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Further evidence supporting high diversity of cyathealean tree ferns in the Early Cretaceous of Antarctica

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ABSTRACT

Two new specimens of a cyathealean fern stems collected from the Lower Cretaceous (Aptian) Cerro Negro Formation, which crops out at the South Shetland Islands, Antarctica, are described in detail. The specimens are dictyostelic stems with U-shaped meristeles without sclerenchyma sheaths and petiole bases with numerous, small, vascular strands, and a mantle of adventitious roots. The anatomy of the stems show similarities with Cibotiaceae, but given they are not well preserved, some critical features that would allow a conclusive referral to this family are lacking. Preserved in the surrounding matrix, fragmentary pinnules were found, showing sori with bivalvate indusia, and sporangia with more than 20 spores, attached to an elongate receptacle. The features observed in these fertile remains suggest cyathealean affinities, but are difficult to refer to a particular family. These findings increase the diversity of cyathealean tree ferns in the Cerro Negro Formation, supporting previously suggested warm climatic conditions for this region of Antarctica during the Aptian.

1. Introduction

Cyathealean tree ferns are a typically arborescent group among Polypodiopsida, which are divided in eight familial (or subfamilial) units using phylogenetic studies with four protein coding plastid loci (Korall et al., 2006; Smith et al., 2006; Christenhusz et al., 2011; Christenhusz and Chase, 2014). The fossil record of cyathealeans shows an important taxonomic diversity since the Jurassic (Tidwell and Nishida, 1993; Tidwell and Ash, 1994), and many fossils (in particular permineralized stems) show anatomical features that preclude a classification among the molecular data-recognized taxa (e.g., Lantz et al., 1999; Stockey and Rothwell, 2004; Vera, 2009, 2013; Vera and Herbst, 2015), suggesting that the diversity of tree ferns was probably higher than in present times. Recent studies using molecular data and dealing with the global biogeography of a particular family of the Cyatheales, the Cyatheaceae, suggest that this family diverged from the Dicksoniaceae during the Late Jurassic, and representatives of the crown Cyatheaceae would have been present since the mid-Cretaceous (96 MYA, Korall and Pryer, 2014). Noteworthy, the area of origin of Cyatheaceae is controversial, being both South America and Australasia equally probable (Korall and Pryer, 2014). Given the proximity and connections between South America, Australasia and Antarctica during most of the Mesozoic, the study of fossil cyathealean ferns from the latter continent may provide further information to clarify the area of origin of scaly tree ferns clade.

Cyathealean tree ferns are an important element in the Cerro Negro Formation (Aptian) of Antarctica, represented by impressions/compressions of fertile fronds (*Eocyathea remesaliae* Césari, 2006, *Sergioa austrina* Césari, 2006, *Lophosoria cupulata* Cantrill, 1998), permineralized stems (*Alienopteris livingstonensis* Vera, 2009, *Yavanna chimaerica* Vera, 2013 and a yet unpublished taxon), and isolated spores (e.g. *Cyatheacidites annulatus* Cookson 1947) (Askin, 1983; Duane, 1994; Cantrill, 1998; Hathway et al., 1999; Césari et al., 2001; Césari, 2006; Vera, 2009, 2013). Other taxa recorded in the unit include non-vascular plants, horsetails, ferns, seed ferns, bennettitaleans, cycads, and conifers (Hernández and Azcárate, 1971; Torres et al., 1997; Césari et al., 1998, 1999, 2001; Cantrill, 1998, 2000; Falcon-Lang and Cantrill, 2001, 2002; Césari, 2006; Párica et al., 2007; Vera, 2007, 2010a, 2011, 2012; among others).

In this work, two permineralized stems and associated fertile structures are described in detail.

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2. Material and methods

Specimens were collected in the Aptian Cerro Negro Formation at Byers Peninsula, Livingston Island, South Shetland Islands (Antarctica), at the Rotch Dome locality (sensu Párica et al., 2007) (Fig. 1). For a detailed revision of the geology of the area, see Párica et al. (2007) and Vera (2012).

Specimens are preserved as permineralizations, with the fertile remains, as well as other fragmentary remains and plant debris, contained within the rock matrix surrounding one of the specimens, separated from the stem by less than 1 cm. The peel technique gave poor results, and thin sections were prepared and mounted on microscope slides. Preservation quality of the specimens is variable, although in most cases it is good enough to study cellular details, or at least tissue position. Photographs were taken with a Nikon Coolpix 995 adapted to an Olympus BX-51 or a Nikon SMZ-2 t Microscope. The specimens are housed in the collection of the Museo Argentino de Ciencias Naturales "Bernardino Rivadavia", División Paleobotánica, under BA Pb (hand specimens) and BA Pb Pm (microscope slides) numbers. Specimen BA Pb 14977 also preserves the moss *Livingstonites gabrielae* Vera 2011.

