Review of Palaeobotany and Palynology 211 (2014) 66–77

Contents lists available at ScienceDirect

Review of Palaeobotany and Palynology

journal homepage: www.elsevier.com/locate/revpalbo

Research paper

The palynology of late Miocene sinkhole deposits from Upper Silesia, Poland

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ARTICLE INFO

Article history:
Received 14 May 2013
Received in revised form 5 September 2014
Accepted 7 September 2014
Available online 12 October 2014

Keywords:
Late Miocene
Palynology
Freshwater algae
Sinkhole
Paleoenvironment
Poland

ABSTRACT

This paper presents the results of a palynological investigation of an assemblage of pollen, spores and organic-walled microalgal remains from the paleosinkhole infill exposed at Górażdże, Upper Silesia, SW Poland. The results of previous palynological studies indicate that the infill was deposited in the late Miocene, probably during the more humid Tortonian stage.

The sinkhole at Górażdże was filled with shallow water that periodically might have dried out or, at least, undergone seasonal warming. Green algae (Chlorophyta) such as Zygnemataceae, *Botryococcus* and *Pediastrum*, as well as *Sigmopollis* were major components of the algal community. The presence of planktonic algae *Pediastrum* and *Tetraedron* as well as pollen grains of aquatic plants, such as *Nuphar* and *Nymphaea*, indicate that there were extended periods of standing water. The pond was surrounded by vegetation composed of herbs and riparian forests dominated by *Alnus*, *Salix*, *Ulmus*, *Pterocarya*, *Carya*, and others. More dry terrains were presumably covered by mixed forests composed of *Pinus*, *Tsuga*, *Picea*, *Quercus*, *Carpinus*, *Fagus*, *Betula*, and others, with only a small admixture of thermophilous plants, such as *Castanea*. Ericaceae were presumably a component of the groundcover of the forests, or they formed their own open dwarf-shrub communities, such as bush swamps or heathlands. A high frequency of Poaceae pollen grains might reflect the development of open landscapes. The climate during the deposition of sediments in the sinkhole was warm temperate and mild, without severe winters. A comparison of the sporomorph association from the studied sinkhole with another Neogene paleosinkhole palynoflora from the neighboring Tarnów Opolski site revealed asynchronous karst development in the western part of the Upper Silesian Upland, with the infill sediments being at least middle and late Miocene in age.

1. Introduction

During the geological investigation of the Neogene paleosinkhole deposits at Górażdże, Upper Silesia, Poland (Figs. 1, 2), rich and well-preserved pollen and spore assemblages, as well as abundant organic-walled microalgae were encountered. A preliminary study was carried out on these microfossils to determine the age of the sinkhole infill. The composition of the pollen spectra and frequencies of paleotropical and arctotertiary elements, when compared with data from other pollen sites in Poland (*e.g.*, Ziembińska-Tworzydło, 1998), would appear to indicate that the deposit dates from the late Miocene (Szulc and Worobiec, 2012). This paper presents the results of an investigation of both the aquatic, wetland and mesophytic vegetation, and the microalgal assemblage preserved in the pond sediments deposited in the paleosinkhole at Górażdże, thus providing new data relating to the paleoenvironment of this locality. The Górażdże paleosinkhole is actually the second one studied from the western part of the Upper Silesian Upland, SW Poland. The first examined paleosinkhole infill comes from Tarnów Opolski (Worobiec and Szulc, 2010a,b; Worobiec, 2011; Fig. 1), which is situated some 7 km SW from the Górażdże locality. The results of the current study enabled comparison of palynofloras and algal assemblages from two Neogene paleosinkholes developed in this region within the Middle Triassic limestone.

Additionally, in Poland, lower and middle Miocene strata, generally deposited during warm and wet climatic phases (Ważyńska, 1998; Ziembińska-Tworzydło, 1998), possess well-documented paleobotanical evidence collected from studies of numerous sections (*e.g.*, Grabowska and Słodkowska, 1993; Kohlman-Adamska, 1998), mainly taken from lignite deposits. In contrast, upper Miocene strata, which originated during cooler and less humid climatic conditions, possess much poorer paleobotanical evidence from studies undertaken on relatively uncommon sections of that age (*e.g.*, Doktorowicz-Hrebnicka, 1957; Stachurska et al., 1971, 1973; Oszast and Stuchlik, 1977; Stuchlik et al., 1990; Sadowska, 1991; Słodkowska, 2009; Worobiec et al., 2009; Worobiec and Gedl, 2010). The Górażdże site is located at the southern border of the late Miocene epicontinental basin (Fig. 3). This makes the palynoflora important for paleoenvironmental reconstructions.

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http://dx.doi.org/10.1016/j.revpalbo.2014.09.001
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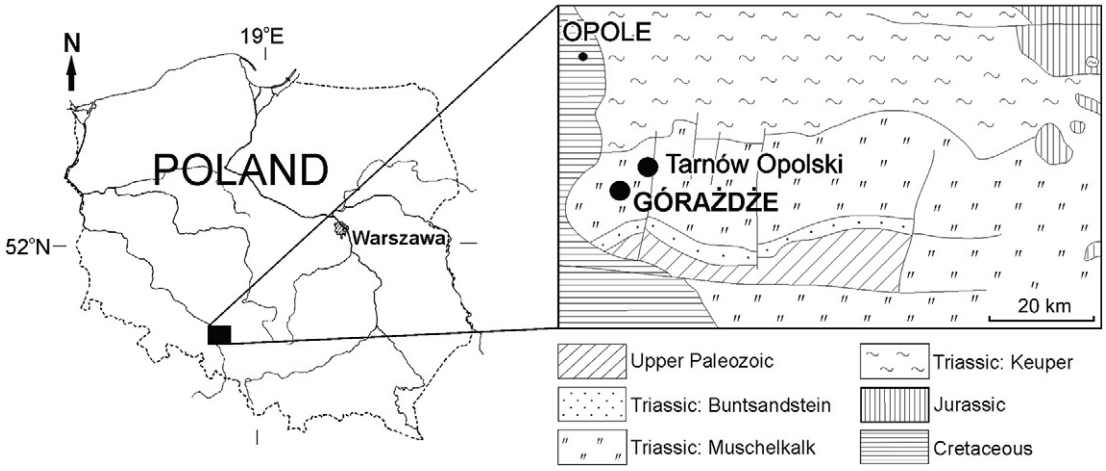

