Revised Age of the Mały Bożków Limestone in the Kłodzko Metamorphic Unit (Early Givetian, Late Middle Devonian): Implications for Geology of the Sudetes

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The Kłodzko metamorphic unit in the eastern part of the West Sudetes (central Sudetes) is composed of sediments and variable, mostly basic, igneous rocks and granitoids altered under greenschist to amphibolite facies conditions (Wojciechowska 1966, 1990; Narębski et al. 1988). These metamorphic rocks form a NW-SE elongated outcrop zone (ca. 100 km^2) bounded

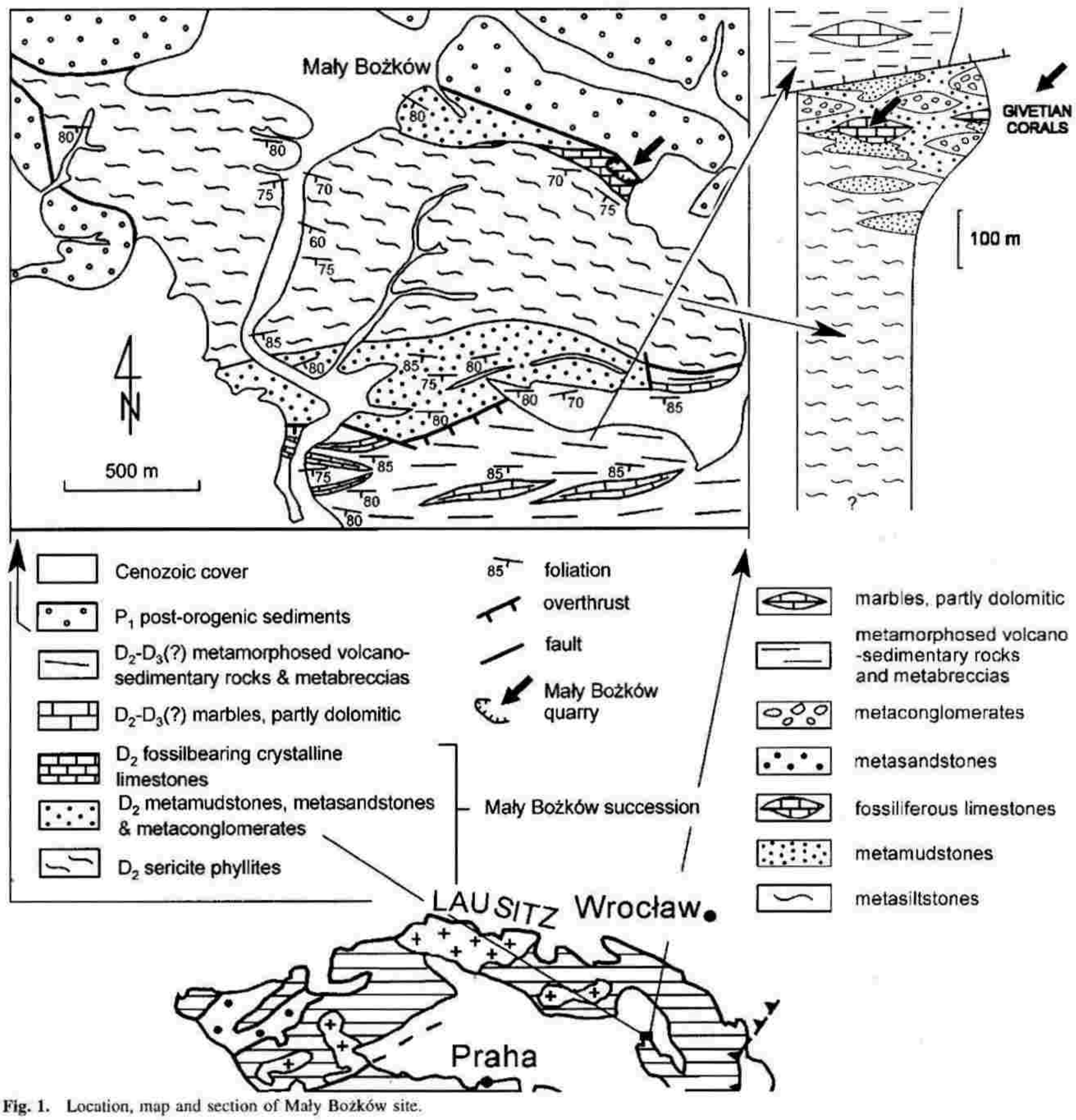

Fig. 1. Location, map and section of Mały Bożków site.

