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ON THE NEW WILDFLYSCH-TO-FLYSCH, BLUESCHIST-RICH LOWER VISEAN SUCCESSION OF THE WESTERN SUDETES (SW POLAND)

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Abstract: Field and laboratory works realized in last years allowed us to redefine one of the lithotectonic units of the western Sudetes, till now considered to be composed of Cambrian to Lower Carboniferous, stratigraphically coherent, volcano-sedimentary succession, as the Lower Carboniferous, probably lower Visean, wildflysch-to-flysch succession. This unit forms the westernmost part of the Kaczawa Complex and is situated at the boundary zone between the Kaczawa Mts. (Polish Sudetes) and the Görlitzer Schiefergebirge (Germany) or – at a larger scale – between the Sudetes and Lugian tectonostratigraphic zones of the Variscan orogen. Petrographical studies of rocks sampled from the larger allochthonous bodies (olistolithes and slide-sheets) of the wildflysch sequence have revealed some peculiar features of the lithic composition of this succession. They consist in the presence of: (1) – unmetamorphosed and metamorphosed volcanites with a distinct HP-overprint, characteristic of supra-subduction zones, gabbro-type plutonites, and relatively numerous detrital chromite grains indicating the occurrence of ophiolite ultramafics in the source area; and (2) – large block(s) of rock composed of quartz (almost 100% SiO_2), previously interpreted as Palaeozoic quartz vein, now documented by the authors to be totally silicified primary evaporites, composed of gypsum (selenite), anhydrite and salt. The last finding would be of special significance as the first strong evidence of evaporites within the Variscan orogenic complex in Europe, if further studies confirm proposed here tectonic position of the silicified evaporites.

General lithic composition of the Jędrzychowice/Ludwigsdorf wildflysch detrital material is characterised by the presence of such lithologies, as: black and gray-to-green cherts, black shale mudstones and cherts, (turbidite-)siliciclastics, carbonates (both bioclastic and diagenetic), basic and acid, unmetamorphosed and epi-to-HP-metamorphosed volcanites, and gabbros and ultrabasites (the latter noted only by detrital chromites). Moreover, the siliciclastic material of the olistosthrome matrix discloses the presence of acid magmatic (granites) and high-grade metamorphics of gneiss-to- mica-schist type in the source areas. Such a composition of detrital material clearly reflects a typical tectonic mélange as the source terrane for the wildflysch deposit. It would mean that the Jędrzychowice/Ludwigsdorf wildflysch should be considered as the next, strong and unequivocal signal of large-scale tectonic mélange stage in a tectonic/geodynamic evolution of the Central European Palaeozoic orogenic system.

Key words: wildflysch, olistosthromes, blueschists, silicified evaporites, Variscan orogen, Lugo-Sudeticum.

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INTRODUCTION

The aim of this paper is to present a new, large-scale Variscan wildflysch-to-flysch rock-unit, and to situate it within the tectono-stratigraphic structure of the Sudetes part of the Central European Variscan orogen (further referred to as CEVO). Such a limited purpose must be preliminary accepted, even if some peculiar exotic wildflysch lithologies, like HP/LT metamorphosed basalts and (silicified) evaporites can be the basis to propose the new tectonic/geodynamic reconstructions. However, the present level of recognition of this mélange-related, evaporite-bearing wildflysch and its tectono-stratigraphic position in the structure of CEVO, is still not sufficient to undertake such reconstructions.

A rock unit dealt with in this paper, proposed here to be named as the Jędrzychowice rock-unit, is situated in the westernmost Sudetes, in the Zgorzelec/Gorlitz region of the Polish/ German frontier zone. It crops out in a small area in the vicinity of the Jędrzychowice villlage, some hundred metres to the east of the Nysa Łużycka/Lausitzer Neisse frontier river (Fig.1). Geologically, it is situated (Fig. 2) be-

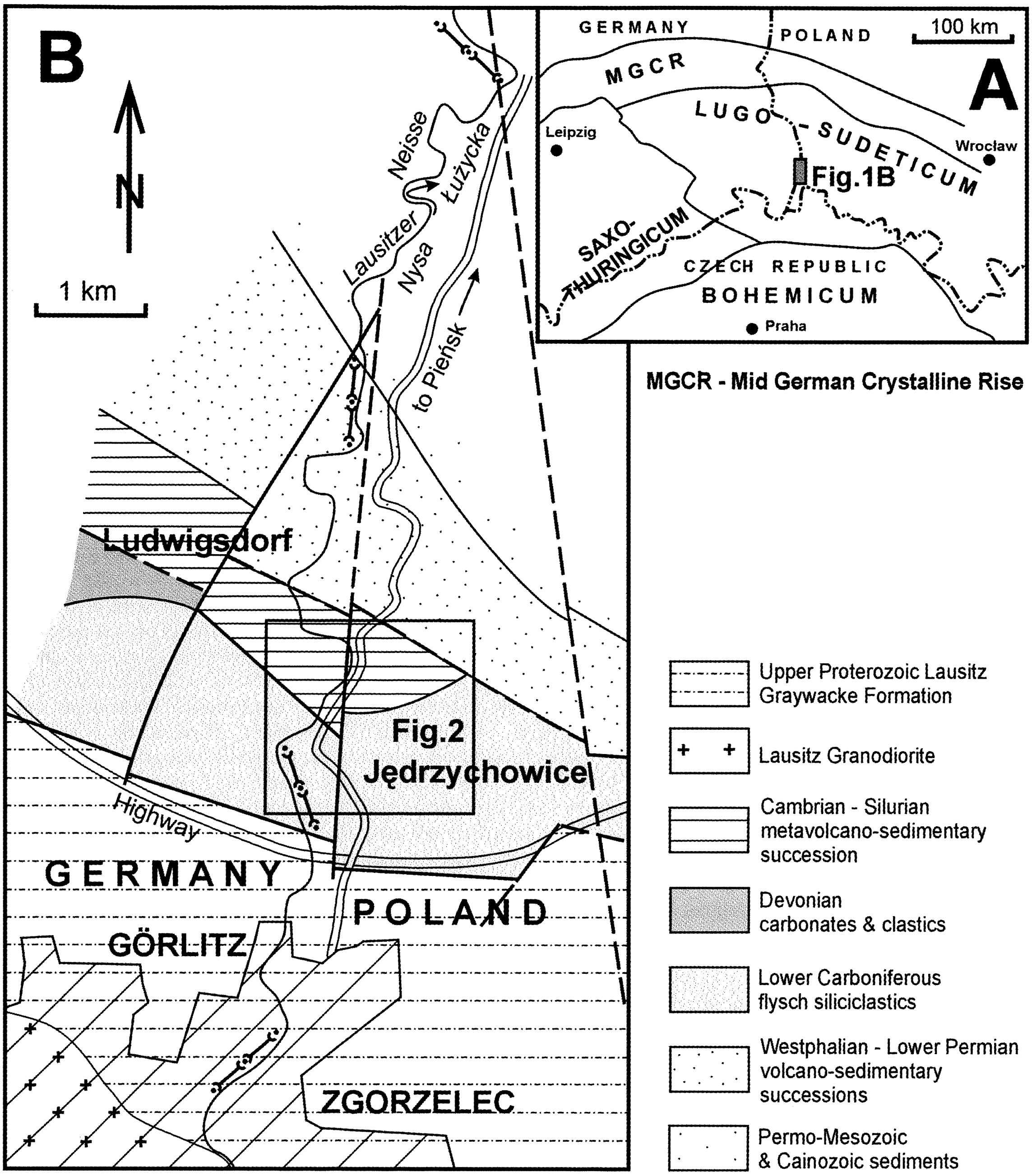

Fig. 1. Tectonic setting of the Jędrzychowice rock-unit in a tectono-stratigraphic structure of the Central European orogen (**A**), and in the West Sudetes region (**B**) (after Frydrychowicz & Frydrychowicz, 1959; Geological Map Lausitz-Jizera-Karkonosze, 2001)

tween the similar, Lower to middle Palaeozoic (Cambrian to Lower Carboniferous), volcano-sedimentary, low-degree to unmetamorphosed, weakly deformed rock complexes of the Görlitzer Schiefergebirge and the Western Kaczawa Mts. units (for overview see Kozdrój *et al.*, 2001, and references therein).

According to one of the oldest geological map of the region (Frydrychowicz & Frydrychowicz, 1957), the Jędrzychowice rock-unit forms a part of the rise of the basement rocks, isolated among the Cenozoic terrestrial deposits (Fig.1). From the south it is tectonically juxtaposed by Upper Proterozoic siliciclastics of the Lausitzer Graywacke Formation, interpreted to be deposited in a foreland basin of the Cadomian orogen (Kemnitz & Budzinski, 1994; and references therein). To the north, the Jędrzychowice rock-unit is unconformably overlain by Lower Permian (or the Upper Carboniferous to Lower Permian, according to Milewicz, 1972) sedimentary and volcano-sedimentary terrestrial successions. The Jędrzychowice rock-unit itself is drawn on the commented map as a succession composed of carbonates, quartz-sericite fyllites, diabases, and siliceous shales of Cambrian to Silurian age. According to newer biostratigraphic data (see Chorowska & Sawicki, 1975, and references therein; Chorowska *et al.*, 1981), the Western Kaczawa Mts. rock complex, including the Jędrzychowice rock-unit, has appeared to be of Cambrian to Early Carboniferous in age. Finally, recently published Geological Map of the Lausitz-Jizera-Karkonosze (Kozdrój *et al.*, 2001) presents

