Palynoflora of Livingston Island, South Shetland Islands: Contribution to the understanding of the evolution of the southern Pacific Gondwana margin

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Summary Palynoflora are reported from morainic deposits at several localities on Livingston Island, South Shetland Islands. The palynomorphs observed include Pteridophyta, Pinophyta, Magnoliophyta and fungal spores. It is possible to distinguish two different palynological assemblages from the moraine deposits of Shirreff Cape, arbitrarily called Type A and B. Pteridophyta and Podocarpaceae dominate in the Type A association and in the Byers Peninsula palynoflora. Warm and humid conditions and an Early Cretaceous age are attributed to it. The Type B assemblage is characterized by a subantarctic flora with Pteridophyta, Pinophyta and *Nothofagidites* spp., a cold-temperate and humid climate, and a probable Late Cretaceous-Paleogene age. The palynological associations from Williams Point and Hannah Point are characterized by Pteridophyta, Pinophyta and Magnoliophyta with a probable Late Cretaceous age and temperate-humid climate. The palynomorph assemblage of Hannah Point is later than the one observed from Williams Point.

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Introduction

This research is part of the Instituto Antártico Chileno Universidad de Concepción Project (INACH 04-01) and Proyecto Anillo Antártico (CONICYT N°ARTG 04.2006-09). The project's goal is to demonstrate that the evolution of the southern Pacific margin of Gondwana can be considered from a paleobotanical point of view. Furthermore, the project intends to develop a model of the Mesozoic-Cenozoic evolution of the Antarctic Peninsula and its relation with southern South America. To achieve this, fieldwork has been undertaken on Livingston Island (Shirreff Cape, Byers Peninsula, Williams Point), Seymour Island (in collaboration with the Instituto Antartico Argentino) and King George Island (Fildes Peninsula) since 2002. The fossil record of macroflora and microflora in the Antarctic contributes to a better understanding of plant migration throughout the western margin of Gondwana.

Localities

As a result of the first Antarctic scientific expedition in 2002 lateral morainic deposits of the Aranda Glacier at Shirreff Cape were found to contain terrestrial palynomorphs (Fig. 1; Palma-Heldt et al., 2004). These morainic deposits contain fragments of fine green sandstone and gray sandstone with abundant vegetation fossils. Fossils had not previously been recorded from Shirreff Cape and it is now designated a Specially Protected Area.

Samples from Byers Peninsula were collected during the 2005 scientific expedition from a 50 meter profile located 600 meters to the west-southwest of Cerro Negro (61°01´03"W - 62°39´25"S) and can be correlated with the upper portion of the Cerro Negro Formation. This section consists of a sequence of green conglomeratic sandstones, fine green sandstone and fine brownish sandstone containing a macroflora record (Palma-Heldt et al., 2005).

Williams Point, located in the northwest of Livingston Island, was sampled in 2006 and is a two kilometer square ice-free area exposing a sedimentary sequence. Fifty metres of conglomerate with volcanic clasts are gradationally overlain by interbedded sandstone, conglomeratic sandstone, shale and coal lenses, with some pyroclastic influence. The fine grain upper part of the column has the most of the microfloral and macrofloral fossil content. Finally, concordantly overlaying the Williams Point beds are laminar lava flows of basaltic composition unconformably overlain by polimictic volcanic breccias.

The samples from Punta Hannah were collected during the scientific expedition of 2007. The observed palynomorphs are in fine green feldspathic sandstone with chlorite-smectite alteration, that also contain macroflora.

Palynological record

Selected palynomorphs are illustrated in Figure 2. The palynological record of the lateral moraine deposits at the Aranda Glacier (Shirreff Cape) include Pteridophyta, Pinophyta and Dicotyledoneae. It is possible to distinguish two different palynological assemblages. The first (Type A) is dominated by Pteridophyta, mainly Cyatheaceae and Gleicheniaceae (*Cyathidites minor, C. australis, Clavifera triplex, Gleicheniidites senonicus, G. concavisporites, Trilites tuberculiformis, Deltoidospora* sp. and *Laevigatosporites ovatus*) and *Podocarpidites* spp. (*P. otagoensis, P.marwickii*), also *Myrtaceidites eugenioides* and epiphyllous fungal spores (mainly *Multicellaesporites* spp.). This assemblage is indicative of warm and humid conditions and an Early Cretaceous age has been assigned to it (Palma-

Heldt et al., 2004). The Type B assemblage is characterized by a subantarctic flora with *Nothofagidites (N. cranwelliae, N. flemingii, N. kaitangata, N. deminutus)*, *Araucariacites australis*, *Podocarpidites otagoensis, P. marwickii*, *Proteacidites parvus* and also epiphyllous fungal spores, typical of a cold and humid temperate climate. A Late Cretaceous age is assumed for this assemblage (Palma-Heldt et al., 2004; Leppe et al., 2003*)*.

