

## NOTA PALEONTOLÓGICA

# LIVINGSTONITES GABRIELAE GEN. ET SP. NOV., PERMINERALIZED MOSS (BRYOPHYTA: BRYOPSIDA) FROM THE APTIAN CERRO NEGRO FORMATION OF LIVINGSTON ISLAND (SOUTH SHETLAND ISLANDS, ANTARCTICA)



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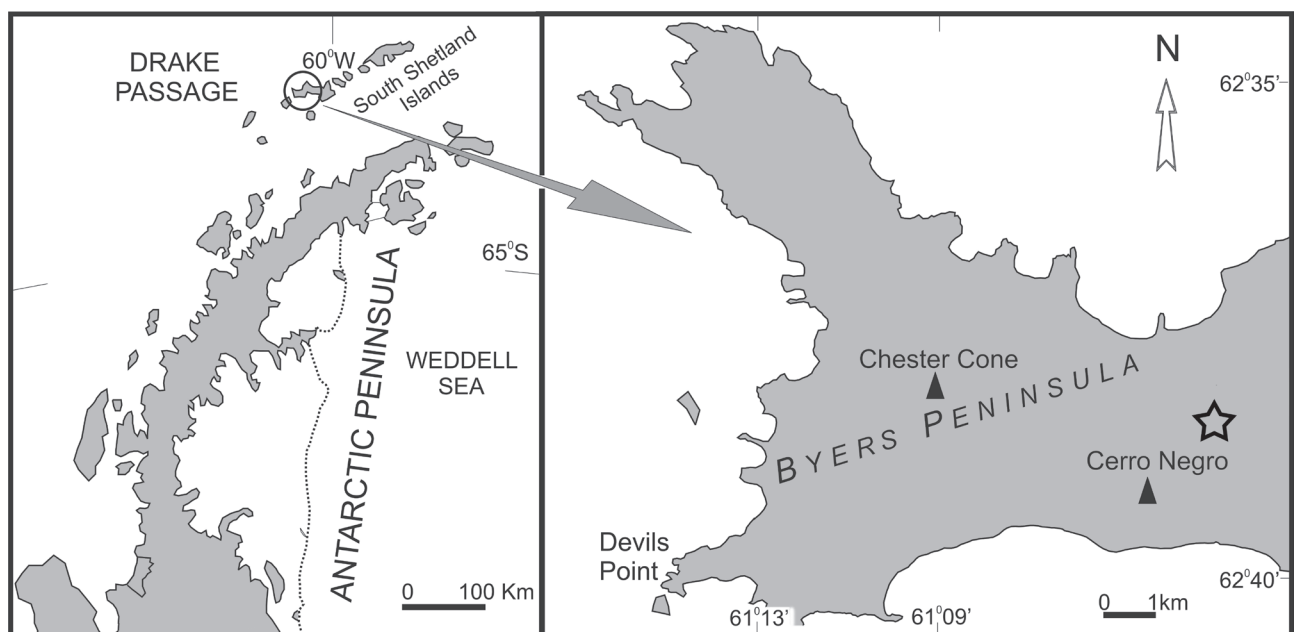
**Keywords.** Mosses. Cretaceous. Antarctica. Cerro Negro Formation. Fossil.

**Palabras Clave.** Musgos. Cretácico. Antártida. Formación Cerro Negro. Fósil.

THE Cerro Negro Formation is a non-marine succession that outcrops in Byers Peninsula (Livingston Island) and Williams Point (Snow Island). Both islands belong to the South Shetland Islands Archipelago, Antarctica.  $^{40}\text{Ar}/^{39}\text{Ar}$  age of the Cerro Negro Formation was estimated at  $120.3 \pm 2.2$  Ma,  $119.4 \pm 0.6$  Ma and  $119.1 \pm 0.8$  Ma (Aptian) (Hathway, 1997; Hathway *et al.*, 1999). A highly diverse palaeoflora, containing mosses, liverworts, hepatophytes, horse-

tails, ferns, corystosperms, Caytoniales, bennettites, cycads, and conifers was recorded by several authors from the unit (Hernández and Azcárate, 1971; Torres *et al.*, 1997; Césari *et al.*, 1998, 1999, 2001; Cantrill, 2000; Falcon-Lang and Cantrill, 2001; Césari 2006; Parica *et al.*, 2007; Vera, 2007, 2009; among others).