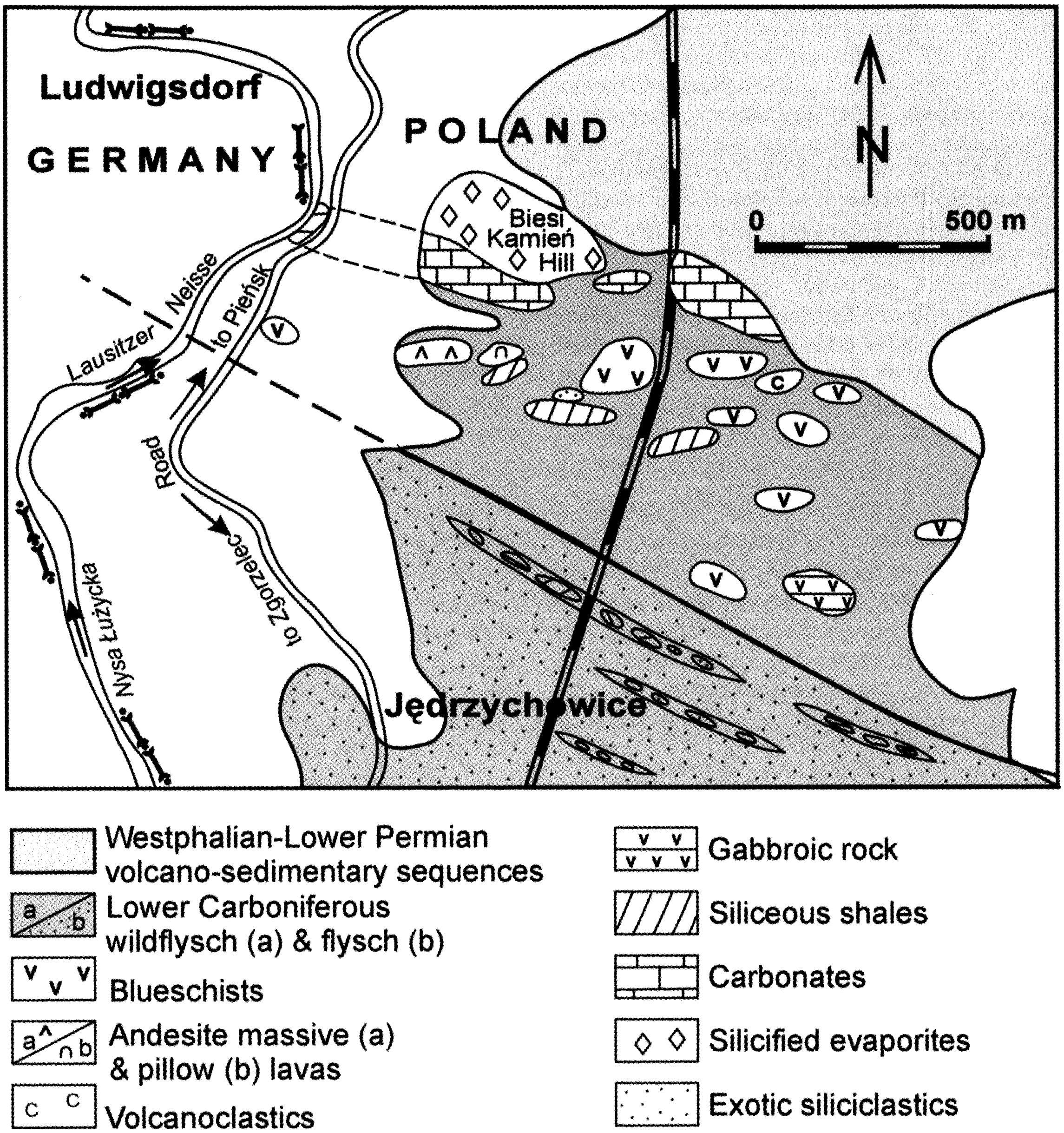

Fig. 2. Geological sketch-map of the Jędrzychowice rock-unit

the area of the Jędrzychowice rock-unit as dominated by Lower Cambrian carbonates (mostly dolomites), shales, and mafic volcanics and pyroclastics, and Lower Carboniferous undivided graywackes, sandstones, shales (partly fyllites), limestones, and conglomerates with characteristic Kieselschiefer-Hornstein Conglomerate.

In the present paper, the Jędrzychowice rock-unit, till now unequivocally interpreted to be the Lower-Middle Palaeozoic, coherent stratigraphic volcano-sedimentary succession, is redefined to be the wildflysch sequence of Early Carboniferous age. Detailed mapping and some structural observations suggest that the flysch sediments rest on the wildflysch deposits. A distinctly normal position of the flysch beds confirms the described unit as the fining upwards, wildflysch to flysch succession. Both the base and cover of this succession have not been recognised till now.

TECTONOSTRATIGRAPHIC SETTINGS

The Jędrzychowice rock-unit generally belongs to the westernmost part of the Sudetes and, more precisely, it forms the westernmost part of the Kaczawa Mts. unit. The Sudetes is one of tectonostratigraphic units of the CEVO. According to traditional, large-scale tectonostratigraphic zonation by Kossmat (1927), subsequently modified but still commonly accepted (for review compare: Franke, 1989; Franke & Żelaźniewicz, 2002), the CEVO is composed of the Moldanubian, Saxothuringian and Rhenohercynian/Avalonian zones/terranes, where the latter two ones are separated by a narrow crystalline belt, the Mid-German Crystalline Rise. The Sudetes, in the frame of this zonation, are marked as the eastern part of the Saxothuringian zone. Suess (1926), taking into account some differences in litho-tectono-stratigraphic composition of both the units, has proposed to subdivide the Saxothuringian zone into the Saxothuringicum *sensu stricto* and the Lugicum (Fig. 1A; for discussion see Hirschmann, 1988). The Sudetes, according to this proposition, form the eastern part of the Lugicum. Paszkowski *et al.* (1990) proposed the term Lugo-Sudeticum as better expressing the differences in litho-tectono-stratigraphic structure of both the parts of the Lugicum sensu Suess (1926). The Jędrzychowice rock-unit is situated exactly at the boundary between Lugicum and Sudeticum (Fig. 1A).

The Sudetes appear to be a composed mosaic of fault-bounded geological units of different tectono-stratigraphic and metamorphic histories. One of largest units is the Kaczawa Mts. unit which forms a northwestern part of the Sudetes. It is, in general, composed of low-to-greenschist-grade, HP-containing, metamorphosed, strongly deformed, and extremely differentiated in its lithological and stratigraphic composition volcano-sedimentary, ?Cambrian (or Ordovician/Silurian, according to Skowronek & Steffahn, 2000) to Lower Carboniferous (Chorowska, 1978) rock complex (Baranowski *et al.*, 1990, and references therein).

The Kaczawa rock-complex (Kaczawa Complex, Kaczawa Metamorphic Complex – as proposed in some recent publications (Collins *et al.*, 2000; Kozdrój *et al.*, 2001; respectively) can be subdivided into three main parts, strongly differentiated in their litho-tectono-stratigraphic composition: the northern, southern and western ones (Baranowski *et al.*, 1990). A distinct feature of the northern part is the presence of Upper Devonian–Lower Carboniferous, olistosthrome-type mélange rock-sets, composed of slab-like and lensoidal blocks of metavolcanites, sandstones, shales, and metacherts hosted within highly deformed, but weakly metamorphosed (up to greenschist facies) mélange matrix (Haydukiewicz, 1987). Some metavolcanite inclusions locally preserve glaucophane overprinted by actinolite (Kryza, 1993). The southern part of the Kaczawa Complex (Southern Kaczawa Complex) is interpreted by Collins *et al.* (2000) as a set of coherent thrust slices of Cambrian–Ordovician acid and basic volcanites of within-plate to MORB geochemistry (Furnes *et al.*, 1994), and carbonates, mudstones and sandstones. This rock-assemblage consists of glaucophane-bearing blueschists (ca. 10 kbar, 300–400 °C), overprinted by lower greenschist-facies (<6–8 kbar, 350–400 °C; Kryza *et al.*, 1990). The mélanges occur in this part of the Kaczawa complex too, but they are restricted to the outcrops that overlie the coherent thrust sheets and highly deformed, mud-rich lithologies between the thrust sheets (Collins *et al.*, 2000).

The Western Kaczawa Complex is fundamentally different. It is generally composed of the Upper Ordovician to Lower Carboniferous (Chorowska *et al.*, 1981), low-grade to unmetamorphosed, weakly deformed succession, dominated by pelitic shaly rocks, which is comprising the intercalations of black, often siliceous, radiolarians-bearing mudstones with phosphorite concretions, radiolarites, fine-grained siliciclastics, carbonates (mostly Upper Devonian; Chorowska & Ozonkowa, 1975), and both the acid (older, probably Ordovician) and basic (Silurian and Devonian) volcanites and their tuffs (Chorowska *et al.*, 1981). The Jędrzychowice/Ludwigsdorf wildflysch to flysch succession builds up the westernmost part of such defined Western Kaczawa unit.

GENERAL CHARACTERISTICS OF THE SUCCESSION

LITHOLOGY, PETROGRAPHY, AND CORRELATIONS OF EXOTIC MATERIAL

The age of the majority of lithologies noted within the Jędrzychowice/Ludwigsdorf sequence can be estimated now mostly on the base of lithological correlations with similar, often almost identical and biostratigraphically proved lithologies of the adjoining rock units. The western Kaczawa Mts. (Chorowska *et al.*, 1981) and the Görlitzer Schiefergebirge (Schwarzbach, 1936; Brause, 1969; Brause & Hirschmann, 1964) rock complexes, as well as other Variscan, well recognised wildflysch-type successions of the Saxothuringicum (Linnemann & Schauer, 1999, and references therein) and the Sudetes (Wajsprych, 1978, 1986, 1995; Haydukiewicz, 1987; Baranowski *et al.*, 1990), have been used as a reference system for the presented below stratigraphy of the exotic rock-material.

A first attempt to the question of age of the rocks of the Jędrzychowice unit has been presented by Berezowski & Chorowska (1968). According to these authors, the rock-succession exposed in a digged graben, is represented by strongly tectonised but stratigraphically coherent volcano-sedimentary Lower Cambrian to Lower Carboniferous succession, dipping generally to the south. It was interpreted as dominated by the Upper Devonian sedimentary and volcanic rocks in the northern part of the graben, and by the Lower Carboniferous monotonous siltstone-sandstone series in the southern part. As the Lower Cambrian, Frydrychowicz & Frydrychowicz (1958) and Berezowski & Chorowska (1968) describe the light-gray, fine grained crystalline massive limestones, found in the northern part of the Jędrzychowice unit (the Biesi Kamień hill area – Fig. 2). This limestone looks to be identical to that of the limestone-phyllite series from Ludwigsdorf, defined by Schwarzbach (1934) as Lower Cambrian. According to K. Pietsch (*vide* Berezowski & Chorowska, 1966), the carbonates of the Biesi Kamień hill area are Devonian in age.The Upper Devonian in the "graben sequence" is represented by basic volcanites (diabases), red, reddish-violet and gray-to-green mudstones and clay-siliceous shales, dark to black shale mudstones, fine-grained quartzites, and dark, brownish to black carbonates (Berezowski & Chorowska, 1968). Some of the coloured shales these authors correlate with those known as the "shales from Sproitz"/Gorlitzer Schiefergebirge, where the Upper Devonian conodonts have been found by Freyer (1965). The reddish-violet shales of the "graben sequence", Berezowski & Chorowska (1968) compare to the shales known from the Halbensdorf borehole which are biostratigraphically proved to be also of Late Devonian age (Freyer, 1965). In consequence, the diabase tuffites found in the "graben section" as intercalations within reddish-violet shales, Berezowski and Chorowska (1968) interpreted as resulted from the Late Devonian synsedimentary volcanic activity. Such a conclusion finds its confirmation in the Emmerichswalde region/Görlitzer Schiefergebirge, where the diabases form synsedimentary intercalations within the Upper Devonian Sproitz series (Brause & Hirschmann, 1964). Consequently, all the other bed-like, up to several meters thick bodies of diabases, found in the graben, have been interpreted by Berezowski and Chorowska (1968) as being of Late Devonian age. Some brownish-gray, fine-grained to pelitic carbonates from the northern part of the graben have also been classified by Berezowski & Chorowska (1968) as Upper Devonian rocks, since they are identical to the Reichstein's (1961, *vide* Berezowski & Chorowska, 1968) Upper Devonian Kunnersdorf limestone from the central part of the Görlitzer Schiefergebirge.

The results of both field and microscopic studies have allowed the present authors to extend a list of the lithologies with some peculiar, till now not recognised ones, as cherts, blueschists, andesite volcanoclastics and lavas, and silicified evaporites.

The class of **cherts** is represented by gray, grayish-green and beige cherts, which frequently contain numerous radiolarians (Fig. 3A). They are commonly found both as the clasts and the bigger blocks within the olistosthrome deposits, as well as characteristic, grain to granule in size, constituents of the flysch siliciclastics. The cherts are generally unmetamorphosed and do not disclose any trace of penetrative deformation. As far as their age is concerned, (biostratigraphic examination is in progress now), their distinct similarity to cherts well known from many Upper Devonian, deep-water successions of the Saxothuringian and the Sudetes realms, strongly supports the conclusion on Late Devonian age of the cherts in question.

