating weak deepening of the basin toward NE.

With the exception of Platypeltoides and the very rare Niobina, all other asaphids, shumardiiids and nileids are absent in the Tremadocian of the Prague Basin. Dysoxic environments, which commonly host olenids, are also absent. Information about palaeobathymetry of the Hemibarrandia–Parapilekia and Proteuloma associations is based on lithology, and especially on the presence of cyclopygids in the Milina Fm. Pricyclopyge is characteristic of deep-water conditions, with a suggested depth range of 150-200 m (McCormick and Fortey, 1998; Owens, 2002; Turvey, 2005). It is the only genus with a suggested depth range in the Milina Fm. Noteworthy, remains of Pricyclopyge are rare and other cyclopygids are absent. Pricyclopyge is not associated with black-shale lithofacies and indicates, as does Prospectatrix in Wales (Fortey and Owens, 1987), that the typical Cyclopygid Biofacies was not established before the end of the Tremadocian. The trilobites are always associated with the low-diversity orthid brachiopod assemblage containing Jivinella, Paramborthis and Kvania, organophosphatic brachiopods, sponges, "cystoids" and the hyperstrophic gastropod Mimospira. The brachiopod fauna indicates the inner shelf and is typically representative of the peri-Gondwanan Thysanotos Assemblage, which is supposedly of shallow subtidal setting (Bassett et al., 2004). The somewhat deeper site of the Proteuloma Associations is indicated by rare benthic fauna. Presence of conglomerates combined with abundant occurrence of calcymenids and absence of ofagnostids indicate depths of several tens of metres in the Třinec Fm.

General maximum depth limit of 150 m for the fauna is consistent with suggested upper range of Pricyclopyge. Agerina and Geragnostus are characteristic for the outer shelf and deeper part of the inner shelf (Turvey, 2005) in the subtropical to tropical South China Plate. However, these forms undoubtedly occupied shallower conditions in the Prague Basin. A closely related equivalent of the Hemibarrandia-Parapilekia Association has been established in Bavaria (Sdzuy et al., 2001). Rare trilobites (Agerina, Hemibarrandia, Holubaspis, Parapilekia, Parabathycheilus and Holubkova) provide very poor paleobathymetric data for the Bavarian fauna; a depth equivalent of the inner shelf on volcanogenic accumulations is probable. Dominance of brachiopods and "cystoids" above trilobites could indicate a slightly shallower condition compared with the Hemibarrandia-Parapilekia Association of the Milina Fm.

2 FLOIAN

The Floian (Klabava Fm) trilobite fauna is rather different from the Tremadocian fauna (Text-fig. 2: 8, 10-13). Trilobite assemblages of moderate diversity are known from five localities only; trilobite finds at other place are very rare, represented only by several fragments or unique specimens. All sites are located in the western part of the Prague Basin (between Klabava and Komárov). This trilobite fauna was newly partially revised especially. Lists and general reviews of trilobite associations have been presented by Havlíček and Vaněk (1966, 1990), Mergl (1991) and Havlíček et al. (1994).

The trilobite exoskeletons preserved in clayey shales (Mýto Shale) are often complete, indicating a deep and calm environment; this is also evidenced by associated planktonic graptolites. Poor trilobite remains from several graptolite-bearing sequence show traces of dissolution, indicating diagenetic destruction of calcareous material. Trilobites from reworked tuffs, hematite tuffs (Ejpovice Mbr) and siderite intercalations in volcanogenic rocks
Text-fig. 3 Diagrammatic spatial distribution of the benthic trilobite associations and significant trilobite genera in the Tremadocian (A) and Floian (B). Depth of the sea estimated on distribution of the Cyclopygid Biocacies; *Paraplikia olesnaensis* and *Ceratopyge mareki* are illustrated.
are highly fragmental, indicating substantial transport, breakage, and size-sorting; some monospecific accumulations could originate by washing of moulded parts.

Putting together all available data, equivalents of the Illaenid-Cheirurid, Nileid and cyclopygid biofacies (sensu Fortey, 1975 and Fortey and Owens, 1987) can be distinguished.

The Illaenid-Cheirurid Biofacies is represented by the Pliomerops Association. This association in known only from pyroclastic accumulations of the Komárov Volcanic Centre. Apart from the cheirurids Pliomerops (dominant) and Cyrtometopus (very rare), illaenids Ectillaenus and a poorly known (?) hystricurid are known. This association probably occupied sheltered parts on the volcanic accumulations, being associated with orthid brachiopods (Prantina, Ferrax, Nereidella, Styxorthis), hyperstrophic gastropod (Mimospora) and hexactinellid sponges. Despite taxonomic differences, this environment can be compared with the Hemibarrandia-Parapilekia Association of Tremadocian age.

