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Research Paper

Megaglomerospora lealiae nov. gen., nov. sp. from the upper Carboniferous of Portugal: the largest glomeromycotan fungal spores ☆

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ABSTRACT

A new genus and species of fossil fungus, *Megaglomerospora lealiae*, is described from the Buçaco Carboniferous Basin (upper Stephanian C, Upper Pennsylvanian, upper Carboniferous), in central western Portugal. The new fossil fungus consists of a dense cluster of silicified large spores. These new fungal spores are oblong, subelliptical to subspherical-shaped, with a glabrous surface characterized by having a lipid-filled lumen, and display a strong septate-like hypha attached. The presence of lobe-shaped germination shields suggests close affinities to Diversisporales (Glomeromycota). *Megaglomerospora lealiae* nov. gen., nov. sp. is remarkably distinctive because it is by far the largest fossil fungal spore (~1.6 mm long) documented for the phylum Glomeromycota. This is the first report of an endomycorrhizal-like fungus from the Carboniferous of Iberia.

1. Introduction

Fungi are a group of organisms that occur in virtually every single ecosystem today, where they colonize a wide variety of (micro-)habitats and are responsible for numerous functions ranging from decomposing organic matter to immobilizing nutrients (Cantrell et al., 2011; Taylor et al., 2015). However, despite the remarkable diversity of the different types of fungi, the levels of interaction with other organisms, and their role as drivers of many processes in modern ecosystems, it is surprising that fungi and fungal activities (e.g., parasitism, mycorrhizal symbiosis) have not been consistently studied in the fossil record. Therefore, fossil materials of these organisms have not been adequately collected (Taylor et al., 2015). On the other hand, the study of fossil fungi is very restricted because its fossil record is rarely preserved. These facts have resulted in an underrepresentation of the different types of fossil fungi and an underappreciation of both their biodiversity and their distribution in time and space (Taylor et al., 2015).

Systematic analyses of fossil fungi are a rather new research approach, although fossil plants and animals have been studied for more than 250 years. However, many palaeobotanists and palaeozoologists, particularly during 19th and early 20th centuries, sometimes referred to or imagined (what they believed to be) fungi or evidence of fungal activity coexisting with plant and animal fossils or sediment samples that were to study. Even the most famous naturalist Charles Darwin also noted the presence of fungi associated with some plant fossils (Smith, 1884). In fact, the first report of fungal fossils was published in 1898 (Meschinelli, 1898). Meschinelli's book is a fascinating and richly illustrated work that illustrates the interest of the scientific community at the time in fossil fungi (Taylor et al., 2015). More recently, a new emphasis on the palaeodiversity and evolutionary history of fossil fungi has emerged. The earliest terrestrial fungi were documented from the Ordovician of Wisconsin (with an age of ca. 460 Ma), in USA, which strongly resemble modern arbuscular mycorrhizal fungi (Redecker et al., 2000, 2002). Nevertheless, much of our current knowledge about fossil fungi comes from the extraordinary fossil record of the Lower Devonian Rhynie Chert, a lagerstätte in the Rhynie village (Aberdeenshire), in Scotland. This palaeomycological record comprises a large variety of endomycorrhizal/mycorrhizal, saprotrophic and parasitic forms (Taylor et al., 1995, 2015; Karatygin et al., 2006; Dotzler et al., 2006, 2009; Krings et al., 2007a, 2007b, 2009, 2010, 2015, 2017; Krings and Harper, 2018, 2020; Krings, 2022; Brundrett et al., 2018; Walker et al., 2018, 2021; see also Lalica and Tomescu, 2022: table 1). Associated with this advanced knowledge, significant discoveries have also been reported from the Permian and Triassic of Antarctica (Phipps and

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