The next characteristic and often observed lithology of the Jędrzychowice/Ludwigsdorf wildflysch is dark-gray to black, gently laminated to massive **mudstones**. A peculiar feature of this lithology is the radiolarian fauna, found in some specimens as singular individuals, irregularly dispersed in the rock mass. Meso- and micro-scale observations have shown this rock to be the most abundant exotic lithology of the olistosthrome deposits, represented as angular clasts of the grain- to boulder-size. Also the matrix of the olistosthrome deposits seems to be constructed mostly of sheared dark-gray and black mudstone. The clasts of dark-gray to black, also radiolarians-containing cherts (Fig. 3B) and fine-grained, quartz-rich, dark-gray siliciclastics, commonly found among the relatively fine debris of the olistosthrome clastics, belong probably to the same mudstone association. In some thin sections, the coarse-grained, often limonitised, detrital material of siderite composition has been found in a close spatial relationship with the black mudstone detritus. Concluding, the above reconstructed sedimentary, mudstone-dominated exotic association indicates a sequence composed of black, radiolarians-bearing mudstone, containing siderite conrections, and rarely intercalated with black to gray radiolarian cherts and thicker inserts of gray-to-black, fine-grained, quartz-rich, turbidite siliciclastics as an important lithostratigraphic member of the source rock complex.

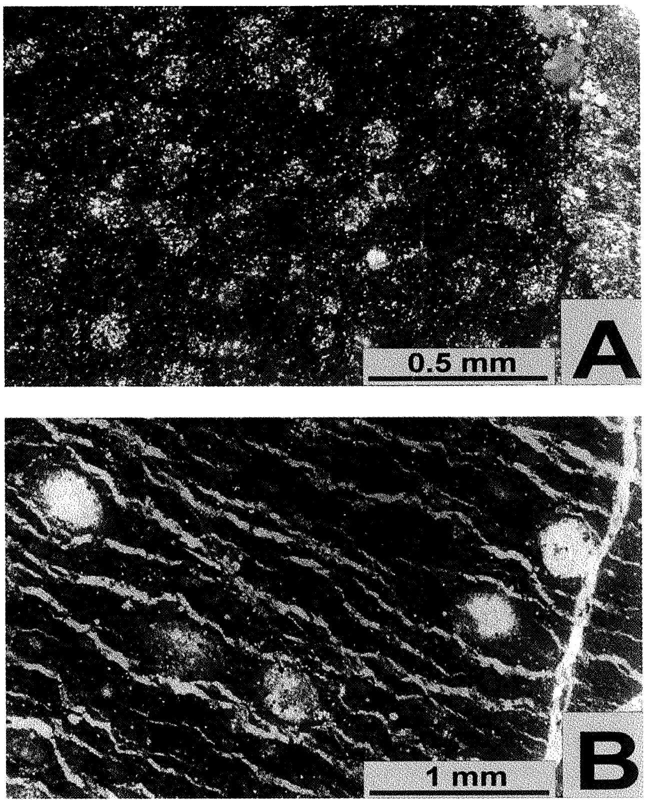

Fig. 3. Greenish-gray radiolarite (**A**) and radiolarians-bearing dark-gray to black mudstone (**B**) exotics from the Jędrzychowice/Ludwigsdorf wildflysch. Parallel polars

Such a reconstructed sequence can be lithologically correlated with the middle Tournaisian (lower cdII), generally black shale sequence, typical of the Saxothuringian, Sudetes and Rhenohercynian realms, interpreted to have originated due to well documented global eustatic transgression of the Lower *crenulata* – *isosticha* – Upper *crenulata* Zones in age (for summary see Herbig, 1993; Becker, 1992). For example, the Gołogłowy Formation (Wajsprych, 1986) of the Bardo Mts. rock complex in the Central Sudetes, which is biostratigraphically proved to be of middle Tournaisian age (Haydukiewicz, 1981; Chorowska & Radlicz, 1992), contains all the lithological members distinguished above. It is composed of black mudstone, rarely interbedded with thin-bedded cherts, some levels of relatively big (up to 12 cm in diameter), usually limonitised, siderite concretions, and thicker inserts of dark-gray, thin-bedded and fine-grained, quartz and detrital mica-rich, often graded turbidite siliciclastics.

Another important group of the exotics are the **volcanics**. The diabases described by the former authors (Frydrychowich & Frydrychowicz, 1959; Berezowski & Chorowska, 1968) have appeared to be a strongly diversified set of basic to intermediate rocks represented by dolerites and basalts, accompanied by andesitic lavas and their volcanoclastics. It is characteristic that basic volcanogenic rocks are mostly highly metamorphosed (blueschists) in contrast to more acid ones, which recorded very low grade metamorphism or none.

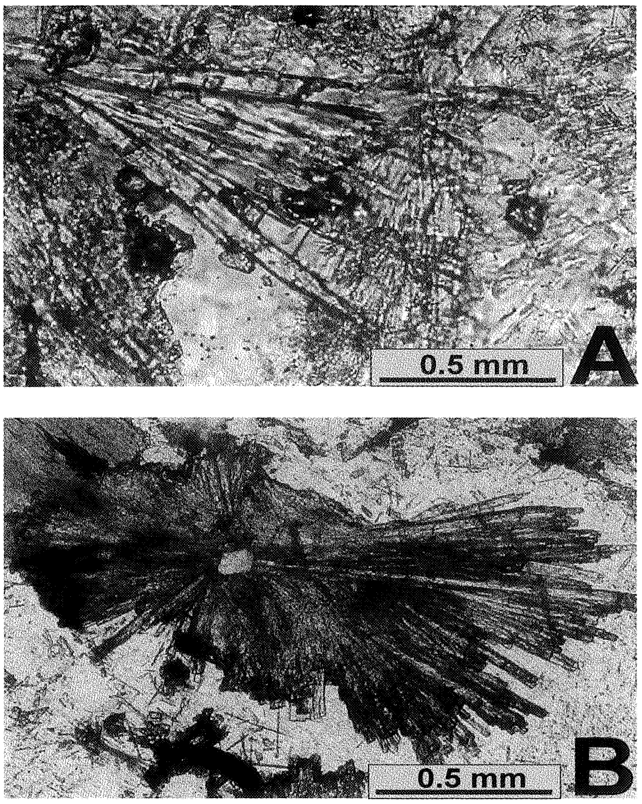

Fig. 4. Homogenous structure of jadeite-bearing blueschist exotic blocks within the Jędrzychowice/Ludwigsdorf wildflysch. The jadeite blasts are spatially connected with chlorite and seladonite (indistinguishable here) and overprinting albite grains. The fan-like (**A**) and the rosette-like (**B**) arrangements of jadeite are observed. Parallel polars

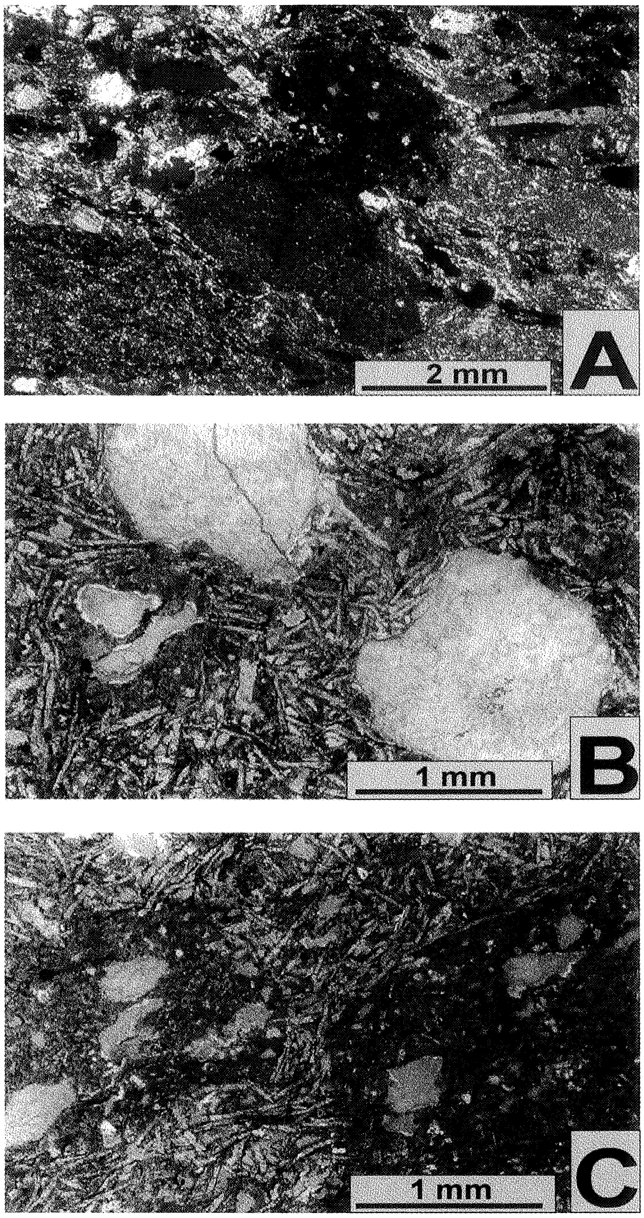

Fig. 5. Different types of andesite lava exotics: **A** – volcanoclastics, composed of clasts which are structurally differentiated from lava containing plagioclase phenocrysts to glass and pumice varietes; **B** – pillow-lava with fluidal texture and abundant vesicles; **C** – pillow lava including numerous fragments of glassy shards of different size

The **blueschist** blocks are the dominating constituent of a group of volcanic exotics of the Jędrzychowice/Ludwigsdorf wildflysch. The biggest (up to 250 m in diameter) allochthonous slabs found in the northern part of the Jędrzychowice rock-unit are composed of blueschist basalt. In the prevailing cases, the blueschist basalts are fresh and their texture is massive and never showing any traces of dynamic recrystallisation. A well preserved magmatic structure of former dolerites is evidenced by ophitic matrix embedding bigger (1–7 mm in diameter) igneous clinopyroxene xenocrysts. In some of the examined metabasite blocks (samples Z224, Z225, Z300), igneous amphiboles of peculiar Fe-edenite composition have been found. The grains of igneous pyroxene, usually altered, are zoned. Their cores are formed of brown Ti-augite ($0.38<Ti<0.61$ atoms per formula unit – a.p.f.u.) and the rims are composed of pale-green sodic pyroxene ($Jd_{13}Aug_{67}Aeg_{20}$). The metamorphic pyroxene is pure jadeite, which concordantly overgrows the phenocrysts of igneous pyroxene or is forming individual crystals up to 1.5 cm long, arranged in the form of fan-like aggregates of up to 1.5 cm long crystals (Fig. 4A) or the rosettes (Fig. 4B). Often, jadeite forms a moss-like aggregates, located at rim of the albite laths. Finally, three different, garnet-free and albite-rich assemblages have been recognised among the till now examined blueschist metabasalts: (1) Fe-glaucophane – stilpnomelane – phengite (Si > 3.75 apfu) – chlorite; (2) jadeite – epidote – phengite – chlorite, and (3) jadeite – glaucophane – epidote – phengite – chlorite. The assemblage (1) indicates the lower pressure overprint (max. 6–7 kbar at 300°C), while the (2) and (3) assemblages document distinctly higher pressure conditions (> 10 kbar at 350°C).