Fossil bryophytes are scarce in the fossil record, probably because of their small size and delicate structure. The



**Figure 1.** Location map showing the fossiliferous locality (star). Modified from Césari *et al.* (1999) / *mapa de ubicación, mostrando la localidad fosilífera (estrella).* Modificado de Césari *et al.* (1999)

oldest records of this group are a few Carboniferous representatives (e.g., Walton, 1928; Thomas, 1972; Ottone and Archangelsky, 2001). Permian mosses are more abundant, with rich and diverse associations recorded in Siberia and Russia (Neuburg, 1960; Ignatov, 1990). Among the Permian records is *Merceria augustica* Smoot *et* Taylor, a permineralized bryalean gametophyte preserved with anatomical details (Smoot and Taylor, 1986). Fossil record of Triassic–Early Cretaceous true mosses is also sparse (Taylor *et al.*, 2009). Younger deposits (Late Cretaceous) contain beautifully preserved mosses, represented by gametophytes and sporophytes, such as *Eopolytrichum antiquum* and *Campylopodium allonense* (Konopka *et al.*, 1997, 1998). Post Mesozoic records are among the best preserved mosses, including impression/compression and amber fossils (e.g. Frahm, 1993, 1994, 1996a, b, c, 1999a, b, 2000, 2001, 2004a, b, 2006a, b; Frahm and Reese, 1998; Frahm and Newton, 2005).

Several permineralized moss gametophytic stems are described in detail herein and referred to a new genus and species. They come from exposures of the Cerro Negro Formation in Livingston Island, Byers Peninsula, Antarctica.

## MATERIAL AND METHODS

Fossil mosses are preserved in consolidated sediments surrounding two cyathealean tree-fern stems. They were collected in the Cerro Negro Formation outcrops at Byers Peninsula, Livingston Island (South Shetland Islands, Antarctica), at the Rotch Dome locality (62° 38' 41" S; 60° 58' 12" W; Fig. 1). Several thin sections of the material were cut and mounted on microscope slides. Observations were made using light microscopy (Olympus BX-51 or Nikon C-DSS115 microscopes), and photographs were taken with a Nikon DS-L2 camera.

Specimens are housed in the Palaeobotanical Collection at the Museo Argentino de Ciencias Naturales “Bernardino Rivadavia”, under BA Pb (megascopic remains) and BA Pb Pm (microscope slides) numbers.

## SYSTEMATIC PALAEOONTOLOGY

Division BRYOPHYTA Schimper 1879

Class BRYOPSIDA Rothmaler 1951

Genus *Livingstonites* gen. nov.

*Type species.* *Livingstonites gabriellae* gen. et sp. nov.

*Derivation of name.* The generic name derives from Livingston (Island), the geographic origin of the specimens.

*Generic diagnosis.* Same as for species, by monotypy.

## *Livingstonites gabriellae* gen. et sp. nov.

Figures 2, 3

*Holotype.* BA Pb 14977 (BA Pb Pm 631-634).

*Additional specimen.* BA Pb 14978 (BA Pb Pm 635-637).

*Type locality.* Rotch Dome Locality (Párica *et al.*, 2007), Byers Peninsula, Livingston Island, South Shetland Islands, Antarctica.

*Stratigraphic horizon.* Cerro Negro Formation.

*Age.* Early Cretaceous (Aptian).