Fig. 1. Map of Poland with the location of the study site and inset geological map of Górażdże vicinity according to Worobiec and Szulc (2010a,b) and Worobiec (2011), modified.

2. Geological setting

The studied material originates from one of the paleosinkholes that developed in Middle Triassic deposits at Górażdże, in the western part of the Upper Silesian Upland, SW Poland (Fig. 1). The studied sinkhole developed in thick-bedded and coarse-grained bioclastic, oncoidal and ooidal limestone, interbedded with fine-grained nodular limestone, building the 15-m-thick succession of the Górażdże Beds. These pure limestones are underlain by the poorly permeable, marly sediments of the Upper Gogolin Beds, limiting the downward progress of the karstic processes. The examined sinkhole has an hourglass shape, extending 17 m across and more than 12 m deep. Its ultimate depth is unknown due to scree covering the basal part of the outcrop.

The previous geological study enabled the three main stages of the Górażdże sinkhole's evolution to be distinguished (Szulc and Worobiec, 2012). During the initial stage, the subterranean and surface karstification proceeded concurrently. As a result, *terra rossa*-type variegated clays developed at the surface, and a cavern system originated in the underlying bedrocks. During the second phase, both systems became connected and the surface karst deposits sank down into the underlying cavern. This, in turn, involved the formation of a depression in the land surface. With time, meteoric water began to accumulate in the sinkhole, giving rise to a small pond. The pond was filled with a plant material giving way to lignite formation. During the third stage = final stage, the sinkhole was filled with molding sands derived from eroded Upper Cretaceous sandstones and marls (Szulc and Worobiec, 2012).

3. Material and methods

Fifteen samples collected in one of the paleosinkholes exposed in the Górażdże quarry were subjected to preliminary palynological investigation. The samples for pollen analysis were prepared according to the modified Erdtman's acetolysis method (Moore et al., 1991), using hydrofluoric acid to remove mineral matter, and the material was sieved at 5 μm through a nylon mesh. The microscope slides were made using glycerine jelly as a mounting medium. Six samples taken from dark, coal-like sediment yielded a rich and very well preserved palynological material suitable for further study (Fig. 2). Preliminary

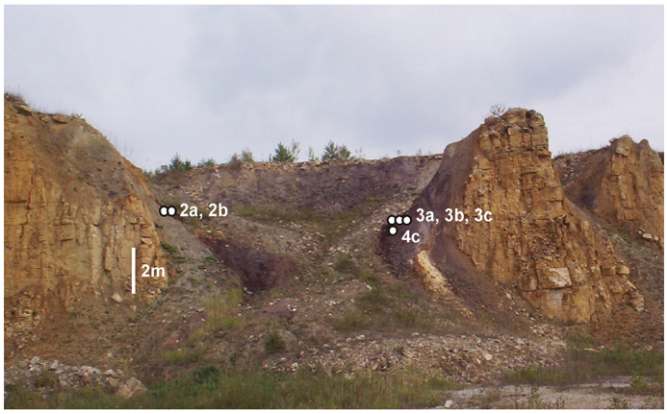

Fig. 2. Field photograph of the studied paleosinkhole in the Górażdże quarry (phot. J. Szulc). Dots indicate the studied sample positions (only samples with well-preserved palynological content are shown).

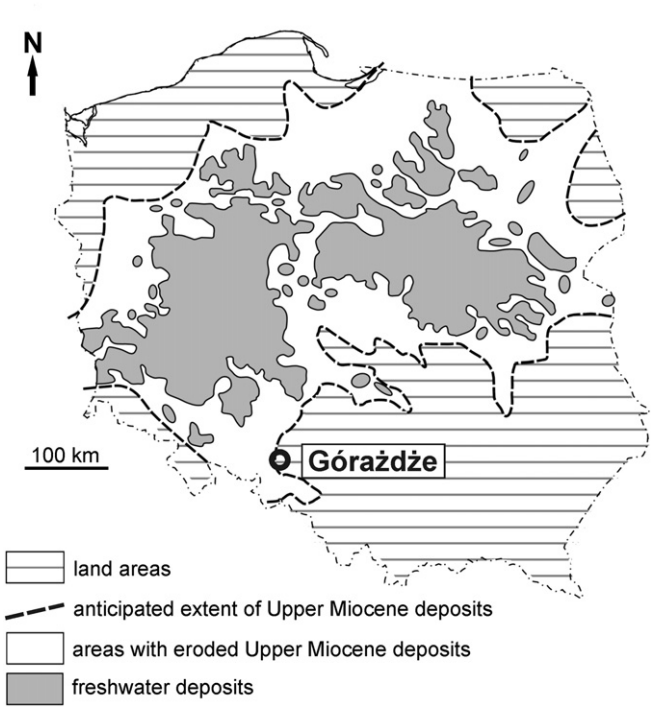

Fig. 3. Location of Górażdże on a geological map showing the late Miocene paleogeography (according to Worobiec et al., 2009).
Geological map from Piwocki, 1998; changed.