The exotic **andesite** volcanogenic rocks are represented by volcanoclastics and lavas. It should be emphasized that andesites are typical volcanics of supra-subduction zones. The volcanoclastics occur in subordinate amounts. They are composed mostly of angular fragments of structurally differentiated (e.g., fluidal, ophitic or vascular) lavas, and altered volcanic glasses (Fig 5A). The fluidal lavas contain plagioclase (An = 28–36 mol %) phenocrysts. The lava-type andesite volcanites are represented by massive and pillow lavas. The ophitic-vascular structure, with variable number of vesicles, is typical of massive lavas, found there in the field mostly as large blocks. Pillow lavas, met in the field as smaller blocks and angular, pebble-sized debris, are usually associated with detrital material of black-shale type described above. Fine-crystalline ophitic structure and numerous vesicles are characteristic feature of these pillow lavas (Fig. 5B). The spherical and ovaloidal vesicles, 5–10 mm in diameter, usually more or less homogenously distributed, are filled with spherulitic silica or chlorite + prehnite + quartz ±zeolites ±calcite aggregates. Locally, fluidal structure within the matrix has been observed. Moreover, the vesicles are elongated and orientated along a fluidal lamination, what is typical of lateral zones of pillows.

The mineral paragenesis: chlorite + zeolite + prehnite + quartz ± calcite, established for the andesite lavas, suggests a very low grade alteration at the presure < 1 kbar and temperature < 200°C, what does not exceed the degree of alteration of the whole wildflysch succession.

The **gabbroic** rock, recognised by the authors as a large mapable rock-body (Fig. 2), represents the next new, surely allochthonous component of the described wildflysch deposit. The rock shows a coarse-grained cumulate structure, expressed by large and relatively fresh plagioclase crystals and idiomorphic Fe-Mg minerals (Fig. 6). The latter are completely altered to chlorite, serpentine, talc, sphene, calcite, and opaque minerals, what indicates serpentinisation as the alteration mechanism.

Numerous detrital chromite grains, found within the flysch siliciclastics, disclose also a high share of the **ophiolite**-type ultramafic rocks within the source rock complex.

The lack of any direct data makes the question of age of all the igneous exotics described above as related to the model solutions. Since, this question will be undertaken in the final chapter of this paper.

Another exotic component of the allochthonous rock-assemblage of the Jędrzychowice/ Ludwigsdorf wildflysch is a rock composed in almost 100% of quartz and interpreted by the authors as totally silicified **evaporites**. Till now, this rock has commonly been described as a quartz vein (Frydrychowicz & Frydrychowicz, 1958; Śliwa, 1967; Milewicz *et al.*, 1979). However, Śliwa (1967), having established some peculiar features of petrographic composition of this quartz-rock, like the presence of the "limonite-chalcedone, losenge and square in shape, post-magnetite pseudomporphs... in some parts of the rock...", has underlined its individuality when compared with other large quartz veins known from the Sudetes.

This quartz rock forms a large (more than 350 m in diameter), slab-like body, situated in north part of the Jędrzychowice rock-unit. It probably forms an allochthonous body, though this question needs further studies. The rock is rich in silica pseudeomorphs of idiomorphic crystals of various evaporite minerals which are visible under parallel nicols only (Fig. 7A). The shapes of silica pseudomorphs and the common presence of the length-slow chalcedony are, following Folk & Pittman's (1971) opinion, the evidence of vanished evaporites. These diagnostic features were used by the present authors to consider the Biesi Kamień quartz rock as metasomatically transformed protoevaporites.

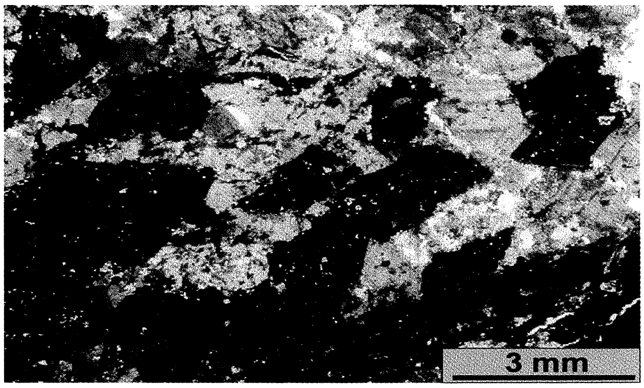

Fig. 6. Exotic of the gabbroic rock. Its finer-crystalline parts display cumulate structure of amphibole and pyroxene with interstitial plagioclase. Crossed polars

The selected samples presented in Fig. 7 (B and C) illustrate commonly microscopically observed outlines of primary evaporite minerals that are marked by usually double, very thin layer of transversely laminated fibrous silica. A characteristic feature of this fibrous silica is its c-axis parallel to the fibbres, what was defined by Folk & Pittman (1971) as diagnostic feature of the length-slow chalcedony, and – in consequence – a diagnostic feature of silicified evaporites.

Small, regular, "diamond"-shaped rhombohedra of secondary dolomite (Fig. 8A) have been found to be dispersed in more massive, ?anhydrite or ?selenite protolith. The chalcedony spherulites, 0.5 mm in diameter on the average (Fig. 8B), found within the felt-like microstructural silica, can be interpreted to be anhydrite nodules within the claystone or marlstone protolith, if compared to the situations often described (e.g., Vejnar, 1953; Folk & Pittman, 1971; Milliken, 1971; Siedlecka, 1972; Paszkowski & Szydłak, 1986).

As much more spectacular and convenient for more unequivocal interpretation are two other lithofacies distiguished within the Biesi Kamień series. The first one is a very coarse-grained rock, where perfectly preserved texture of the protolith discloses coarse-crystalline gypsum (selenite) deposit. A distinct network of breccia-type structure observed under the microscope is interpreted by present authors as resulting from *in situ* brecciation of selenite rocks before their silicification. Another possibility is to explain the described rock as sedimentary breccia originated from the gravity mass flow deposition. Such breccias are commonly described from many evaporite basins; e.g., Peryt & Jasionowski (1994) related the origin of similar breccia deposits to increased tectonic activity on slopes of the Carpathian Foredeep basin. Vai & Ricci-Lucchi (1977) reported from the Messinian basin in Northern Appenines chaotic selenite deposits resulting from turbidity currents, debris flows and slumpings.

The second of the above mentioned is also a completely silicified rock, but under the parallel nicols disclosing beautifully expressed pisolithic-oolithic primary depositional structure (Fig. 9A, B). The cores of ooliths are of peculiar,

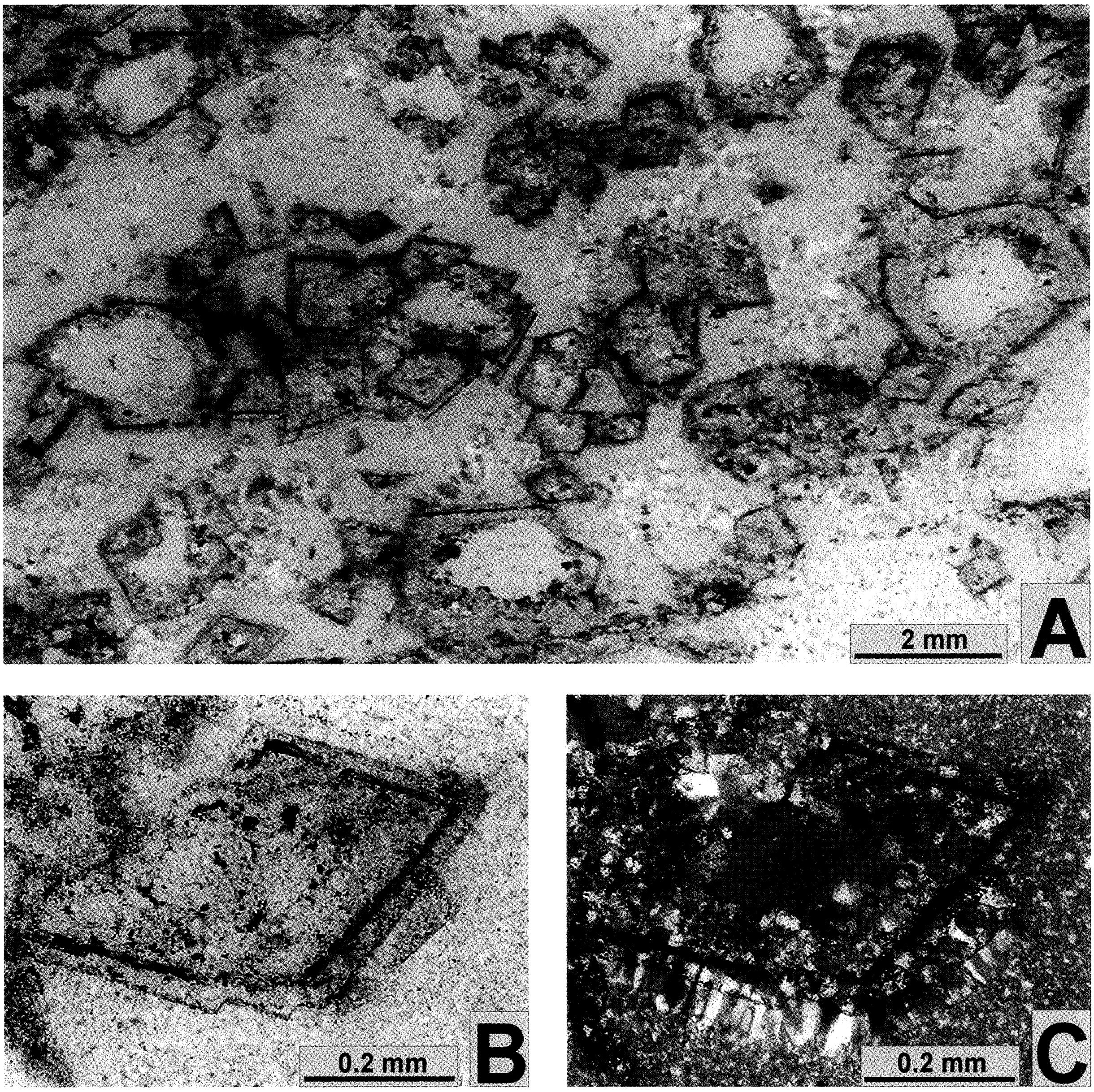

Fig. 7. Microphotographs illustrating the structure of exotic silicified evaporites from the Jędrzychowice/Ludwigsdorf wildflysch: **A** – crystalline structure of primary evaporitic rock. Note idiomorphic shapes of silica pseudomorphoses after dolomite and salt minerals. The former outlines of the dolomite and salt crystals are marked by haemathite. Parallel polars; Selected crystal of dolomite replaced by silica under parallel (**B**) and partially crossed polars (**C**). Before silicification this crystal has undergone a partial dissolution (upper left part of photos B & C). The length-slow chalcedony is visible along the crystal edges

till now not recognised composition; they are formed of crystals or fragments of druses of the ?evaporite and/or ?dolomite minerals (Fig. 9A, B). For instance, the gypsum crystals as nuclei of gypsum ooides from the Miocene deposits from the Holy Cross Mountains in Central Poland have been described by Kasprzyk (1993).

Summing up, the quartz rock of the Biesi Kamień series, now consisting in almost 100% of quartz, can be interpreted to be, subsequently totally silicified, evaporite deposits. The problem of the age of this evaporite sedimentation will be presented below.

Another large fragment of quartz-rock is exposed in central part of the Jędrzychowice village, about 1 km south of the Biesi Kamień hill (Fig. 2). It forms a slab about 60 – 80 m long and about 6–10 m thick. On the geological map of Frydrychowicz & Frydrychowicz (1959) it is marked also as a large-scale quartz vein. In the present authors' opinion, this quartz rock also resulted from a total silicification of sedimentary rock series, probably limestone. The nature of this rock protolith, however, is not so distinctly readable as the evaporite nature of the Biesi Kamień quartz-rock protolith is.