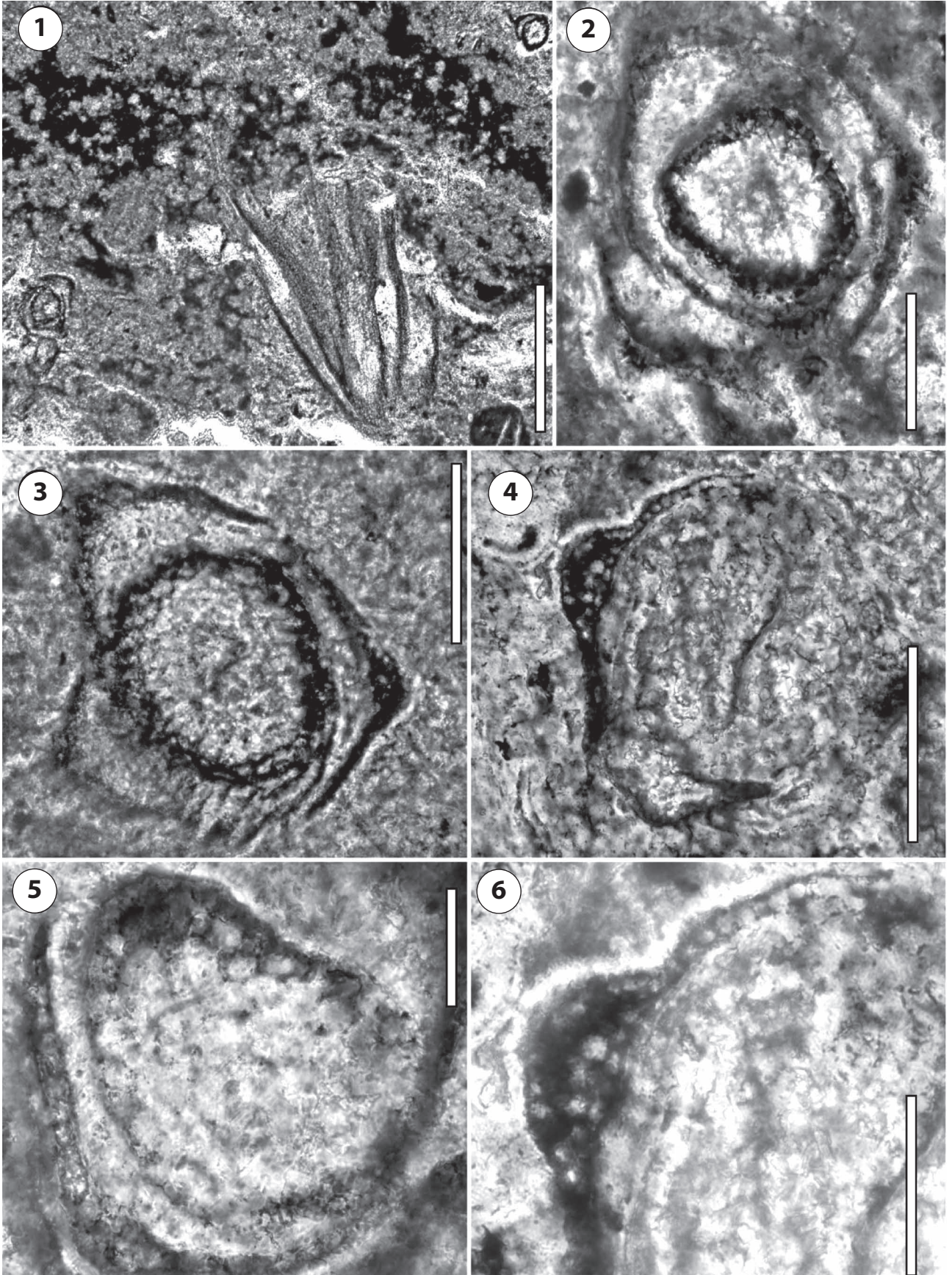
*Derivation of name.* The specific name honors Dr. Gabriela Hässel de Menéndez, for her many contributions to bryology.

