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Spesia antarctica gen. et sp. nov. – a new fertile fern spike from the Jurassic of Antarctica

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Abstract: The well-known Jurassic macrofloras from Hope Bay at the northernmost tip of the Antarctic Peninsula continue to yield new taxa. This paper reports on a new type of plant reproductive organ. The affinity of this organ remains unclear; it may be affiliated with the Schizaceae or Osmundaceae, but similarities to pollen organs of the Podocarpaceae are also discussed. Because the fossils differ from hitherto known Mesozoic fertile fronds and conifer pollen organs in some details, the new taxon, *Spesia antarctica* nov. gen. et sp. is proposed.

Key words: Antarctic Peninsula, Mount Flora Formation, Jurassic, palaeobotany, plant reproductive organ.

Introduction

The fossil flora from Hope Bay has been studied for more than 100 years (Nathorst 1904, 1906; Halle 1913; Gee 1989; Rees and Cleal 2004). Two recently published papers (Ociepa 2007; Birkenmajer and Ociepa 2008) have presented a survey on new material collected from Hope Bay by Prof. K. Birkenmajer in 1988 during the 3rd Polish Geodynamic Expedition to West Antarctica and from Prof. A. Gaździcki during the following 4th Polish Geodynamic Expedition. The age of the Hope Bay flora is considered to be Early or Middle Jurassic (Birkenmajer 1993) or Middle Jurassic based on new radiometric data (Hunter *et al.* 2005).

The Polish collections from the Mount Flora Formation include fossil plants collected from loose blocks of the Five Lakes Valley Member and the Flora Glacier Member as well as from an outcrop of the Flora Glacier Member which is a site of the examined specimens collected *in situ* (Figs 1, 2; see also Birkenmajer 1993, fig. 7; Birkenmajer in Birkenmajer and Ociepa 2008, figs 3–7).

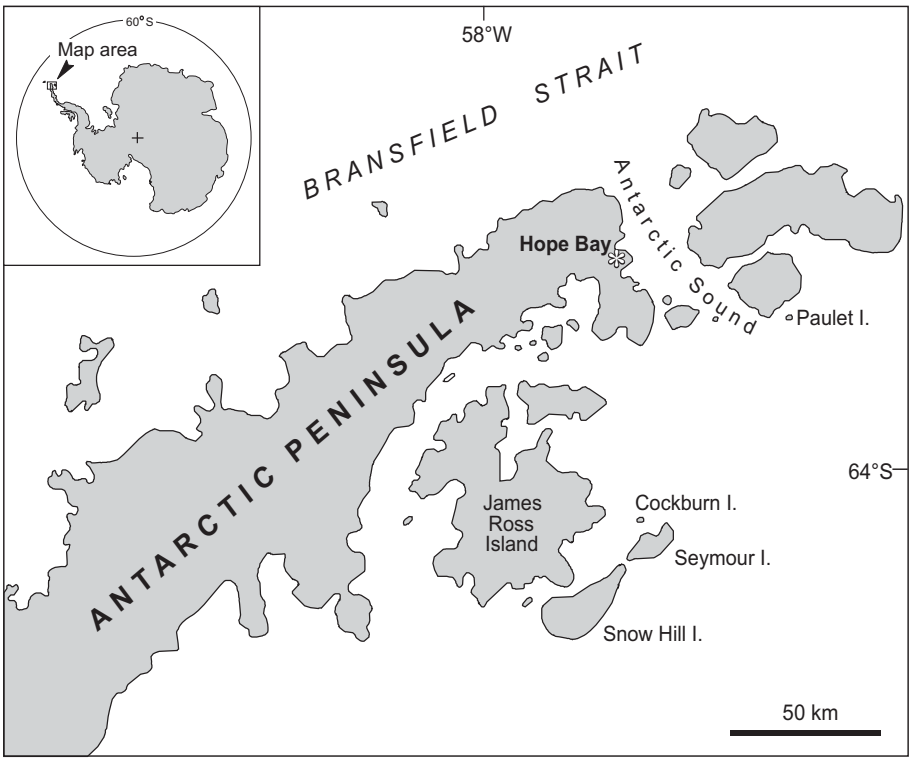

Fig. 1. Map of the northern Antarctic Peninsula showing the position of the Jurassic flora locality at Mount Flora in the Hope Bay region.