Carbonates. There are four classes of carbonate material identified within the allochthonous clastic material of the Jędrzychowice-Ludwigsdorf wildflysch: (1) – carbonates (dolomites) from the Biesi Kamień hill area which originated due to late/post-diagenetic carbonatisation (dolomitization) of primarily siliceous sedimentary rock; (2) –

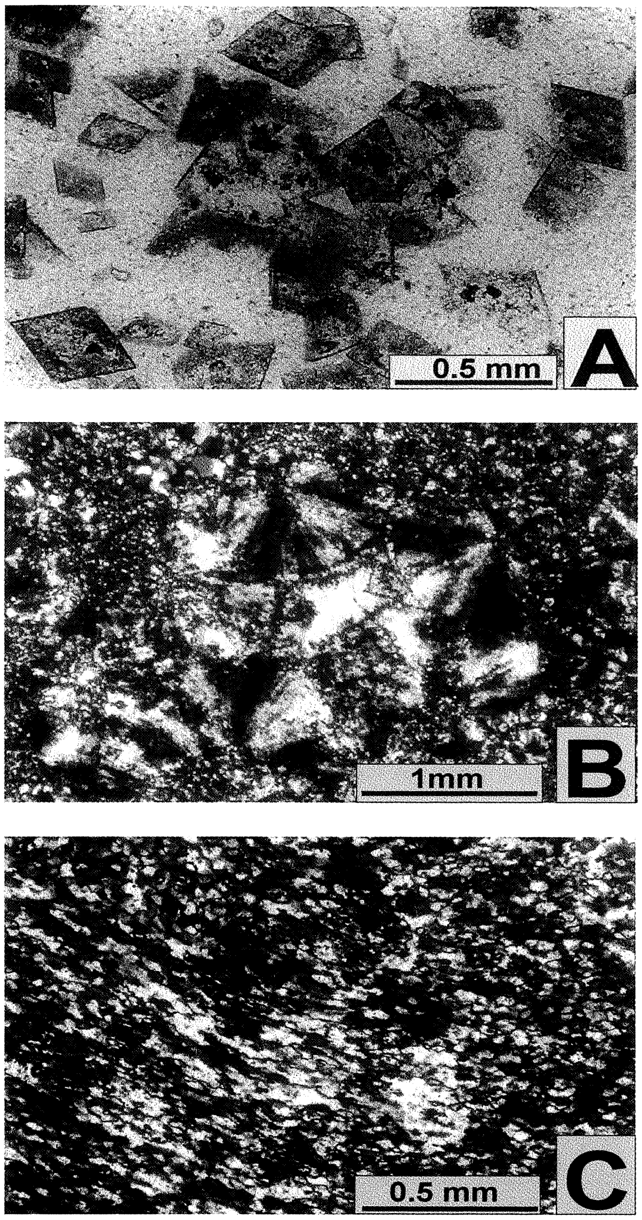

Fig. 8. Microphotograph examples of textures inherited after silicified evaporites from the wildflysch of the Jędrzychowice/Ludwigsdorf sequence: **A** – the inner part of silicified selenite is composed of homogenous, felt-like silica. The former presence of dolomite crystals included in this selenite is visible as silica pseudomorphoses, rhombic in shape. Parallel analysers; **B** – spherulitic silica marks former nodular anhydrite. Parallel analysers; **C** – parallel lamination of silica inherited after the primarily laminated anhydrite. Crossed polars

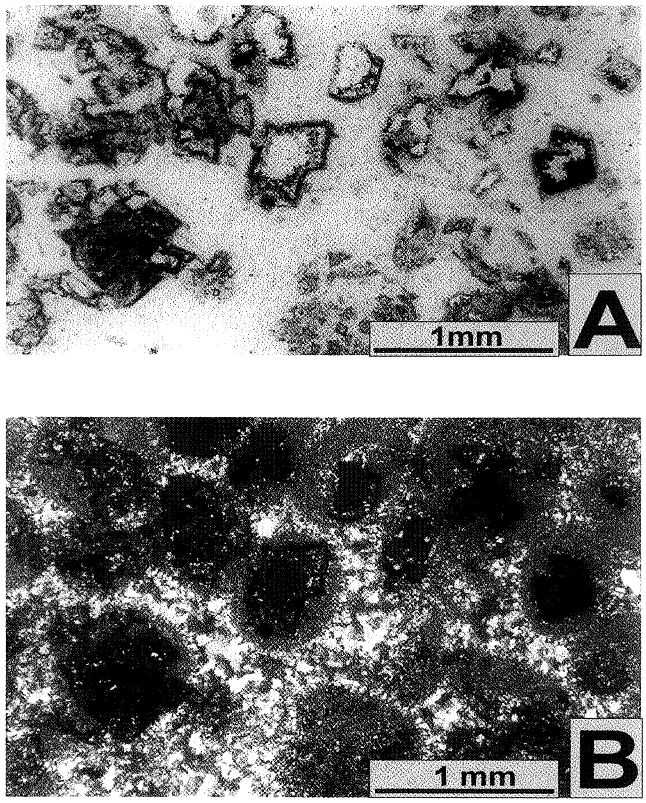

Fig. 9. Silicified pisolithic ?gypsum oolithes. Note the peculiar, crystalline cores of the oolithes. Parallel (**A**) and crossed (**B**) polars

other diagenetic carbonates probably originated from carbonatisation of primary evaporites; (3) – secondary quartz-rock originated by a total silicification of primary, poorly recognisable, in part thin-laminated, probably micritic but unfossiliferous limestones; and (4) – bioclastic, unaltered limestone.

The Biesi Kamień evaporites are situated in close spatial relationship to the carbonates, still described as the Lower Cambrian dolomites (Kozdrój, 2001; Geological Map, 2001). However, the results of preliminary petrographic studies indicate this rock to be a carbonatised (dolomitised) siliceous shale. Its primary structure is marked by intercalations of gently laminated claystone. The final carbonatisation, which has touched ca. 70–85% of the primary rock volume, was preceded by two other, late- to post-diagenetic events: (1) – the early dolomitisation, and (2) – silicification. The early dolomitisation produced small rhombohedral dolomite crystals, irregularly dispersed throughout the siliceous rock-mass. The subsequent silicification has overprinted the siliceous-clayey rock-mass and only partly removed the dolomite crystals, perfectly preserving their original outlines, what resulted in the ghost-structure of the rock. Such trasformed rock was subjected to final carbonatisation.

It is worth to note that the set of the above established late- to post-diagenetic changes within the described "dolomite" is identical to that found within the Biesi Kamień quartz rock, where the silificaton was also preceded by dolomitisation. It does finally mean a common syn-to-post-diagenetic history of both the lithologies which has developed there in the place of their deposition.

The last of the above distinguished groups is represented by siliciclastic material of flysch deposits. It is composed mostly of quartz, plagioclases, K-feldspars and mica flakes, as well as the aggregates of these minerals, indicating the domination of gneisses, mica schists, and undeformed granitoids in lithological composition of the source complex. Such detrital material, psammite to granule in size, is a prevailing constituent of the grain framework of generally thin-bedded turbidites, which form sedimentary background for the olistosthrome and large olistolith inclusions. Till now, no bigger clasts or boulders of granites, gneisses or mica-schists have been found within the Jędrzychowice/Ludwigsdorf wildflysch-to-flysch succession. The mineral and lithic compositions of detrital siliciclastic material characterised above seem to indicate generally pre-Carboniferous age of gneiss – mica schist complexes, typical of the Saxothuringian and the Sudetes units. In this context, a high contribution of granitic detrital material sounds to be of special interest and demands further investigations.

LITHOTECTONIC COMPOSITION OF THE JĘDRZYCHOWICE UNIT; WILDFLYSCH DEFINITION

The lack of larger exposures makes the surficial ralationships among different lithologies and petrographic/petrological and biostratigraphic features of these lithologies, the main way to recognise the wildflysch nature of the studied rock-unit. Our schematic geological map (Fig. 2) presents the Jędrzychowice unit as an archipelago of isolated "islands" of different basement rocks exposed in the "sea" of Recent deposits. The largest of these "islands", concentrated in northern part of the unit, are composed of silicified evaporites, carbonates, siliciclastics, gabbroic rock, and andesite lavas and volcaniclastics (all unmetamorphosed) and basalts altered under the blueschist facies conditions (Fig. 2). Allochthonous position of all these lithologies and chaotic character of their final accumulation are evident. The thin- bedded, mostly fine to medium-grained, silt to pelite material-rich, commonly graded lithic wackes and typical olistosthrome deposits, noted in some parts of the unit, represent the background sediments for emplaced large allochthonous bodies.

Some structural features, like a SSW-ward dipping of the flysch and wildflysch bedding, as well as normal grading, observed in some examined flysch outcrops, indicate the rock-succession of the Jędrzychowice unit as a normal one, generally younging to the south. Domination of large allochthonous bodies in the northern part of the unit and dominance of the flysch deposits in the southern part disclose this succession as a fining-upward, wildflysch to flysch succession.

The lower portion of the wildflysch sequence can be interpreted as a rock-assemblage composed of large fragments of probably Upper Devonian and lowest Carboniferous, sedimentary and volcano-sedimentary, radiolarians-bearing black mudstone dominated series. It is internally sheared but stratigraphically coherent, gravitationally mixed, with large slabs of exotic and evidently older, blueschist basalts and ophiolite-type rocks. The pebble mudstone- rich olistosthrome deposits, containing also large volumes of black mudstone detrital material, as well as black, green or beige cherts, fine-to-medium-grained siliciclastics, are characteristic for the upper part of the wildflysch sequence. The pebble-to-boulder sized clastic material is represented by undeformed and unmetamorphosed volcanites, mostly andesite-type lavas. Such diversified rock-mass forms the background, matrix deposit for large and very large bodies, several tens to 250 m in diameter, of the ophiolite type gabbroic rocks and blueschists.

Siliciclastics typical of flysch sequence form the upper part of the wildflysch sediments. A gradual transition from wildflysch to flysch deposition is noted by the olistothrome-type intercalations within the lower part of flysch and permanent presence of clasts of cherts, typical of the wildflysch deposit within the flysch siliciclastics. The flysch deposit in the recognised part of the succession is composed of quartz-rich lithic wackes, rather thin-bedded but medium-to-coarse-grained, intercalated with siltstone-dominated, fine-grained to pelitic lithologies. Structure of clastic beds is massive to graded.

According to the presently accepted concept (for review see Kozdrój *et al.*, 2001), the Jędrzychowice unit, as a part of the Western Kaczawa complex, is tectonically juxtaposed from the south by the Upper Proterozoic (Cadomian) flysch graywackes. However, some olistosthrome intercalations found by the present authors within this Cadomian flysch, seem to introduce some essential questions to this concept. Lithic composition of these olistosthrome breccias, which are characterised by presence of pebble to boulder sized clasts of the greenish-gray and black cherts and black mudstones, both containing radiolarians and conodont fauna (unpublished data), are typical of lithic composition of the wildflysch olistosthromes. These data led us to conclude about the Early Carbonifeorous age of – at least – this part of the Upper Proterozoic flysch clastics where the breccia-intercalations have been found.

