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The trace fossil *Gyrophyllites* in deep-sea siliciclastic deposits of the Istebna Formation (Upper Cretaceous–Palaeocene) of the Carpathians: An example of biologically controlled distribution

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ABSTRACT

Gyrophyllites kwassizensis Glocker occurs abundantly in deep-sea, density current siliciclastics of the Istebna Formation (Silesian Nappe, Outer Western Carpathians; Poland, Slovakia and Czech Republic), close to the Cretaceous–Palaeogene boundary. It is composed of petal-shaped lobes radiating from a thin shaft, forming rosettes on a few levels in the sediment. The trace fossil is interpreted as a feeding structure produced by a soft-body “worm”, which actively filled the lobes with mud transported from the underlying layer, probably in response to migration of redox boundary in a generally poorly oxygenated environment. Probably due to microbial decomposition of cellulose and other organic particles, the mud from below was more nutritional than the more fresh mud from the sea floor. The number of lobes in a rosette (from 7 to 15) is referred to ontogenetic development of the tracemaker and indirectly to time of burrow occupation. The number varies between localities and may indicate a more hospitable habitat in the areas where the number is higher. *G. kwassizensis* occurs only in a narrow stratigraphic interval after a significant drop of sedimentation rate caused by non-eustatic reasons, in facies conditions, which are not unique during the long history (Late Jurassic–Miocene) of the external Carpathian subbasins. This suggests that facies control was less important for distribution of this trace fossil than some undetermined biological factors, which enabled successful, but incidental invasion of the tracemaker to deep-sea floor of one of the subbasins – the Silesian Basin.

1. Introduction

Distribution of trace fossils in deep-sea siliciclastic deposits of “flysch” formations is mostly facies controlled (e.g., Crimes et al., 1981; Uchman, 1995, 2001; Uchman et al., 2004; Heard and Pickering, 2008; Cummings and Hodgson, 2011; Uchman and Wetzel, 2012; Riahi et al., 2014), however evolutionary trends and events play some role (Uchman, 2004). Beside of distribution of trace fossils predictable on the basis of facies, some ichnotaxa appear incidentally but abundantly in a confined stratigraphic interval, and to some extend independently of facies. This suggests that their occurrence is ruled mostly by some biologic factors, which are commonly neglected in considerations on distribution of trace fossils.

A good example of such trace fossils is *Gyrophyllites kwassizensis* Glocker, 1841, which appears only in a narrow interval within several hundred metres thick deep-sea siliciclastic succession of the Istebna Formation in the Silesian Nappe of the Polish, Slovak and the Czech Flysch Carpathians (Fig. 1), probably close to the Cretaceous–Palaeogene boundary (Fig. 2). Its stratigraphically confined but abundant appearance in the study area is a challenge for interpretation. *G. kwassizensis* is also interesting itself, mostly because of its radial, petal and multi-storey morphology, which is difficult for interpretation. *G. kwassizensis* described originally in the Carpathians (Magura Nappe, Czech Republic) by Glocker (1841) as a plant, interpreted later as different body fossils (Zahálka, 1957; Ślączka, 1971; Plička, 1984) or as a trace fossil by Książkiewicz (1977a), requires new considerations on its origin, variability and environmental interpretations. In this paper, its new ethological interpretation and occurrence in three localities of the Istebna Formation in the Western Beskidy mountain ranges (Fig. 1C) is presented and discussed.

2. Geological setting

The Istebna Formation (*sensu* Menčík, 1983; Wójcik et al., 1996; Picha et al., 2006), also known as the Istebna Beds in the Polish part of the Outer Western Carpathians (Burtanówna, 1936; Burtanówna et al., 1937; Unrug, 1963), is a lithostratigraphic unit which crops out on