The material described here occurs together with liverworts, horsetails, ferns, pteridosperms, cycads, bennettitales, and conifers; 41 taxa have been described so far (Ociepa 2007; Birkenmajer and Ociepa 2008). The assemblage is dominated by conifers, mainly *Sphenolepis* (Taxodiaceae) and *Elatocladus confertus*, with minor proportions of *Pagiophyllum* and *Brachyphyllum*. Ferns are uncommon (species of *Coniopteris* and *Cladophlebis*), contrary to a relatively high number of taxa. The dominant pteridosperm is *Archangelskya furcata*, while *Sagenopteris* and *Komlopteris* are rare. *Nilssonia taeniopteroides* is common; bennettitalean foliage is quite diverse, but comparatively rare. The specimens described in the present paper represent a previously undescribed plant reproductive organ.

Material and methods

This study is based on two rock fragments containing remains of a plant reproductive organ. The fossils are preserved as impressions on black shale that is altered to (semi)anthracite grade or biotite grade due to contact metamorphism. Because of the very delicate structure and small size, the microscopic details are

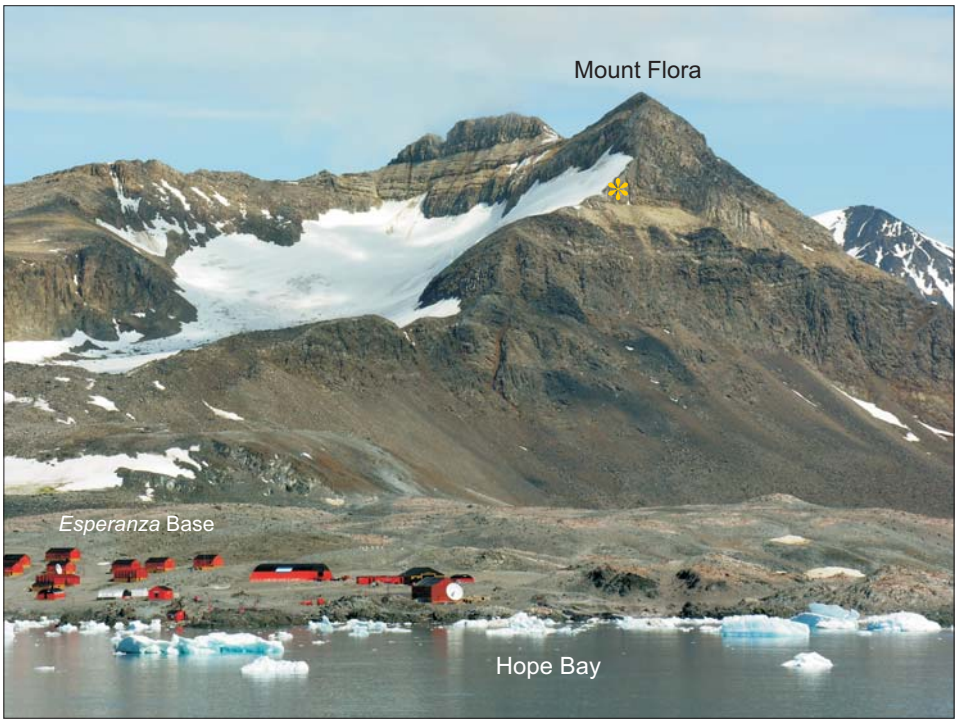

Fig. 2. Mount Flora (Hope Bay), Antarctic Peninsula. Star shows the Jurassic flora locality *in situ*. Photograph by A. Gaździcki, January 2007.

hardly recognizable. Due to the high alteration and very hard and resistant rock matrix, attempts to recover any identifiable spores or pollen grains were unsuccessful; usual treatment of samples with hydrofluoric acid (40%) or hydrochloric acid (35%) appeared ineffective.