Summing-up, the Jędrzychowice rock unit is considered to represent the fining upward, wildflysch-to-flysch succession. As the wildflysch body crosses the Nysa Łużycka/Lausitzer Neisse river, where the Ludwigsdorf locality is situated, we propose, though still informally, to name the described lithostratigraphic unit as the Jędrzychowice/Ludwigsdorf (wildflysch) sequence.

Such a doubled term may be not suitable in using sounds to be still worth to be proposed. First of all, it is joining the rock complexes divided by frontier-river only. Besides, it is introducing the defined here wildflysch sequence to the geology of the Lusatia, where the Sproitz-Ludwigsdorf Thrust is a suture between the shelf margin and accretionary wedge, according to the Göthel's (2001) model.

DEFORMATION

Again, the lack of larger exposures in the area of the Jędrzychowice rock-unit makes an intended structural analysis of the Jędrzychowice/Ludwigsdorf wildflysch sequence as limited to some basic features. At the microscale, the massive, homogenous fabric of the wildflysch matrix has locally been overprinted by penetrative foliation (Fig. 10A). This foliation is restricted to more or less continuous deformation zones, that developed in a simple shear regime. Some mudstone clasts that are close to initiated shear zones have been distinctly rotated and display evidence of blastasy of white mica, arranged parallel to the foliation. The asymmetric fabric with s-c structures have commonly started to develop.

Some traces of incipient dynamic recrystallisation can also be frequently observed within the pelitic domains of the wildflysch matrix deposit. The fine to medium-grained, neomorphic muscovite and chlorite are usually observed to form the perfect, tectonically induced parallel arrangements of flakes. Moreover, the neoformed muscovite and chlorite are observed to overgrow the pressure shadows of the clasts (Fig. 10A).

AGE OF THE WILDFLYSCH DEPOSITION

Taking into account the above presented data, the Early Carboniferous age of the Jędrzychowice/Ludwigsdorf wildflysch deposition is generally evident. Similar chaotic successions of the Saxothuringian zone have been defined to be of Middle to Late Visean ages (Behr *et al.*, 1982; Kurze, 1983; Thomas, 1990; Linnemann & Schauer, 1999), interpreted as reflecting the orogenic, tectono-depositional fronts migrations. There is, however, a feature of the Jędrzychowice/Ludwigsdorf wildflysch lithic composition which suggests the earliest Visean age of its deposition. Domination of black-shale type mudstone, fine to pebble-sized detrital material within the matrix of olistosthrome deposits of the wildflysch seems to be such a feature in the authors' opinion. The mudstone clasts often disclose a plastic deformation pattern, clearly developed after their redeposition into the wildflysch. It does mean that, in part, these clasts came into the wildflysch basin as soft, still not wholly lithified material. Consequently, the conclusion on almost synchronous sedimentation and redeposition of these mudstones to the Jędrzychowice/Ludwigsdorf flysch basin seems to be well justified. The probably late Tournaisian age of primary deposition of these mudstones (as it was concluded above on the base of correlations with the Gołogłowy mudstone rich black shale sequence), makes the latest Tournaisian/earliest Visean times as most probable age of the Jędrzychowice/Ludwigsdorf wildflysch to flysch sedimentation.

The above conclusion is consistent with the earliest Visean, biostratigraphically proved age of recently formulated, the next new wildflysch-to-flysch succession from the Central Sudetes rock-complex (Wajsprych, 1997). Unfortunately, lack of direct data on the nature of both the substratum and the cover of this succession, makes the problem of the tectono-stratigraphic position of the Jędrzychowice/Ludwigsdorf wildflysch-to-flysch succession within the Lugo-Sudeticum rock-complex a still open question.

CONCLUDING REMARKS, DISCUSSION, AND IMPLICATIONS

In conclusion, three basic theses can be formulated. They are as follows:

1. The presence of new, well-proved, and large-scale wildflysch-to-flysch (Jędrzycowice/Ludwigsdorf) succcession of Visean, most probably early Visean age, situated in the westernmost Sudetes and representing the redefined rock-unit, considered till now to be a stratigraphically coherent, Cambrian to Lower Carboniferous succession of the Western Kaczawa Complex;

2. The peculiar lithic composition of the Jędrzychowice/Ludwigsdorf wildflysch, characterised by the presence of a number of often large blueschist olistoliths, associated with the allochthonous bodies of unmetamorphosed to very low grade metamorphosed gabbroic rock, ultrabasites (recognised from the detrital chromites only) of the ophiolite assemblage, andesite (pillow) lavas and volcanoclastics, cherts and turbidite siliciclastics; and

3. The occurrence of large allochthonous bodies of totally silicified evaporites, till now considered in the regional geology as large-scale quartz veins.

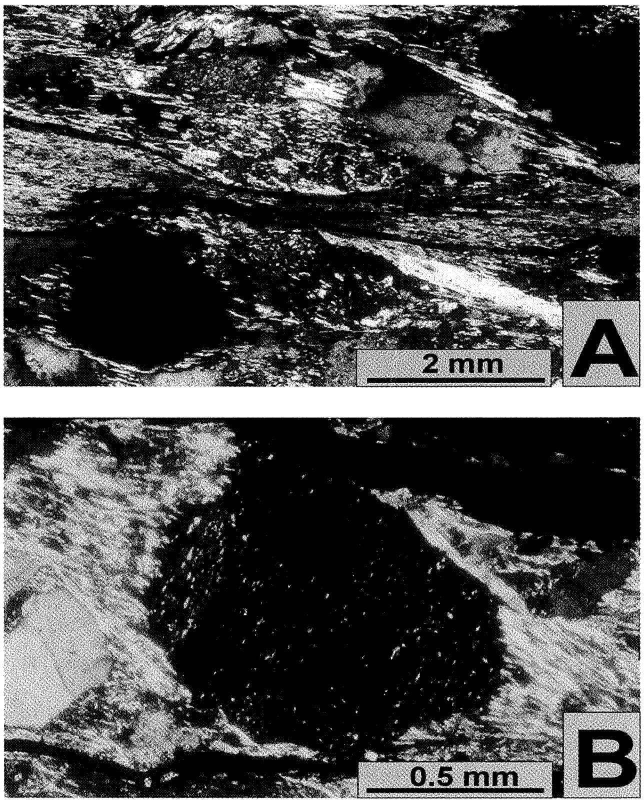

Fig. 10. Microphotographs illustrating the deformational structures developed in the matrix of siliciclastics close to the boundary between wildflysch and flysch series: **A** – the foliation surface is defined by growing of neomorphic white mica and chlorite blasts. These minerals grow within the pelitic matrix and at the boundaries of mudstone clasts. Crossed polars; **B** – the asymmetric fabric of sheared sandstones expressed by asymmetric pressure-shadow spaces filled with the neomorphic white mica aggregates. Crossed polars

The Jędrzychowice rock-unit is situated at the boundary zone between the Görlitzer Schiefergebirge and the Western Kaczawa complexes. Both these units are still considered in the regional geology to represent the stratigraphically coherent, Lower Cambrian to Lower Carboniferous volcano-sedimentary successions which contain the (upper) Visean flysch (Western Kaczawa complex; Chorowska, 1978; Kozdrój *et al.*, 2001) or flysch and wildflysch (Görlitzer Schiefergebirge – Kurze, 1983; Thomas, 1990; Linnemann & Schauer, 1999; Gothel, 2001) sequences.

The problems of origin and tectono-stratigraphic position of the flysch-wildflysch sequences in question have been only marginally discussed. Linnemann & Schauer (1999) define the wildflysch as the "Variscan wildflysch of the Thuringian facies realm". They ascribed its origin to the Variscan collision time, when the whole Saxothuringian Terrane was uplifted at its northeastern margin and tilted downward to the southwest, causing the flysch and wildflysch sedimentation. Linnemann & Romer (2002) have suggested that the entire Görlitzer Schiefergebirge unit can be interpreted as a Lower Carboniferous flysch comprising the allochthonous masses of the dismembered Lower Cambrian to Lower Carboniferous succession. This idea is almost identical to that proved by the present authors in this paper. More recently, Göthel (2001) has interpreted the Görlitzer Schiefergebirge complex as composed of Cambrian to Lower Carboniferous succession of the shelf margin of the Lausitz Block and the accretionary wedge complex of the Görlitzer Synclinorium. According to this proposition, the Sproitz-Ludwigsdorf Thrust is interpreted as the suture between the shelf margin and accretionary wedge successions.

The concept of total allochthonism of all the lithologies of the Jędrzychowice rock-unit formulated in this paper implies some new approach to the problems of (1) – origin of the wildflysch-to-flysch succession, and, subsequently, of tectono-stratigraphic structure of both the Görlitzer Schiefergebirge and the Western Kaczawa complexes; (2) – the lithostratigraphic similarity or even identity of both the complexes, well shown by Berezowski & Chorowska (1966}; and (3) – their location within the CEVO. The position of the Jędrzychowice/ Ludwigsdorf succession within the tectono-stratigraphic framework of the Sudetes orogenic growth is not directly observed, because both its base and cover have not yet been recognised. However, some aspects of this position appear to be well explained in the frame of a model of the litho-tectono-stratigraphic structure of the Central Sudetes, proposed by Wajsprych (1995, 1997). According to this model, the Central Sudetes orogenic growth is composed of three main structural stages:

(1) – the Lower stage, composed of strongly deformed and polygenic (LT/LP, HT/LP and LT/HP) metamorphosed, lithologically extremely differentiated orogenic assemblage (the Eo-Variscan orogen of many authors). It started to be exhumed at the Middle/Late Devonian transition (ca. 360–365 Ma), when accepting tectonostratigraphic relationships in the Central Sudetes region (Wajsprych, 1997; and references therein);

(2) – unmetamorphosed and practically undeformed, Upper Devonian – lowermost Carboniferous volcano-sedimentary cover deposited in the basin developed over the exhumed terranes; and

(3) – the stage composed of large-scale gravity-driven allochthones fed by rock complexes of both the (1) and (2) stages.

When accepting this model, one may interpret the Jędrzychowice/ Ludwigsdorf wildflysch deposit as originated due to the gravity-induced sliding, shearing, and subsequent mixing of the Upper Devonian–Lower Carboniferous (Tournaisian) volcano-sedimentary, unmetamorphosed and undeformed successions. Tectono-stratigraphic position of the Lower Palaeozoic rock-suites within the source orogenic assemblage must remain the open question. The large allochthonous bodies of blueschists probably came from this Eo-Variscan orogenic assemblage. Consequently, the siliciclastic flysch deposit overlying the wildflysch accumulations could be explained as fed by the other, subsequently exhumed lithotectonic units (granitoids, gneisses, mica-schists, etc.) of this orogenic assemblage.

The problem of age of volcanic exotics needs further studies, but one of its aspects is already clear: these magmatic rocks must represent at least two different tectonostratigraphic and geodynamic domains, where andesites are typical of supra-subduction zones, whereas basalts, gabbros and ultrabasites probably represent ophiolite suite. Taking into consideration the main features of the tectonostratigraphic evolution of the Central Sudetes orogenic upgrowth (Wajsprych, 1995, 1997) – as it was presented above – the blueschist metabasalts must be generally pre-Late Devonian. The unmetamorphosed to very low grade metamorphosed volcanites are probably of Late Devonian–Tournaisian age.