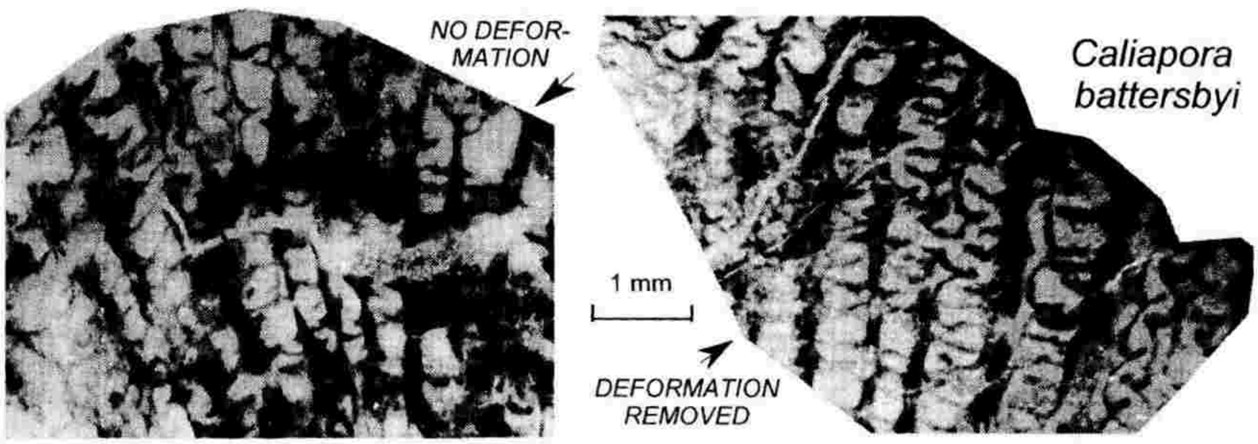

Fig. 2. A cosmopolitan leading index of Givetian age - tabulate coral *C. battersbyi*. Two details of longitudinal sections from the new collection from Mały Bożków.

in the south, west and north by brittle faults, separating metamorphic basement from Upper Carboniferous and Lower Permian clastic sediments of the Intra-Sudetic Basin. Only in the east, the Kłodzko metamorphic unit is in tectonic contact with the Upper Devonian - Lower Carboniferous non-metamorphic to slightly metamorphic Bardo Complex, mostly of flysch and wildflysch characteristics (Wajsprych 1986; Haydukiewicz 1990).

The age of the metamorphosed basement in the Kłodzko unit remained unknown until the discovery of fauna in crystalline limestones of Mały Bożków by Gunia and Wojciechowska (1964, 1971). An Upper Silurian, probably Ludlovian, age ascribed by Gunia and Wojciechowska (1971) to corals from this locality was in agreement with the late Caledonian, Early to Middle Devonian age of the regional metamorphism and folding postulated by these authors.

The area to the SW of Mały Bożków exposes a continuous sedimentary succession of about 600-meters minimum thickness. A monotonous sequence of siltstones/mudstones, metamorphosed into sericite phyllites, grade upwards into metacoglomerates, metasandstones and metamudstones with lenticular intercalations of dark crystalline, fossil-bearing limestones and calcareous phyllites. The whole sequence is overlain by another sedimentary succession, exposed further to the south, comprising chlorite schists, sedimentary breccias and lenses of carbonate rocks. Both successions are separated by a tectonic contact, probably representing a thrust. In the area south of Mały Bożków the contact is partly modified by a semi-brittle shear zone of approximately strike-slip kinematics.

Both new sampling and revision of the collection of Gunia and Wojciechowska show that the Silurian age assumed by these authors is, factually, Givetian (Devonian). The main argument against the Silurian age is the presence of excellent material on *Caliapora battersbyi*, which is the index cosmopolitan fossil clearly identifying the Givetian. Lens-like flattened colonies of *C. battersbyi* are better preserved than other corals, owing to fine crystalline low-Mg calcite, small volume of sparite fill and clayey-organic coating. The lenses were not too strongly damaged by shear and recrystallization, so the sectioning in foliation-parallel planes provided good results. A population morpho-analysis has confirmed the early Givetian age of the coral colonisation. *C. battersbyi* is undoubtedly a index fossil of the Givetian and can be hardly interpreted as a Silurian coral, like the brachiopod *Stringocephalus* can be hardly interpreted as a Silurian fossil.

All other tabulate corals, chaetetids and stromatoporoids (sponges) are also Givetian in age. The rugose corals can also be interpreted as Devonian cystiphyllids or ptenophyllids, but the present revision is considerably constrained by lack of comparative material as well as by problems with the microstructure and morphology of the fossils (original high-Mg calcite to ?aragonite composition of the corals, voluminous sparite fills, large dimension of the objects). However, a section of possible *Calceola* supports the Givetian age of rugose corals. Resedimentation of "old" corals to undoubtedly Givetian coral banks is constrained by absence of abrasion on the corals.