The specimens were studied using a Nikon SMZ 1000 stereo dissecting microscope, and further analysed using a Hitashi S-2600 N scanning electron microscope. Images were taken as backscattered electron image at 15 kV accelerating voltage (Fig. 3E–F) and secondary electron image at 15 kV accelerating voltage (Fig. 2G).

The material is housed in the Palaeobotanical Museum of the W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków, Poland (KRAM-P).

Systematic descriptions

Incertae sedis

Genus *Spesia* Ociepa *et* Barbacka nov.

Etymology: The generic name refers to the type locality at Hope Bay, Antarctica (*spes* = "hope" Latin).

Type species: *Spesia antarctica* Ociepa *et* Barbacka sp. nov.

Diagnosis. — Fertile fern frond. Delicate naked axis at least bipinnate. Fertile spikes narrow-elliptical, situated terminally on each ultimate axis. Sporangia arranged in two (or possibly four) rows on the axes, rhomboidal or rounded in shape.

Spesia antarctica Ociepa *et* Barbacka sp. nov.
(Fig. 3A–G)

Holotype: KRAM-P S 78/38, preserved in black shale, Fig. 3A, B, F.

Paratype: KRAM-P S 78/85, Fig. 3C–D.

Repository: Palaeobotanical Museum of the W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków, Poland.

Type locality: Mount Flora (Hope Bay), Antarctic Peninsula (Fig. 2).

Stratigraphic horizon: Flora Glacier Member, Mount Flora Formation, Botany Bay Group. (Birkenmajer 1993, fig. 7).

Age: Early or Middle Jurassic.

Etymology: the specific epithet refers to Antarctica.

Material. — KRAM-PS 78/38, 78/85.

Diagnosis. — Fertile fern frond. Delicate naked axis, bipinnate, with narrow-elliptical spikes *ca* 2 mm long situated terminally on ultimate axes. Sporangia arranged in two (or possibly four) rows on the axes, rhomboidal or rounded in shape.

Description. — The examined organ has a very delicate, bipinnate axis 0.2 mm wide. The most complete secondary axis is 7.5 mm long. The secondary axes arise from the main axis at an angle of 50–60° and at distances between 1 to 3 mm (Fig. 3A–D). The fertile spikes arise alternately to almost oppositely from the secondary axes at an angle of 40–50°, and the distance between them is 0.5 to 2 mm.

The fertile spikes are narrow-elliptical in shape, 1.5–2.5 mm long and 0.5–0.75 mm wide. The sporangia are arranged in two (or possibly four) rows, although some appear to be arranged in spirals (or alternately? Fig. 3F). They are nearly rhomboidal or roundish in shape, 0.26–0.45 mm long and 0.2–0.32 mm wide, with slightly irregular or sinusoid outline (Fig. 3G). The sporangia are situated closely to each other and their margins tend to overlap. Sometimes their surface is slightly wavy, which suggests presence of small structures on the lower surface. In one case a fragment of a broken sporangium can be observed with an imprint of 5–6 radial elongated structures about 70 μm long, which can be interpreted as annulus (Fig. 3E).

Discussion

Due to its very delicate structure and branching axes, *Spesia antarctica* has a unique morphology that does not correspond fully to other, superficially similar organs. A systematic placement of *Spesia antarctica* remains difficult, especially