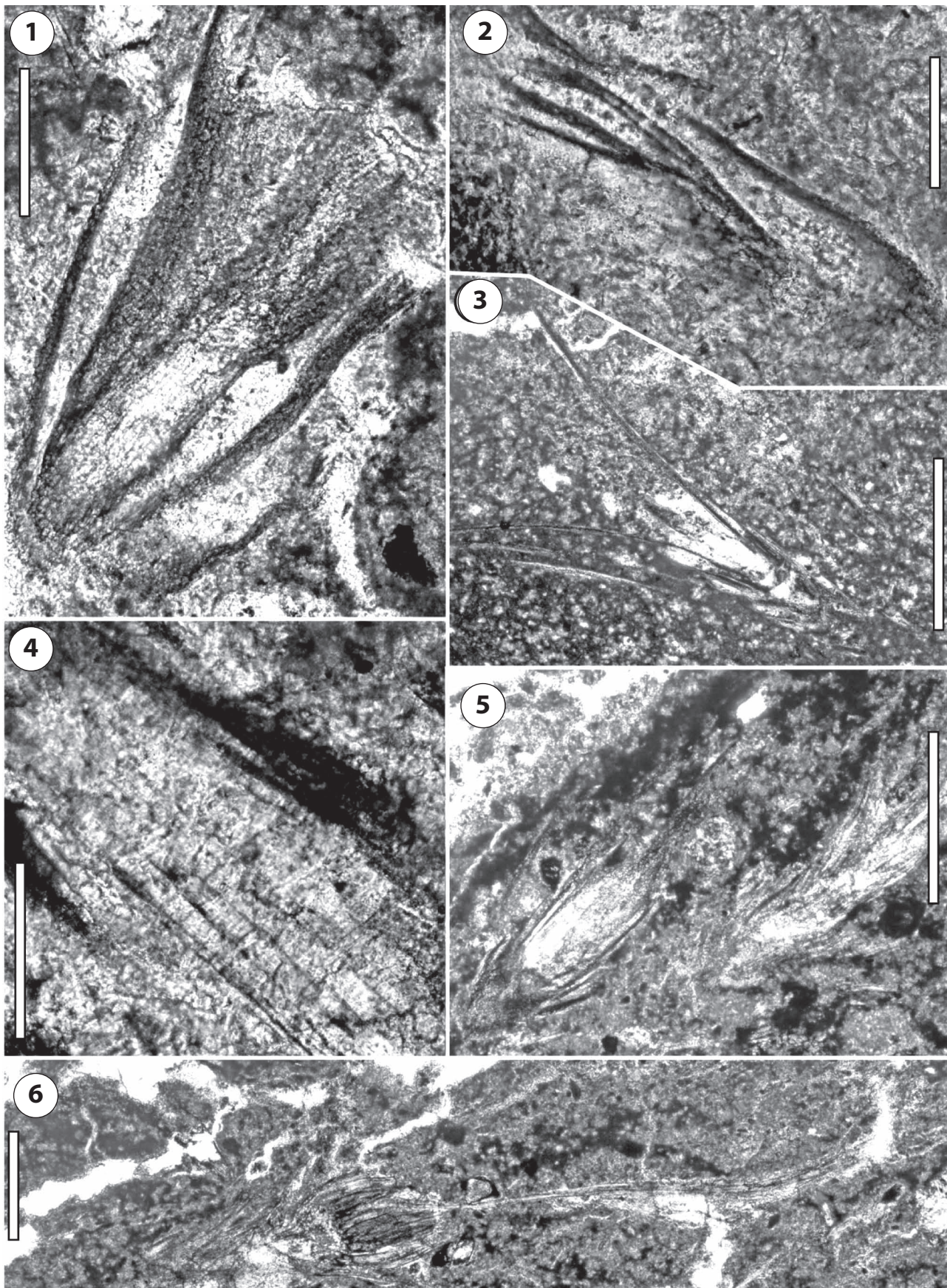
*Specific diagnosis.* Small and delicate stems surrounded by helically distributed leaves. Stems circular in cross section, generally lacking internal differentiation, and with inner parenchymatic cortex and narrow sclerenchymatic outer cortex. Rhizoids absent. Leaves with prominent heterogeneous midrib, laminae unistratose.