The next, completely new group of problems has been opened by evaporite rocks, found by the authors as the protolith of quartz-rock of the Biesi Kamień hill, in the northern part of the Jędrzychowice rock-unit. The Biesi Kamień rock itself is an exceptional lithological series from the point of view of the size of silicified objects, and the scale of silicification processes. Moreover, the question of tectonic position of the Biesi Kamień evaporites is of special significance, because it is the first evaporite deposit found within the orogenic rock complexes of the CEVO. Consequently, their age must be a subject of special care, what needs further research works.

The position of evaporite rocks within the succession of the Jędrzychowice rock-unit seems to be clear; it is an allochthonous component of the Jędrzychowice/Ludwigsdorf wildflysch what indicates the pre-Visean age of the evaporite sedimentation. Because the block was incorporated into the wildflysch deposit as the silicified evaporite, this same age-frame concerns the silicification event.

The question of the lower age-limit needs to introduce again some aspects of general tectono-stratigraphic structure of the Sudetes orogenic upgrowth. The hypothesis on Late Devonian–early Carboniferous, syn-exhumation basin system, overlying the extended Eo-Variscan orogenic upgrowth, and followed by large-scale gravity allochthonism (Wajsprych, 1995, 1997) is of conclusive significance for this question. The analysed evaporites, as a constituent of a group of unmetamorphosed exotic rocks should be rather connected with this basin system than with the exhumed orogen. Since the Late Devonian to Tournaisian/Visean transition time-span seems to be the most probable age-frame for the Biesi Kamień evaporites deposition and its subsequent silicification.

Another possiblity, offered by regional geological data set is the Early Cambrian age of the discussed evaporites. Such an age is suggested by the presence of gypsum-containing carbonate sequence, known from the Torgau-Doberlug rock-unit of the north-western part of the Lausitz domain of the Saxothuringicum, biostratigraphically (Archeocyatha) evidenced by Elicki (1994) to be Early Cambrian in age. It seems to be an interesting possibility, since the Lower Cambrian evaporites are well known from almost all the platforms of the western Gondwana margin, like the Ossa-Morena, Cantabrian-Iberian, Armorican, and Montagne Noire-Sardinia basins (Gandin, 1987; Demange, 1994; Alvaro *et al.*, 2000).

The results of our preliminary studies have evidenced that the Lower Cambrian carbonates (Frydrychowicz & Frydrychowicz, 1959; Kozdrój *et al.*, 2001; and references therein) from the Biesi Kamień Hill area are, in fact, secondary, and have originated from carbonatisation of the protolith composed (maybe in the examined part only) of the siliceous mudstone, or even evaporite, if the siliceous mudstone is secondary, too. In this context, however, it is clear that the solution to the problems of age, nature, and primary facies composition of the Biesi Kamień evaporite association need further careful studies.

Another set of data presented in this paper disclose that at least the northern part of the Upper Proterozoic Lausitz Graywacke Formation, interpreted by many contemporaneous authors (see Linnemann and Romer, 2002; and references therein) as being a foreland succession of the Cadomian orogeny widely developed in the whole of the Saxothuringian zone is, in fact, the Lower Carboniferous flysch of the Jędrzychowice/Ludwigsdorf succession. The presence of several metres thick olistosthrome intercalations, found in the"Cadomian" siliciclastics, leads to some basic doubts. The lithic composition of these olistosthrome intercalations is identical to those found within the Jędrzychowice wildflysch. However, the presence of probably Upper Devonian conodonts (unpublished materials), found in a thin section of one of green chert clasts, and the abundance of radiolarian fauna in many black-shale mudstone and chert clasts (probably of Upper Tournaisian age) occurring within these olistosthrome intercalations, are of conclusive significance. Consequently, at least some part of the "Cadomian Graywacke Formation" in the western Sudetes must be of Early Carboniferous (Early/Middle Visean) age.

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REFERENCES

Alvaro, J. J., Rouchy, J. M., Bechstädt, T., Boucot, A., Boyer, F., Debrenne, F., Moreno-Eiris, E., Perejón, A. & Vennin, E., 2000. Evaporitic constraints on the southward drifting of the western Gondwana margin during Early Cambrian times. *Paleogeography, Paleoclimatology, Paleoecology*, 160: 105–122.

Baranowski, Z., Haydukiewicz, A., Kryza, R., Lorenc, S., Muszyński, A., Solecki, A. & Urbanek, Z., 1990. Outline of the geology of the Góry Kaczawskie (Sudetes, Poland). *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 179: 223–257.

Becker, R. T., 1992. Analysis of Ammonoid paleobiogeography in relation to the global Hangenberg (terminal Devonian) and lower Alum Shale (Middle Tournaisian) events. *Annales de Société géologique de Belgique*, 115: 459–473.

Behr, H.-J., Engel, W. & Franke, W., 1982. Variscan wildflysch and nappe tectonics in the Saxothuringian Zone (Northeast Bavaria, West Germany). *American Journal of Science*, 282: 1438–1470.

Berezowski, Z. & Chorowska, M., 1966. Remarks on the Palaeozoic formations occurring in the vicinity of Zgorzelec (West Sudetes). (In Polish, English summary). *Przegląd Geologiczny*, 3: 259–269.

Brause, H., 1969. Das verdeckte Altpaläozoikum der Lausitz und seine regionale Stellung. *Abhandlungen des Deutschen Akademie der Wissenschaften, Montangeologie*, Berlin, 1: 143 p.

Brause, H. & Hirschmann, G., 1964. Die tektonogenetische Entwicklung im Variszikum der Lausitz. *Exkurssionfürher der 11 Jahrestagung der Geologischen Gesellschaft der DDR in Leipzig*, 183–204.

Chorowska, M., 1978. Visean limestones in the metamorphic complex of the Kaczawa Mts. (Sudetes). (In Polish, English summary). *Rocznik Polskiego Towarzystwa Geologicznego*, 48: 245–261.

Chorowska, M., Radlicz, K. & Tomczyk, H., 1981. Ordovician, Silurian and Devonian rocks of Lubań. (In Polish, English summary). *Kwartalnik Geologiczny*, 25: 243–264.

Chorowska, M. & Ozonkowa, H., 1975. Stratigraphic position of limestone from the Lubań region. (In Polish, English summary). *Kwartalnik Geologiczny*, 19: 193–207.

Chorowska, M. & Radlicz, K., 1994. Revision of the age of the Lower Carboniferous deposits in the northern part of the Góry Bardzkie (Sudetes). (In Polish, English summary). *Kwartalnik Geologiczny*, 38: 249–288.

Chorowska, M. & Sawicki, L., 1975.On the occurrence of the metamorphosed Upper Devonian and the Lower Carboniferous in the Kaczawa Mts. (In Polish, English summary). *Kwartalnik Geologiczny*, 19: 261–276.

Collins, A. S., Kryza, R. & Zalasiewicz, J., 2000. Macrofabric fingerprints of Late devonian–Early Carboniferous subduction in the Polish Variscides, the Kaczawa complex, Sudetes. *Journal of the Geological Society, London*, 157: 283–288.

Dahlgrün, F., 1934. Zur Altersdeutung des Vordevons in westsudetischen Schiefergebirge. *Zeitschrift für deutschen geologischen Gesellschaft*, 86: 385–393.

Demange, M., 1994. Antevariscan evolution of the Montagne Noire (France): from a passive margin to a foreland basin. *Compte Rendus de Academie des Sciences, Paris*, Serie II, 318: 921–933.

Elicki, O., 1994. Lower Cambrian carbonates from eastern Germany: Paleontology, stratigraphy and palaeogeography. *Neues Jahrbuch für Geologie und Paläontologie, Abhandlungen*, 191: 69–93.

Franke, W., 1989. Tectonostratigraphic units in the Variscan belt of Central Europe. *Geological Society of America, Spec.Publ.*, 230: 67–90.

Franke, W., Żelaźniewicz, A., Porębski, S.J. & Wajsprych, B. 1993. Saxothuringian zone in Germany and Poland: differences and common features. *Geologische Rundschau*, 82: 583–599.

Franke, W. & Żelaźniewicz, A., 2002. Structure and evolution of the Bohemian Arc. In: Winchester, J.A., Pharaoh, T.C. & Verniers J. (eds), *Palaeozoic Amalgamation of Central Europe*. Geological Society, London, Spec. Publ., 201: 279–293.

Folk, R. L. & Pittman, J. S., 1971. Length-slow chalcedony: A new testament for vanished evaporites. *Journal of Sedimentary Petrology*, 41: 1045–1058.

Freyer, G., 1968. Conodontenfunde aus dem Paläozoikum der Lausitz. *Abhandlungen und Berichten des Naturkundemuseums Görlitz*, 40: 7–54.

Frydrychowicz, E. & Frydrychowicz, M., 1959. *Geological map of the Sudetes, sheet Zgorzelec, 1:25,000*. Instytut Geologiczny, Warszawa.

Furnes, H., Kryza, R., Muszyński, A., Pin, C. & Garmann, L.B., 1994. Geochemical evidence for progressive, rift-related early Paleozoic volcanism in the wetern Sudetes. *Journal of the Geological Society, London*, 151: 91–109.

Gandin, A., 1987. Depositional and paleogeographic evolution of the Cambrian in south-western Sardinia. *Newsletter*, 7: 151–166.

Geological Map, Lausitz-Jizera-Karkonosze (without Cenozoic sediments), 1:100 000. 2001. Sächsisches Landesamt für Umwelt und Geologie, Państwowy Instytut Geologiczny & Český Geologický Ustav, Warsaw.

Göthel, M., 2001. Das autochtone und allochtone Paläozoikum des "Gorlitzer Schiefergebirges" (Mitteleuropeische Varisziden, Deutschland). *Zeitschrift fur geologischen Wissenschaften*, 29: 55–73.

Haydukiewicz, J., 1981. Pelagic Tournaisian deposits in SW part of the Bardo Mts. (Sudetes). *Geologia Sudetica*, 16: 219–225.

Haydukiewicz, A., 1987. Melanże Gór Kaczawskich. (In Polish, English summary). In: *Przewodnik 58 Zjazdu Polskiego Towarzystwa Geologicznego, Wałbrzych 17-19 września 1987*, Pol. Tow. Geol., Wrocław: 106–114.

Herbig, H.-G., 1993. Eustatic forcing of latest Devonian and Dinantian Culm sequences, Rheinisches Schiefergebirge, Germany. In: Streel M. (ed), *Early Carboniferous Stratigraphy Conference*, Ličge/Belgium.

Hirschmann, G., 1988. Connections between Moldanubicum, Bohemicum and Saxothuringicum from a lithostratigraphic viewpoint. In: Kukal, Z. (ed.), *Proceedings of the 1th International Conference on the Bohemian Massif, Prague, Czechoslovakia, Sept. 26-Oct. 3, 1988*, Czech Geological Survey, Prague: 112–120.

Kasprzyk, A., 1993. Lithofacies and sedimentology of the Badenian (Middle Miocene) gypsum in the northern part of the Carpathian Foredeep, southern Poland. *Annales Societatis Geologorum Poloniae*, 63: 33–84.

Kemnitz, H. & Budzinski, G., 1994. Die Grauwacken der Lausitz und ihre cadomische Prägung. *Abhandlungen des Staatlichen Museums für Mineralogie und Geologie Dresden*, 40: 37–98.

Kossmat, F., 1927. Gliederung des variszischen Gebirgsbaues. *Abhandlungen des Sachsen Geologie*, 1: 1–39.