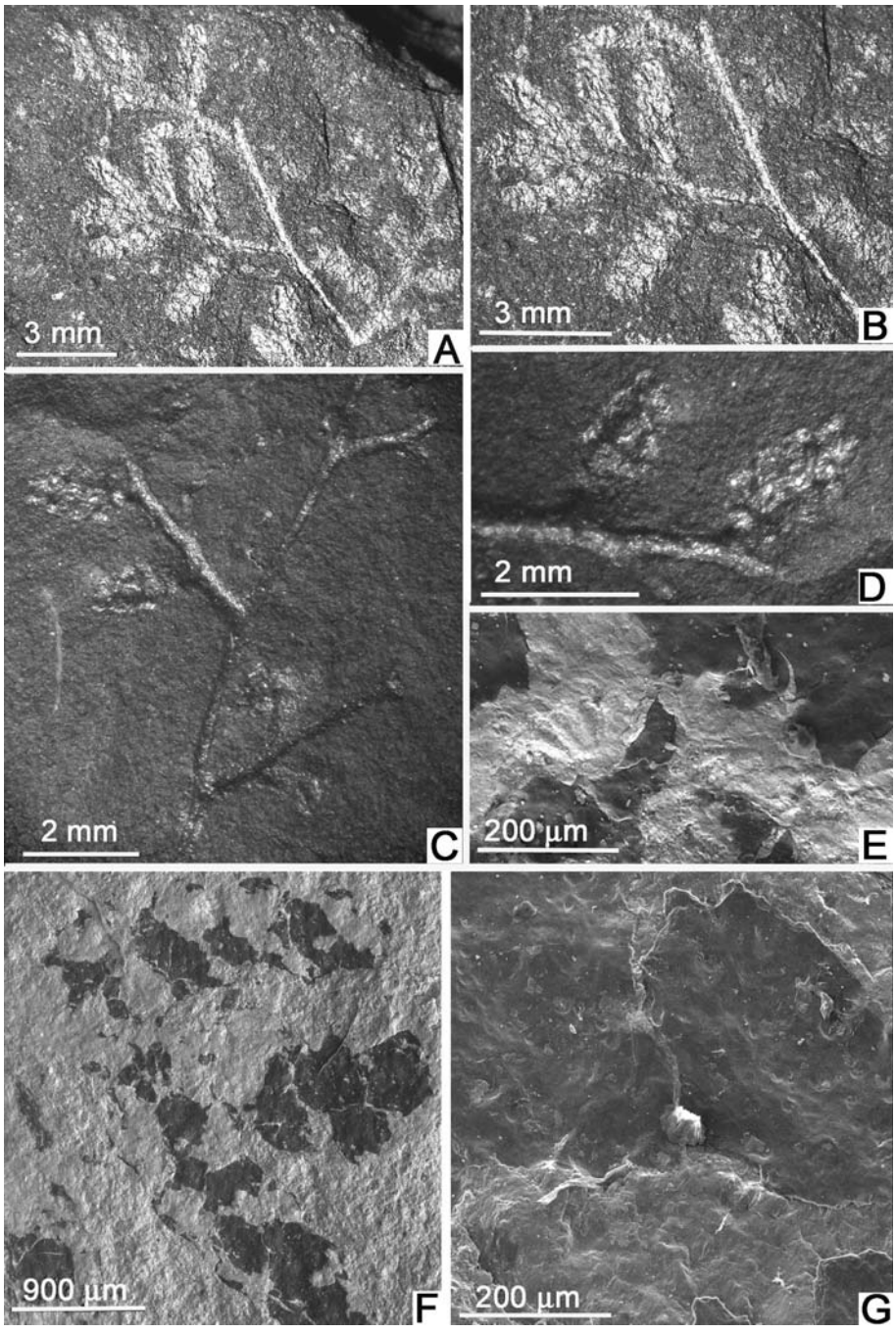

Fig. 3. *Spesia antarctica*, Ociepa *et* Barbacka gen. et sp. nov. A–B – holotype, fragments of fertile fronds, No KRAM-P S 78/38. C–D – paratype No KRAM-P S 78/85. E – SEM picture, showing structure interpreted in this paper as annulus (?) No KRAM-P S 78/38. F–G – holotype, SEM pictures, showing details of fertile spikes. Mount Flora, Flora Glacier Member.

because no palynomorphs could be isolated and no foliage is preserved. The only similarity to any known form could point to a fern fertile frond or, less possibly, conifer pollen organ.