*Diagnosis específica.* Tallos pequeños y delicados, rodeados por hojas distribuidas helicoidalmente. Tallos circulares en sección transversal, generalmente careciendo de diferenciación interna, y presentando una corteza interna parenquimática y una delgada corteza externa esclerenquimática. Rizoides ausentes. Hojas con una vena media prominente y heterogénea, y presentando una lámina unistratosa.

*Detailed description.* *Livingstonites gabriellae* gen. et sp. nov. is represented by many small and delicate gametophytic stems, which have been cut in several directions (transverse, oblique and tangential) (Fig. 2.1). The stems are long, and bear helically disposed leaves. Stems are circular in transverse section, reaching 100–150 µm in diameter. Internally, they possess a parenchymatic inner cortex surrounded by a sclerotic outer cortex, generally two-cells wide, composed of thick-walled cells. In some specimens, the central region of the stem looks different from the par-

**Figure 2.** *Livingstonites gabriellae* gen. et sp. nov. (BA Pb 14977, excepting 2 which corresponds to BA Pb 14978/ con excepción de 2 que corresponde a BA Pb 14978). 1, general view of a petrographic slide, showing the abundance of the taxon / aspecto general de un corte petrográfico, mostrando la abundancia del taxón. 2–3, 5, transverse sections of the stem, showing inner and outer cortex. In 2 and 3, the central region may represent a cellular type different from parenchymatic / corte transversal de tallos, mostrando la corteza interna y externa. En 2 y 3 puede observarse una región central que podría corresponder con un tipo celular distinto al parenquimático. 4, transverse section of the leaves / corte transversal de las hojas. 6, detail of 4, showing the “midrib” and the unistratose laminae / detalle de 4, mostrando la “vena media” y la lámina unicelular. Scale bar/ Escalas. 1=500 µm; 2, 3 and 4=100 µm; 5 and 6= 50 µm.





enchymatic inner cortex. Although these cells may represent tracheid-like cells, preservation of the specimens does not permit a precise determination. Externally, the stems lack rhizoids (Fig. 2.2, 2.3, 2.5).

The leaves are helically arranged and at least 5 mm long, and diverge from the stem at angles of 10°–30° (Fig. 3.1–5). Anatomically, they are composed of an elliptical central region, or midrib, 4 to 5 cells wide, which laterally extends as a unistratose lamina (Fig. 2.4, 2.6). The midrib is heterogeneous, composed by at least two layers of guide cells, and at least one abaxial layer of stereids (Fig. 2.4, 2.6). The cells of the laminae are *c.* 10–15 µm in diameter near the midrib, but near the margins they become approximately 50% smaller. The width of the midvein represents 0.33–0.17 of the total width of the leaves (Fig. 2.4, 2.6). In surface view, cells of the lamina seem to be rectangular, with the greater axis parallel to the midrib (Fig. 3.4).

## DISCUSSION

### *Comparisons with other permineralized mosses*

The presence of small stems lacking definite xylem elements, surrounded by helically distributed leaves possessing a prominent midrib that becomes laterally a unistratose lamina, allows taxonomic placement of *Livingstonites gabriellae* among the mosses (Bryophyta). Furthermore, the presence of a heterogeneous midrib, with guide cells and stereids, suggests that *L. gabriellae* belongs to the paraphyletic acrocarp moss grade (Shawn and Renzaglia, 2004; Goffinet *et al.*, 2008). However, a more precise classification is not possible, due to the absence of reproductive structures and leaf margins, among other characters useful in moss systematics.

