Note on the only known record of a cupulate seed from the Middle Pennsylvanian Sydney Coalfield, Nova Scotia, Canada

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ABSTRACT

The only known lyginopterid cupulate seed collected from the Middle Pennsylvanian Sydney Coalfield in Nova Scotia, Canada, comprises a coalified cupule surrounding an ovate structure 3×2 mm in size that is interpreted as an ovule. The ovule is white, reflecting its calcitic mode of preservation, and lacks cellular remains. As the specimen is incomplete, a detailed taxonomic determination is not possible, but its affinities lie within the lyginopterid (or hydrasperman) pteridosperms. This significant discovery of a lyginopterid pteridosperm augments previous accounts of medullosalean pteridosperms from the flora of Sydney Coalfield.

RÉSUMÉ

La seule graine cupuliforme de lyginopteridée connue recueillie du terrain houiller du Pennsylvanien moyen de Sydney, en Nouvelle-Écosse, au Canada, est constituée d'une cupule carbonifiée entourant une structure ovée d'une taille de 3 mm sur 2 qui est interprétée comme un ovule. L'ovule est blanc, couleur témoignant de son mode de conservation calcitique, et il est dépourvu de fragments cellulaires. Comme le spécimen est incomplet, une détermination taxonomique détaillée n'est pas possible, mais ses affinités se manifestent dans les ptéridospermes des lyginopteridées (ou hydraspermans). Cette découverte importante d'un ptéridosperme de lyginopteridée enrichit les signalements antérieurs de ptéridospermes médullosés de la flore du terrain houiller de Sydney.

[*Traduit par la redaction*]

INTRODUCTION

A long-recognized problem in paleobotanical studies is the fragmentary nature of plant fossils (compression/impression), which can pose near-insurmountable taxonomic problems (Sakala 2004; Bateman and Hilton 2009). In the Euramerican Carboniferous, detached ovular seed-fern structures are no exception (Arnold 1938, p. 209). In addition, compression/impression/permineralized ovules connected to other plant parts are extremely rare, making taxonomic assignment of isolated ovules a challenge (e.g., Seyfullah *et al.* 2010). In the Sydney Coalfield in Nova Scotia, fossil-plant collecting by many palaeobotanists and geologists over the past 200 years has yielded one intact 12-mm-long trigonocarpalean compression/impression ovule that is attached to an ultimate neuropterid pinna (Zodrow and McCandlish 1980; Luthardt *et al.* 2021, p. 5). In contrast, 30 or more detached single trigonocarpalean compression/impression seeds up to 120 mm long and superbly preserved have been discovered (Zodrow *et al.* 2014; Zodrow *et al.* 2013; D'Angelo and Zodrow 2011; Cleal *et al.* 2010; Zodrow 2002, 2004). These fossils were collected from a rock pile that derives from the ca. 2-m-thick roof shale of the Lloyd Cove Seam, which was mined in an open pit near Point Aconi (Zodrow and Mastalerz 2019, fig. 1; Zodrow 2002). It is noteworthy that equally well-preserved, compressed male fructifications of *Dolerotheca* Halle 1933, containing the largest-known oval prepollen grains at over 800 μm, were also collected from the same location (Zodrow and Mastalerz 2019). Together, these fossils potentially provide insights into the male and female organs of the same whole plant species.

The specimen documented here is a cupule containing an ovular structure that is the only one known from the Sydney Coalfield, and indeed from the Carboniferous of the Maritimes. However, questionably identified cupules without preserved seeds, for example Pterispermostrobus bifurcatus Stopes 1914 from the Upper Carboniferous "Fern Ledges", Saint John, New Brunswick (Stopes 1914, fig. 15; pls. XVII, 45 and XXV, 69). resemble the presently described specimen.

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MATERIAL, AGE, AND METHOD

The tiny detached coalified structure described here is approximately 10 mm wide and 8 mm high, and consists of a single 3×2 mm ovule (Fig. 1). It was collected by the author from the rock pile of silty roof rocks of the Harbour Seam, at the old Lingan Mine dump, near Glace Bay, Cape Breton Island, Nova Scotia (46.19°N, 59.95°W). Accordingly, the chronostratigraphic age is middle Westphalian D *sensu* Zodrow and Cleal (1985), equivalent to the upper Moscovian Stage of the Carboniferous System (Lucas 2018, p. 3; Nelson and Lucas 2021).

The mode of preservation was investigated by longitudinal, precision serial grinding to the level of the exposed seed. Through this process, eight ground surfaces, approximately 100 µm apart, were produced. Each surface was studied microscopically. The remaining in situ seed is curated in the Palaeobotanical Collection at Cape Breton University, accession number 78-402.