Kozdrój, W., 2001. Kaczawa Region. In: Kozdrój, W., Krentz, O. & Opletal, M. (eds), *Comments on the Geological Map Lausitz-Jizera-Karkonosze (without Cenozoic sediments), 1:100 000*, Sächsisches Landesamt für Umwelt und Geologie, Państwowy Instytut Geologiczny & Český Geologický Ustav, Warsaw: 16–22.

Kozdrój, W., Krentz, O. & Opletal, M., (eds)., 2001. *Geological Map Lausitz-Jizera-Karkonosze (without Cenozoic sediments), 1:100 000, and Comments*. Sächsisches Landesamt für Umwelt und Geologie, Państwowy Instytut Geologiczny & Český Geologický Ustav, Warsaw, 64 pp.

Krawczyńska – Grocholska, H., 1964. Le Namurien du Bassin de Nowa Ruda á la lumière des études palynologique. *Geologia Sudetica*, 2: 323–382.

Krentz, O. 2001. Lusatia. In: Kozdrój, W. *et al.*, (eds), Comments on the Geological Map Lausitz-Jizera-Karkonosze (without Cenozoic sediments), 1:100 000, *Sächsisches Landesamt für Umwelt und Geologie, Państwowy Instytut Geologiczny & Český Geologický Ustav*, Warsaw: 7–12.

Kryza, R., 1993. Basic metavolcanic rocks of the central Kaczawa Mts. (Sudetes): A petrological study. (In Polish, English summary). *Prace geologiczno-mineralogiczne Uniwersytetu Wrocławskiego*, 39: 1–138.

Kryza, R., Muszyński, A. & Vielzeuf, D., 1990. Glaucophane-bearing asssemblage overprinted by greenschist-facies metamorphism in the Variscan Kaczawa complex, Sudetes, Poland. *Journal of Metamorphic Geology*, 8: 345–355.

Kurze, M., 1983. Erscheinungsformen und Probleme olistosthromatischer Sedimentation im Saxothuringikum und angrenzenden Bereichen. *Zeitschrift für geologischen Wissenschaften*, 11: 5–15.

Linnemann, U. & Schauer, M., 1999. Die Entstehung der Elbezone vor dem Hintergrund der cadomischen und variszischen Geschichte des Saxothuringischen Terranes – Konsequenzen aus einer abgedecten geologischen Karte. *Zeitschrift für geologischen Wissenschaften*, 27: 529–561.

Linnemann, U. & Romer, R.L., 2002. The Cadomian Orogeny in Saxo-Thuringia, Germany: geochemical and Nd-Sr-Pb isotopic characteristics of marginal basins with constraints to geotectonic setting and provenance. *Tectonophysics*, 352: 33–64.

Milewicz, J., 1972. Upper Carboniferous of the North Sudetic Depression. (In Polish, English summary). *Biuletyn Instytutu Geologicznego*, 170: 245–252.

Milliken, K. L., 1979. The silicified evaporite syndrome – two aspects of silicification history of former evaporite nodules from southern Kentucky and northern Tennessee. *Journal of Sedimentary Petrology*, 42: 245–256.

Narębski, W., 1994. Lower to Upper Palaeozoic tectono-magmatic evolution of NE part of the Bohemian Massif . *Zentralblatt für Geologie und Paläontologie*, 9/10: 961–972.

Paszkowski, M. & Szydlak, T., 1987. Evidence of hypersaline sedimentary environment in Dinantian carbonate deposits in area of Krzeszowice near Kraków. *Annales Societas Geologorum Poloniae*, 56: 385–397.

Paszkowski, M., Narębski, W. & Wajsprych, B., 1991. Palaeozoic evolution of terrane-basin system of Lugo-Sudeticum. In: *IGCP 233 International Conference: Palaeozoic Orogens in Central Europe*, Göttingen/Giessen, 4 p.

Peryt, T.M. & Jasionowski, M., 1994. In situ formed and redeposited gypsum breccias in the Middle Miocene Badenian of southern Poland. *Sedimentary Geology*, 94: 153–163.

Reichstein, M., 1961. Oberdevon-Kalkstein aus Geiersberg bei Kunnersdorf, nordwestlich von Görlitz. *Geologie*, 10: 246–247.

Roselt, G., 1959. Karbonische Pflanzenreste in einen Tuffit aus der Lausitz. *Geologie*, 8: 778–788.

Rouchy, J.N., Groesens, E. & Conil, R., 1986. Signification des pseudomorphoses d'evaporites associées aux breches viséennes dans les sondages d'Yves Gomezée (synclinorium de Dinant, Belgique). *Bulletin de la Société belge de Géologie*, 95: 167–175.

Schwarzbach, M., 1934. Das Kambrium der Oberlausitz. *Abhandlungen des Naturforschungs Gesellchaft Görlitz*, 32: 7–54.

Schwarzbach, M., 1936. Oberlausitzer Schiefergebirge und Bober-Katzbachgebirge – ein stratigraphish-tektonischer Vergleich. *Abhandlungen der Naturforschungs Gesellschaft Görlitz*, 32: 31–63.

Siedlecka, A., 1972. Length-slow chalcedony and relicts of sulphates – evidences of evaporitic environments in the Upper Carboniferous and Permian beds of Bear Island, Svalbard. *Journal of Sedimentary Petrology*, 42: 812–816.

Skowronek, A. & Steffahn, J., 2000. The age of the Kauffung Limestone (West Sudetes, Poland) – a revision due to a new discovery of microfossils. *Neues Jahrbuch für Geologie und Paläontologie, Monatshefte*, 2: 65–82.

Śliwa Z., 1967. Żyła kwarcu z Jędrzychowic koło Zgorzelca. (In Polish, English summary). *Przegląd Geologiczny*, 6: 289–291.

Thomas, U., 1990. Unterkarbonische Wildflysch Ablagerungen in Südteil der DDR. *Zeitschrift für angewandte Geologie*, 5: 182–184.

Ulmer-Scholle, D.S., Scholle, P.A. & Brady, P.V., 1993. Silicification of evaporites in Permian (Guadalupian) back-reef carbonates of the Delaware Basin, West Texas and New Mexico. *Journal of Sedimenatry Petrology*, 63: 955–965.

Vai, G.B. & Ricci-Lucchi, F., 1977. Algal crusts, autochthonous and clastic gypsum in a cannibalistic evaporite basin: a case history from the Messinian of Northern Apennines. *Sedimentology*, 24: 211–244.

Vejnar, Z., 1953. Stratigraphic-petrographic relations of the copper-bearing series at Horni Kalna. *Vestnik Ustředneho Ustavu Geologickeho*, 28: 10–17.

Wajsprych, B., 1978. Allochthonous Palaeozoic rocks in the Visean of the Bardzkie Mts. (Sudetes). *Annales Societatis Geologorum Poloniae*, 48: 99–121.

Wajsprych, B., 1986. Sedimentary record of tectonic activity on Devonian–Carboniferous continental margin, Sudetes. In: Teisseyre, A. K. (ed), *IAS 7th European Regional Meeting, Excursion Guidebook, Kraków-Poland*, Kraków: 141–164.

Wajsprych, B., 1995. The Bardo Mts. rock complex: the Famennian–Lower Carboniferous preflysch (platform)-to-flysch (foreland) basin succession, the Sudetes. In: Kumpera, O., Paszkowski, M., Wajsprych, B., Foldyna, J., Malec, J. & Żakowa, H. (eds), *Transition of the Early Carboniferous pelagic sedimentation into synorogenic flysch. An example from the Silesian-Moravian zone and adjacent areas*. XIII International Geological Congress on Carboniferous–Permian, 28.08.-2.09.1995, Kraków-Poland, Guide to Excurssion, B2: 23–42.

Wajsprych, B., 1997. Litho-tectono-stratigraphic structure of the Sudetes orogenic upgrowth in the light of fossil sedimentary records. (In Polish, English summary). In: Wojewoda, J. (ed), *Obszary źródłowe: zapis w osadach*, I, WIND – J. Wojewoda, Wroclaw: 65–80.

Streszczenie

DOLNOWIZEŃSKA SUKCESJA WILDFLISZOWO-FLISZOWA ZAWIERAJĄCA ŁUPKI NIEBIESKIE (SUDETY ZACHODNIE, SW POLSKA)

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Terenowe i laboratoryjne prace wykonane w kilku ostatnich latach pozwoliły zredefiniować jedną z litotektonicznych jednostek Sudetów zachodnich, dotychczas uważaną za stratygraficznie koherentną, kambryjsko-dolnokarbońską, wulkaniczno-osadową sukcesję, jako prawdopodobnie dolnowizeńską sukcesję wildfliszowo-fliszową. Jednostka ta, opisana tu jako jednostka skalna Jędrzychowic, stanowi najbardziej zachodnią część kompleksu kaczawskiego. Jest ona usytuowana w strefie granicznej pomiędzy Górami Kaczawskimi (Sudety) i Zgorzeleckimi Górami Łupkowymi na Łużycach (Görlitzer Schiefergebirge/Lausitz), czy też pomiędzy Sudeticum i Lugicum, jako wielkoskalowymi jednostkami tektono-stratygraficznymi orogenu waryscyjskiego Europy Centralnej. Liczne korelacje litologicze i litostratygraficzne pomiędzy zespołami skalnymi jednostki skalnej Jędrzychowic i Zgorzeleckich Gór Łupkowych, wykazanymi przez Berezowskiego i Chorowską (1966), wskazują na przynależność jednostki skalnej Jędrzychowic do Zgorzeleckich Gór Łupkowych.

Opracowaną sukcesję skalną charakteryzuje szczególny skład lityczny materiału detrytycznego. Wśród egzotyków udokumentowano obecność niezmetamorfizowanych skał osadowych (piaskowce, wapienie, mułowce, mułowce z radiolariami oraz radiolaryty), wulkanogenicznych (wulkanoklastyki, lawy poduszkowe), zsylifikowanych ewaporatów oraz zasadowych wulkanitów, zmetamorfizowanych w warunkach facji łupków niebieskich. Egzotyki gabrowe oraz chromowe spinele, lokalnie obficie występujące w matriks olistostromy, dokumentują obecność serii ofiolitowej w obszarze źródłowym. Natomiast detrytus kwarcowy, kwarcowo-skaleniowy i łyszczykowy dowodzi obecności granitoidów, gnejsów i łupków metamorficznych w obszarze alimentacyjnym.

Szczególnie znamienny jest egzotyk (blok o średnicy około 350 m) skały złożonej wyłącznie z kwarcu. W dotychczasowej literaturze regionu skała ta była uznana za kwarc żyłowy (Śliwa, 1967). W niniejszym opracowaniu została ona udokumentowana jako całkowicie zsylifikowane ewaporaty. Rozpoznano tutaj, że wyjściowo ewaporaty ze wzgórza Biesi Kamień koło Jędrzychowic reprezentowały zróżnicowany skład facjalny, zdominowany przez grubokrystaliczny gips (selenit), anhydryt i sól. Sylifikacja w obszarze źródłowym, poprzedzająca powstanie sukcesji wildfliszowo-fliszowej Jędrzychowic/Ludwigsdorfu, była zjawiskiem umożliwiającym: (a) zachowanie skał solnych podczas erozji oraz (b) włączenie ich w obręb melanżu tektonicznego zasilającego depozycję wildfliszu. Zsylifikowane ewaporaty z Jędrzychowic nie mają dotychczas odpowiedników w warycyjskim (przedgórnowizeńskim) kompleksie orogenicznym Europy. Jednakże problem tektonicznej pozycji tych zsylifikowanych ewaporatów w sukcesji jednostki Jędrzychowic wymaga dalszego potwierdzenia.