Permineralized mosses are very rare, and only one taxon with this type of preservation has been identified thus far from Permian sediments from Antarctica, *i.e.*, *Merceria augustica* Smoot *et Taylor* (Smoot and Taylor, 1986). *Livingstonites gabriellae* shares some similarities with *M. augustica*, since both are non-vascularized stems surrounded by helically distributed leaves, bearing a prominent midrib. However, *L. gabriellae* can be differentiated from the Permian taxon by

the circular outline of the stem in the former species, which results from the absence of rhizoids. Rhizoids are very abundant in *M. augustica*, rendering the outer cortex a disorganized aspect (Smoot and Taylor, 1986).

### *Fossil mosses and allies from the Cerro Negro Formation*

As previously pointed out, the fossil record of non-tracheophytic land plants is scarce. However, several specimens preserved as impressions have been identified from the Cerro Negro Formation. These can be referred to the Bryophyta and Hepatophyta. Césari *et al.* (1999) included some fragmentary remains of a leafy thallus in the Division Hepatophyta. Cantrill (2000) identified representatives of this Division, including *Jungermannites stonei* Cantrill and two species of *Hepaticites*. *Thallites* sp., described by Cantrill (2000), is badly preserved and cannot be referred to the Hepatophyta or the Bryophyta. Finally, *Muscites antarcticus* Cantrill, a representative of the Bryophyta, is comparable in gross morphology with *Livingstonites gabriellae*. Both species represent small and delicate unbranched axes, with helically distributed leaves, containing a distinct midrib. However, since anatomical details are unknown for *Muscites antarcticus*, it becomes impossible to determine if this taxon and *L. gabriellae* are conspecific.

### *Palaeoecology of Livingstonites gabriellae*

The palaeoflora preserved in the rocks of the Cerro Negro Formation at the Rotch Dome locality possesses a particularly high abundance of ferns. Osmundaceae are well represented by fronds of *Phyllopteroides* (Párica *et al.*, 2007), *Millerocaulis australis* (Vera) Vera (Vera, 2007; 2008) and a new species of *Millerocaulis* currently under study. Cyathea-lean tree-ferns are also very abundant and diverse, comprising fertile fronds of *Sergioa austrina* Césari, and *Eocyathea remesaliae* Césari (Césari, 2006); and permineralized stems, including *Alienopteris livinstonensis* Vera (Vera, 2009) and three new taxa currently under study. As previously postulated, this abundance of ferns suggests frost-free and humid conditions for this region during the Aptian (Cantrill, 1998; Césari *et al.*, 2001; Falcon-Lang and Cantrill, 2002).

Extant mosses are distributed across several habitats, ranging from very humid (*e.g.*, *Fissidens grandiformis*) to arid (*e.g.*, *Tortula ruralis*) environments (Pearson, 1995). Particularly, the presence of *Livingstonites gabriellae* in this putative humid palaeoenvironment, suggests that this moss was adapted to moist conditions.

**Figure 3.** *Livingstonites gabriellae* gen. et sp. nov. **1, 3, 5** and **6**, different fragments of stems in lateral section, showing the disposition of the leaves / distintos fragmentos de tallos en vista lateral, mostrando la disposición de las hojas. **2**, detail of the insertion of the leaves in the stem / detalle de la inserción de las hojas al tallo. **4**, detail of **1**, showing the rectangular morphology of the laminae cells / detalle de **1**, mostrando la morfología rectangular de las células de la lamina. Scale bars / escalas. 1=200 µm; 2 and 4=100 µm; 3 and 6=1 mm; 5=500 µm.

## CONCLUSIONS

A new genus and species of a fossil acrocarp moss, *Livingstonites gabrielae*, is described in detail and characterized by the presence of a small stem, circular in cross section, with an inner parenchymatic and outer sclerenchymatic cortex, surrounded by small leaves with a prominent heterogeneous midrib. This new taxon, recovered from the Aptian sediments of the Cerro Negro Formation (Livingston Island, Antarctica) represents the first record of a post-Palaeozoic permineralized moss.

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