Assuming that sporangia were originally arranged in rows, similar fertile spikes, although not branching, are found in *Stachypteris spicans* (Pomel) Harris (Harris1961). The radial structures noticed on the lower surface of one sporangium (Fig. 3C) may correspond to an annulus comparable with those of *e.g. Stachypteris spicans* illustrated by Harris (1961, fig. 47e). However, in the mentioned ferns, the fertile spikes occur at the top of sterile pinna and small pinnules occur at the base of spike, which was not observed in *Spesia*. More similar, branching, fine spikes are found in *Norimbergia braunii* (Goeppert) Gothan (= *Phialopteris tenera* Presl) (Gothan 1914; Weber 1968). In this genus, the spikes are arranged on bipinnate, slender axes, but details are unclear, judging from the descriptions and the illustrations. Generally, the whole structure of *Norimbergia* is more massive, the ultimate axes and spikes being bigger and truncate in shape (ovate in *Spesia*) and the arrangement of sporangia being very different. The spike details (sporangia) illustrated by Gothan (1914, pl. 18, fig. 8) are completely different from those observed in *Spesia*, having oval sporangia, obliquely arranged in alternating order.

The absence of a sterile lamina in *Spesia* may indicate that it is a separate (dimorphic) fertile frond, or a fragment of a complex frond with fertile regions. In this feature *Spesia antarctica* resembles representatives of Osmundaceae (Anderson and Anderson 2008), especially the Liassic *Osmundopsis plectrophora* Harris (Harris 1931), Triassic *Osmunda claytoniites* Phipps *et al.* (Phipps *et al.* 1998) as well as extant *Osmunda* (*O. regalis* L.) (Phipps *et al.* 1998, figs 5, 10–11; van Konijnenburg-van Cittert 1996, pl. 1, figs 1–3; pl. 2, figs 2–4; pl. 3, figs 1, 2). Their sporophylls have a reduced blade and spikes situated on naked axes, but, differently from *Spesia*, the sporangia form irregular or radiate clusters.

Other fertile fronds with a strongly reduced lamina similar to *Spesia* occur in representatives of the Ophioglossales. This group, however, has hardly any fossil record – macrofossils are known from the Palaeogene and dispersed spores from the Mesozoic (Taylor *et al.* 2009). The leaf of the recent genus, *Botrychium*, is divided into a vegetative blade and fertile spike (it also may occur separately – Kramer and Green 1990) which resembles the organ from the Mount Flora. The fertile spike is branched (Kramer and Green 1990, fig. 102A), but sporangia are situated separately, each on a short stalk, which is not observed in *Spesia*.

Alternatively, *Spesia* may be discussed as a conifer pollen cone, if the sporangia are interpreted as microsporophylls and their arrangement is interpreted to be helical (Kramer and Green 1990; Taylor *et al.* 2009). In the material from the Mount Flora, conifers are represented by shoots classified in three species of *Pagiophyllum*, one species of *Brachyphyllum*, and two species of *Elatocladus*, cone scales of *Araucarites*, and cones of *Sphenolepis* with shoots of the *Pagiophyllum* type, as well as the genus *Stachyotaxus* (Palissyaceae). Among the pollen organs, species from the

genera *Morenostrobus* and *Squamastrobus* attributed to shoots of *Brachyphyllum* (Archangelsky *et* Del Fueyo, 2010), might be morphologically comparable with *Spesia*, or those of extant Podocarpaceae, especially those of the genus *Nageia* (Wilde 1944). *Morenostrobus* has pollen cones similar in size and shape, with the microsporophylls arranged helically, but axes do not branch and cones are apically situated in groups. In *Squamastrobus* microsporophylls are also helically arranged but the cones are much larger and grow directly on the leafy shoots and not on separate, naked axes. *Spesia* does not show indications of (previously) attached conifer-like foliage (which would be expected if it were conifer cones).

Conclusions

The structure of new fossil remains from the Mount Flora Formation (the Hope Bay flora) is unique and does not correspond fully with any known structures described so far. The new taxon is proposed, *Spesia antarctica* Ociepa *et* Barbacka gen. et sp. nov.

The systematic attribution of the new taxon was discussed in two possible directions, as a fertile fern frond or a pollen organ of conifer. This problem could not be solved because no spores or polen were so far obtained from the material.

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