The work of Christenhusz and Chase (2014) proposed a classification scheme with a single family among Cyatheales, Cyatheaceae, with the eight families previously recognized (e.g., Korall et al., 2006; Smith et al., 2006) treated at subfamilial level. The current study follows the scheme previously used by Vera (2009, 2010b, 2013) and Vera and Herbst (2015) for comparative purposes. Terminology for describing the anatomy of the petiole bases follows Nishida (1984).

3. Systematic paleontology

3.1. Stems

Order Cyatheales A.B. Frank in J. Leunis 1877
Family Cibotiaceae Korall 2006?
Cyatheales indet.
Figs. 2–4

Studied material. BA PB 14977 (Microscope slides BA Pb Pm 631-634) and BA PB 14978 (Microscope slides BA Pb Pm 635-637).

Locality. All the specimens were collected at the Rotch Dome locality (sensu Párica et al., 2007), which is located west of the Rotch Dome, at 62°38′41″S–60°58′12″W, Byers Peninsula, Livingston Island, South Shetland Islands, Antarctica.

Horizon. Cerro Negro Formation (Byers Group), Aptian, Lower Cretaceous.

Description. The description is based on two permineralized stems with attached petiole bases. In transverse section, the stem is 4–6 cm in diameter, containing an amphiphloic dictyostele, and surrounded by a mantle of adventitious roots and petiole bases, the latter structures being badly preserved (Fig. 2A, B).

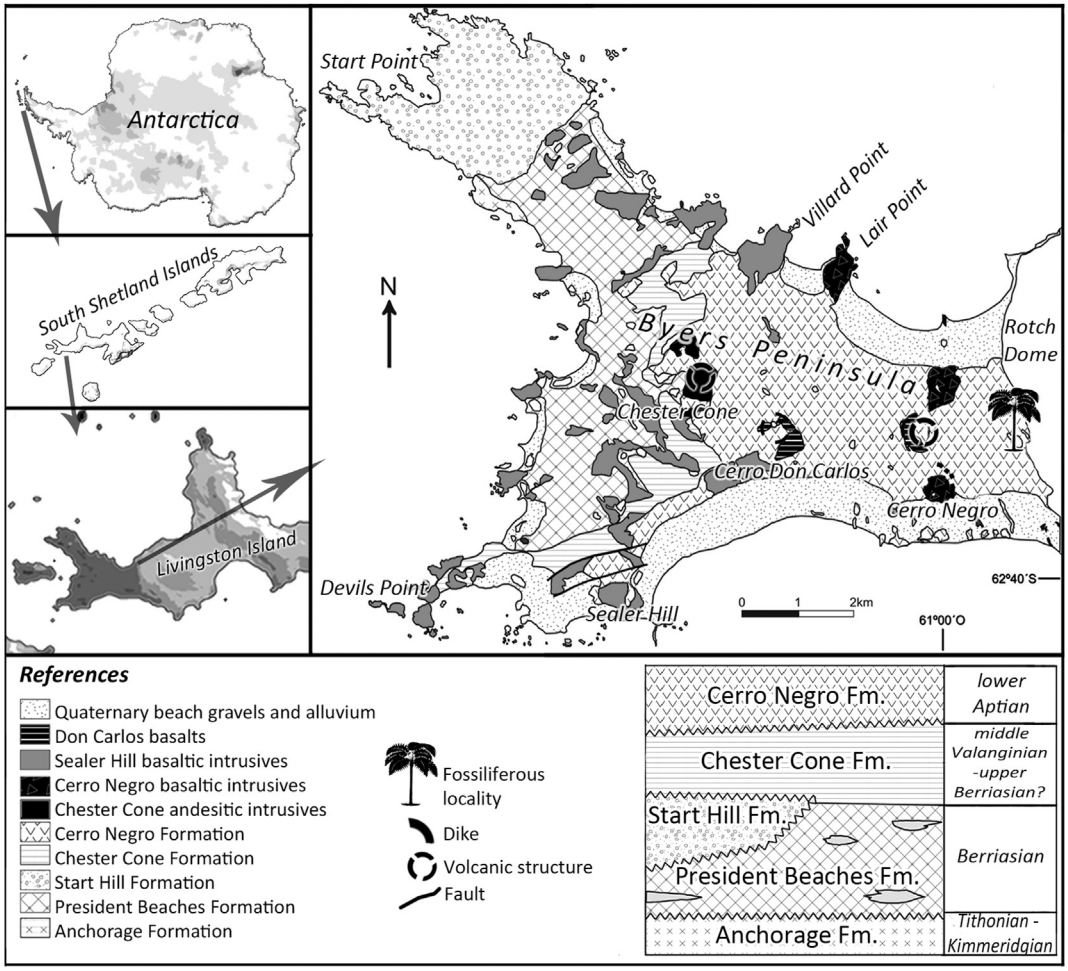

Fig. 1. Location Map (modified from Vera, 2013).