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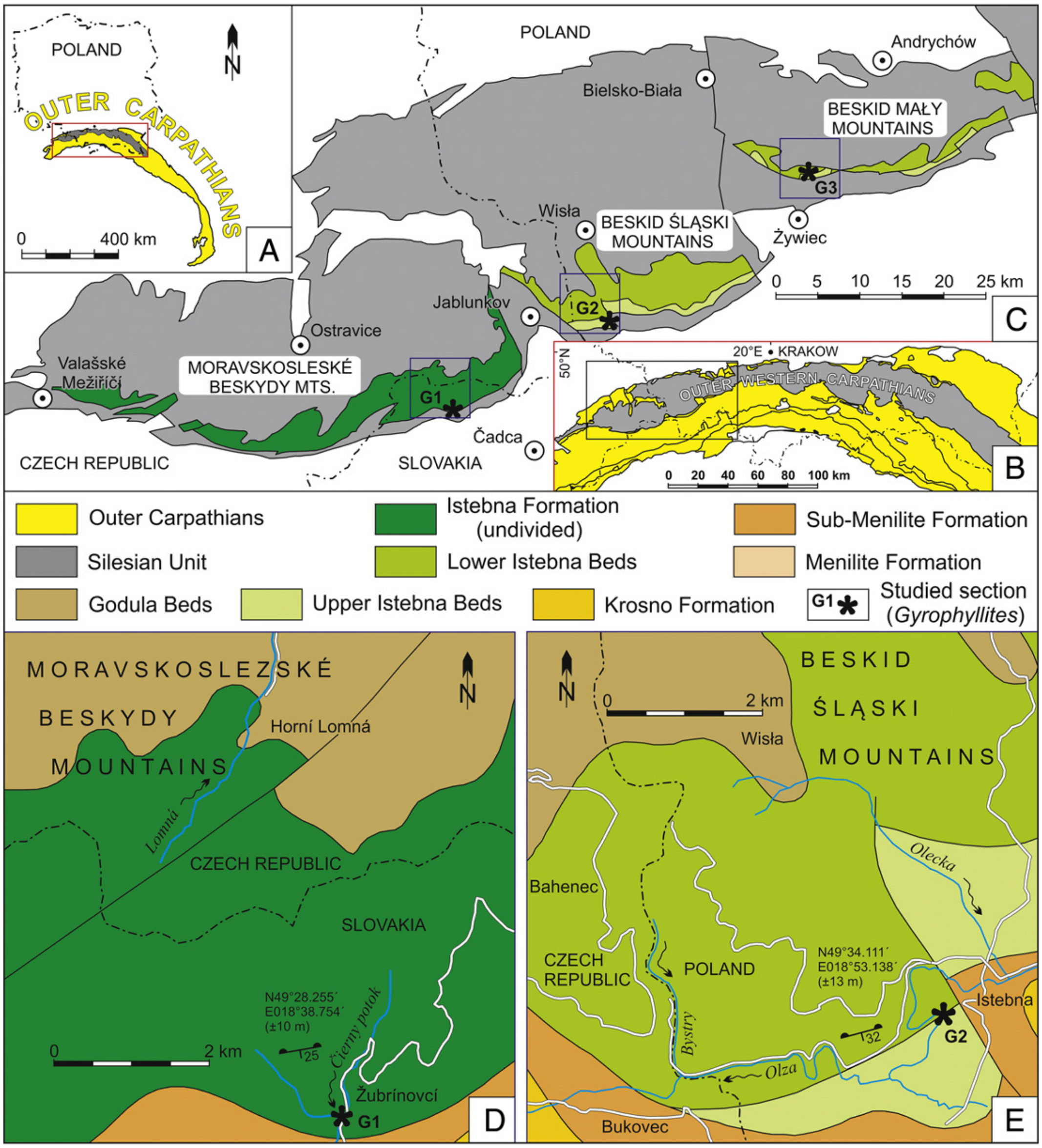

Fig. 1. Location maps. A – the Silesian Nappe (grey) in the Western Flysch Carpathians (in red rectangle), B – indication of the study area in the territory of the Silesian Nappe, C –localities of *Gyrophyllites kwassizensis* in the Western Beskidy mountain ranges (blue squares: Čierny Potok G1 section – Moravskoslezské Beskydy Mts, Istebna G2 section – Beskid Śląski Mts and Oczków G3 section – Beskid Mały Mts), D–E – detailed geological sketch maps of the *G. kwassizensis* localities in the Moravskoslezské Beskydy Mountains (Fig. 1D, Čierny Potok G1 section) and Beskid Śląski Mountains (Fig.1E, Istebna G2 section); simplified and partly changed after Burtan et al. (1956), Burtan (1972, 1973), Lexa et al. (2000), Strzeboński (2005, 2015), Cieszkowski et al. (2012).

large areas of the Silesian Nappe (Unrug, 1963; Menčík and Tyráček, 1985; Żytko, et al., 1989; Fig. 1C).

The Istebna Beds are subdivided into the Lower Istebna Beds and the Upper Istebna Beds, with further subdivision of the latter unit into the Lower Istebna Shale, the Upper Istebna Sandstone and the Upper Istebna Shale (Fig. 2; cf., Burtanówna, 1936; Burtanówna et al., 1937; Burtan, 1973). These subdivisions are clear foremost in the stratotype area of the Istebna Beds in the Beskid Śląski Mountains. In the Beskid Mały Mountains, the Lower Istebna Shale and the Upper Istebna Sandstone pinch out locally, so the remaining subdivisions are merged and indistinguishable (Książkiewicz, 1951; Fig. 2). In the Moravskoslezské Beskydy Mountains, a few to several principal lithological horizons are distinguished within the Istebna Formation, which are hardly to correlate with the mentioned subdivisions from other areas (Fig. 2). Therefore, the Istebna Formation is preferred in this paper as a proper name of lithostratigraphic unit for the discussed deposits in all regions.

The Istebna Formation in the Western Beskidy mountain ranges (Fig. 1C) is composed of 1) sandstone-conglomerate facies association containing sandstones, gravelly sandstones, sandy conglomerates and conglomerates, 2) sandstone-mudstone facies association containing sandstones and mudstones, 3) mudstones and 4) gravelly mudstones (e.g., Unrug, 1963; Menčík, 1983; Strzeboński, 2005, in press; Fig. 2).

Siliciclastic material of these deposits was accumulated in the deep-sea Silesian Basin within a slope-apron depositional system, mainly via sediment gravity-driven processes. Initially, the siliciclastic material was chaotically redeposited from edge of a shelf-margin by mass wasting processes (slides, slumps) and mass flows (avalanches, different types of debris flows), which formed covers of a proximal slope apron. During further downslope redeposition, these slides, slumps or debris flows were partly transformed into fluid-sediment-gravity flows, including turbidity currents (e.g., Unrug, 1963; Felix et al., 2009; Strzeboński, in press). Later structural changes of these sediments and final accumulation could took place under the influence of in situ liquidization, bottom current reworking and tractional deposition. Hemipelagic sedimentation also occurred in the background.