Shannon-Wiener index of diversity is fairly low, 3.4 for the new collection, 3.6 for the old one { $H=-\sum^{S}_{i=1}[p_i \cdot \log_2(p_i)]$, where $p_i = N_i/N$ }. The taxonomical disparity is apparently medium but has large windows (gaps). The assemblage was resistant to immigration of many common taxa, which were largely settled in other environments (nearshore platforms, volcanic seamounts and transpressional open sea elevations). There exists a bidirectional relationship to the southern Laurussian margin (SLM) and northern Gondwanan margin (NGM) palaeogeographical segments. The mean values of Otsuka coefficient of taxonomical similarity fluctuate between 17.9 and 25. The tabulatomorphs of Mały Bożków are imperfectly linked to Konice (36.5; Moravia, SLM), then to Koněprusy (35.4; central Bohemia, NGM). The highest linking value of stromatoporoids is 26.7 (Horní Benešov, SLM) { $O = 100\,C / \sqrt{(N_1 \cdot N_2)}$, where C = number of common species, N_1 = number of species in the first assemblage, N_2 = number of species in the second one }. These values of diversity, disparity and similarity indicate that Mały Bożków and Ještěd were located in one or at least within similar basins until the Givetian.

The present revision of the biostratigraphy (this contribution) calls in question previous interpretations assuming the Early to Middle Devonian age of the regional metamorphism and major folding in the Kłodzko unit (Bederke 1924, 1929; Wojciechowska 1966, Gunia and Wojciechowska 1971). The early Givetian age of metamorphosed limestones from that area implies continuous basinal sedimentation until the Givetian and, consequently, a post-Middle Devonian age for the deformation and metamorphism. The palaeontological data provide, therefore, a new argument against a Caledonian (early to mid-Devonian) tectono-metamorphic event in the Kłodzko unit and in the entire West Sudetes.

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Stratified Magma Chambers Versus Granitization in the Central Bohemian Plutonic Complex (CBPC)

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It is well known from gravimetric data that the NW and N parts of CBPC of Lower Carboniferous age (Holub et al. 1997) comprise some great volumes of mafic rocks in some depth. On the surface, there are isolated bodies of gabbroic to dioritic rocks and enclave swarms surrounded by prevailing granitoids of the calc-alkaline (the Sázava type) and the high-K calc-alkaline to shoshonitic series (the Kozárovice, Blatná and "marginal" types).

In the Příbram area in NW margin of CBPC, Vlašímský has found that volumes of mafic rocks increase with depth. From investigation of many mining works he was able to draw a profile with some subhorizontal or gently dipping enclave-rich layers, forming a "shallow synclinal structure", and some subvertical mafic bodies within the granitoid complex. Such a structure has been interpreted in terms of "relict stratigraphy" and granitisation hypothesis (Vlašímský et al. 1992; Vlašímský 1993). Accordingly, the mafic enclaves (referred to as "amphibole hornfelses" by Vlašímský or "granitised basic xenoliths" by Patočka) represent strata of Cambrian volcanic and pyroclastic rocks interbedded with sediments (now granitoids) and intruded by pre-granitisation subvolcanic mafic stocks and dikes (now the subvertical gabbroic to dioritic masses). The major process responsible for changing the volcanic and sedimentary rocks to granitoids and mafic plutonites is called the "isochemical granitisation in situ" (see Palivcová et al. 1989; Vlašímský et al. 1992).

Recently, extensive mining works for the artificial reservoir of gas in NW marginal part of CBPC near Příbram, about 1 km below the present surface, enabled us to evaluate the granitisation hypothesis and to suggest a new explanation of the geological structure.

This part of CBPC is built of two granitoid groups: (1) the so-called "marginal type" of medium to coarse-grained, often porphyritic biotite to amphibole-biotite granite, containing abundant pink to reddish K-feldspar, (2) the group of variable grey-coloured amphibole-biotite to biotite granodiorites, corresponding to the Kozárovice and Blatná types, and grading into heterogeneous granodiorite to tonalite without any special local name.

Many parts of these granitoids contain huge amounts of mafic enclaves, which could be pillow-shaped or irregular and often tabular with subparallel alignment. Enclaves correspond petrographically to typical mafic microgranular enclaves (MME) with well-developed magmatic textures and no signs of metamorphic recrystallisation. Some MME are ocellar and/or display an increasing grain size from chilled margin to inner parts.

More voluminous mafic masses within the grey granitoids also occur, often surrounded by and passing to, an extreme accumulation of MME. At their contacts we may observe diverse interaction phenomena linked with various stages of granitoid and mafic magma solidification. Early contacts are lobate or crenulate with chilled margins of the mafic magma bodies, pillows and blobs, whereas some later stages of interaction are characterised by mechanical disruption of mafic masses and veining by granitoids with development of enclave swarms. Such enclaves are typically angular and of a block shape without the chilled margin, or with it only along one side of the inclusion.

The most important for our interpretation are those parts of the complex where the mafic and granitoid rocks are interlayered with preserved original shapes and interfaces. Gently dipping to subhorizontal mafic layers are chilled against and separated by much thinner layers of granitoid, which often display textures typical for cumulitic rocks. Basal contacts of the mafic masses are lobate with crests filled by a mobilised granitoid which sometimes form also small pipes and veins extending upward and injecting the mafic layer.

Such phenomena are fully comparable to the stratified mafic-silicic magma chambers, which have been recognised in calc-alkaline plutonic complexes in various part of the world, e.g. in Maine, USA (see Wiebe 1996 and references therein). It can be stated that similar chambers periodically injected by mafic magmas existed also in CBPC. Early mafic intrusions