RESULTS AND CONCLUSIONS

The detached structure is differentially eroded such that it consists partly of a coalified three-ribbed oval-shaped compression devoid of a seed, and partly of an intact, white cupulate seed embedded in situ in the compression. No foliar remains are associated with the fossil.

Each of the ground surfaces consisted of only sub-micron calcitic crystallites without cellular structures, and neither the micropyle nor the chalaza is identifiable. A micron-thick coalified layer surrounding the calcified ovule probably represents the partially preserved integument (CL in Fig. 1).

Most likely during preservation, initial coalification was followed by biological degradation of the original seed tissue, leaving a cavity. This cavity was subsequently infilled with a calcitic solution that on crystallization contracted to form wrinkled folds on the ovule. The process probably modified the overall dimensions of the seed; however, the undeformed coalified structure resisted the compaction pressure of the sedimentary load. Considering Schopf's (1975, table I, 3.) classification, the seed is described as a calcitic cast in a cupulate compression, reflecting a dual preservation process during fossilization.

Determining the taxonomic affinity of the seed is difficult, particularly because it is not permineralized; hence, its anatomy cannot be established (Seyfullah *et al.* 2010). Adding to the problem is the absence of foliar remains. Such small seeds are regarded as lyginopterid (or hydrasperman; Meade *et al.* 2020) forms that had foliage of the sphenopterid–mariopterid type. Macroscopically and in terms of size, the present seed resembles the small seeds described by Van Amerom (1975, p. 25–29, fig. 9, drawings 1, 2, 5, 7); similar forms were described by Gensel and Skog (1977) from the Lower Mississippian, and by Gillespie *et al.* (1981) from the Late Devonian. Based on the author's long experience of plant-fossil collecting from the Sydney Coalfield, the paucity of cupulate seeds is probably due to sample bias resulting from their relatively small sizes.

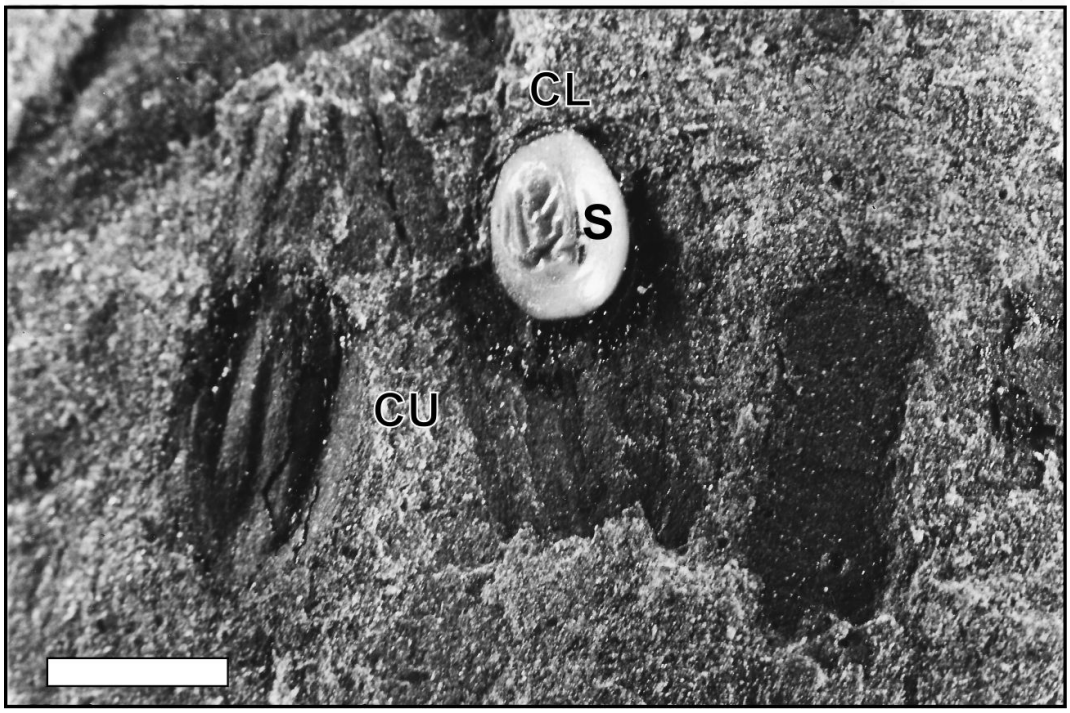

Figure 1. Ovuliferous structure with preserved seed. S = the seed; CL = the thin coalified layer; CU = the cupula; scale bar = 3 mm. Palaeobotanical Collection, Cape Breton University, Sydney, Nova Scotia, Canada, accession number 78-402.

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