Somewhat less consistent is presence of Pseudopetigurus in haemattites of the Komárov Volcanic Centre. The exact collecting data are unknown, but associated Mimospora indicates a shallower environment, similar to the nearby Pliomerops Association. This is also supported by the find of Pseudopetigurus in the Ejpovice area, which is also associated with Mimospora, small orthid and organophosphatic brachiopods related to the stratigraphically older Hemibarrandia-Parapilekia Association. Lithology in Ejpovice indicates close proximity of a rocky shore and thus a shallow environment. This differs from the deep-shelf to upper-slope position of the Pseudopetigurus Association in the Floian of northern Hunan, China (Turvey and Zhou, 2004; Turvey et al., 2006). Outside the Prague Basin, Pseudopetigurus is typically associated with deep-water clastic sediments, and in the Upper Ordovician accompanies offshore trilobites, such as Trinodus and Phillipinsella (Appolonov, 1974).

The Euloma Association, a name given by Havlíček and Vaněk (1990) to the equivalent of the Nileid Biofacies, is developed in the Myto Shale. The association is characterized by a dominance of Euloma and Symphysurus (forming 80-90% of trilobite fauna). Other elements are represented by Asaphellus, Bohemopyge, Klabavia, Illaenopsis, Aspidagelina, Cyclopyge, Microparia, Bohemolichas, Colpocoryphe, Orthomops, Gymnagnostus, and Geragnostus. The presence of Illaenopsis, Orthomops and Colpocoryphe is characteristic of the offshore atheloptic association (Fortey and Owens, 1987). However, the dominant Euloma and Symphysurus retain remarkably large eyes. Unlike other deep water marginal sites (Dean, 1966; Fortey and Owens, 1987), trinucleoids are completely absent. Offshore slope conditions are also consistent with abundance of conularids and planktonic graptolites. High proportion of articulated trilobites, often enrolled, indicates quiet bottom conditions. Presence of cyclopygids should indicate a depth of 200 to 300 m, but they are generally rare and their presence only marks proximity of the cyclopygid biofacies in close by deeper areas. The deeper environment of the Cyclopygid Biofacies is signified by very rare finds of cyclopygids in the Rokycany area.

Another equivalent of the Nileid Biofacies, designated here as the Asaphid Association, has been established recently in the upper part of the Klabava Fm. (Ejpovice Mbr.). The assemblages of the Asaphid Association are dominant small species of Pricyclopyge, associated with Asaphellus, and rare Geragnostus, Bohemolichas and Placoparia. Very small indeterminate fragments indicate rare presence of a small spinose odontopleurid. The assemblage is accompanied by abundant small orthid Ranorthis, ostracodes, and gastropod Modestospira. The fauna is of outer shelf environment. Discrete occurrence of Pricyclopyge does not represent a reliable indicator of the Cyclopygid Biofacies. Pricyclopyge is characteristic of deep-water conditions, with suggested depth range 150-200 m (McCormick and Fortey, 1998; Owens, 2002; Turvey, 2005). The depth of 100-150 m inhabited by the Asaphid Association is consistent with mixing of benthic Asaphus, Placoparia, Geragnostus and Bohemolichas with mesopelagic Pricyclopyge in fossil assemblages.

The Neseuretus Association is yet unknown from
the Prague Basin, although is widely distributed in Floian and younger inshore lithofacies at many high to low latitude sites of peri-Gondwana (Dean, 1966; Fortey and Owens, 1978, 1987; Cocks and Fortey, 1988; see also Turvey, 2005). This absence can be explained by scarcity of inshore sandy sea floor habitats. Only red siltstones of the Olešná Mbr. yielded Rusophycus and Cruziana ichnofossils (Mergl and Mikulš, in prep.), which could represent the equivalent of the Neseuretus Association. Accumulation of reworked volcanic ash and other pyroclastic material along the shore of the Prague Basin are not now preserved. Rewashed volcanogenic deposits preserved in deeper environments bear trilobite fauna (Asaphid Associations) of the outer shelf, equivalent to the Nileid Biofacies. The Euroma Association represents a deeper portion of the Nileid Biofacies, in the deep outer shelf to upper-slope position and seems to be comparable with the marginal to slope position of the Cyclopygid Biofacies.

3 CONCLUSION

Six trilobite associations in the Tremadocian to Floian have been recognized in the Prague Basin. The Illaenid-Cheirurid Biofacies is represented by the Hemibarrandia-Parapilekia Association occupying the level-bottom during the Tremadocian, and by the Pliomerosop Association on top of volcanogenic accumulation during the Floian (Text-fig. 3). Locally, the Pseudopetigurus Association was present. The Nileid Biofacies was represented by the Ceratopyge-Proteloma Association during the Tremadocian and by the Asaphid and Euloma associations during the Floian. The Cyclopygid Biofacies is known since the Floian.

Portions of the basin inhabited by trilobites range from several tens to 150-200 m in depth. The inner to shallower outer shelf is indicated by the Hemibarrandia-Parapilekia, Pliomerosop and Pseudopetigurus associations, while outer shelf to upper slope is characterized by the Euloma and Asaphid associations. In the warm tropical or subtropical zone, Priscopeltyge and Pseudopetigurus were confined to deeper and colder (“psychrospheric”) waters below the thermocline.

These genera penetrated into surface waters of the inner shelf in high-latitude and cooler areas without a “termospheric” layer, e.g. in Perunica. The equivalent of the Neseuretus Assemblage is unknown in the Prague Basin, but it could be marked by Cruziana-like trace fossils in the Floian.

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