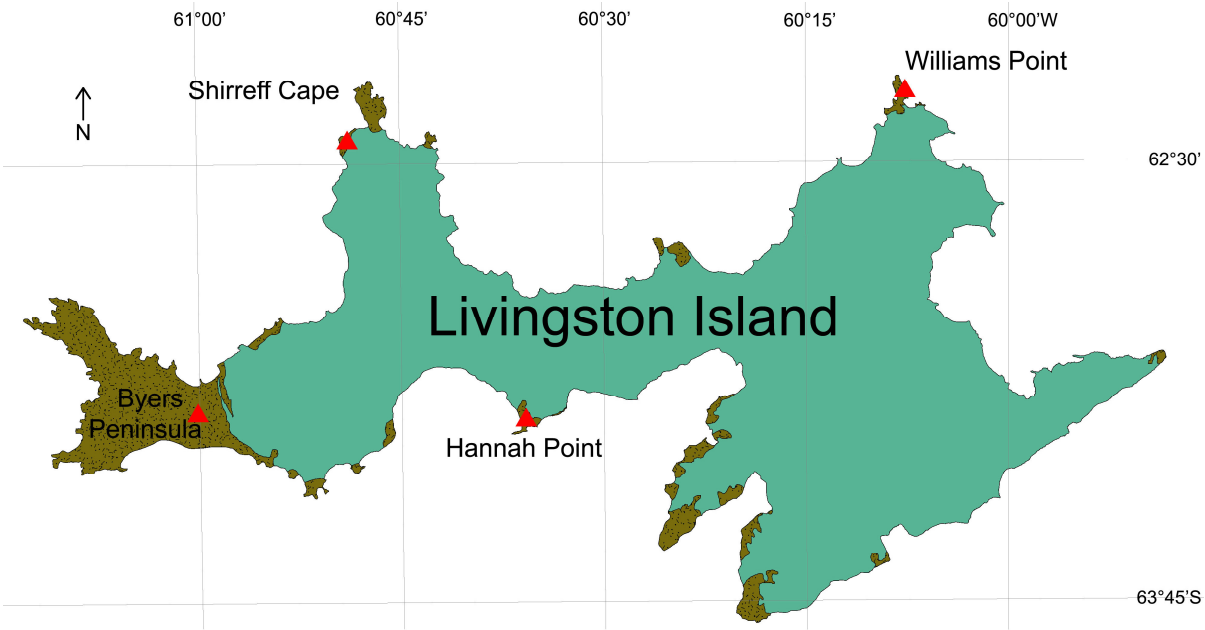

Figure 1. Sketch map of Livingston Island, showing the main ice-free areas (brown speckled shading) and sample localities (red triangles) during this project.

The palynological association from Byers Peninsula is characterized by abundant Pteridophyta (*Cyathidites minor, C. australis, Cyatheacidites annulatus, Gleicheniidites senonicus, G. circinidites, G. concavisporites, Clavifera triplex, Deltoidospora minor, Cibotiidites tuberculiformis, Cicatricosisporites australiensis, Matonisporites* sp., *Dictyophyllidites* sp. and *Laevigatosporites ovatus*), Pinophyta (*Podocarpidites ellipticus, P.otagoensis, P. marwickii, Araucariacites australis and Vitreisporites signatus*) and minor amounts of epiphyllous fungal spores.

Pollen grains of Magnoliophyta have not been observed in Byers Peninsula samples. The climate is inferred to have been warm temperate and very humid. The fern spores have botanical affinity with the Cyatheaceae, Dicksoniaceae, Gleicheniaceae, Schizaeaceae and Matoniaceae. The tree ferns of the Cyatheaceae and Dicksoniaceae are now of tropical distribution; indicators of a humid climate. The Gleicheniaceae are mainly distributed in modern tropical and subtropical regions. At Byers Peninsula, a humid coniferous forest (mainly Podocarpaceae) with abundant tree ferns and a warm temperate climate associated with high humidity is suggested. In agreement with the literature, these sequences would be Aptian-Albian age (Hathway and Lomas, 1998; Hathway et al.,1999).

The palynomorph assemblage from Williams Point samples is characterized by the presence of epiphyllous fungal spores (*Monoporisporites* sp., *Multicellaesporites* spp., *Granulatisporites* sp.), Pteridophyta (*Cyathidites minor, C. australis, Gleicheniidites circinidites, Laevigatosporites ovatus, Cicatricosisporites australiensis, Dictyophyllidites* sp.); Pinophyta (*Podocarpidites ellipticus, Microcachrydites antarcticus)* and Magnoliophyta (*Psilatricolpites* sp. and a high abundance of *Proteacidites parvus*). A Late Cretaceous age is suggested and is in agreement with radiometric ages (74 - 81 Ma, K-Ar) for the volcanic cover of the Williams Point Beds (Rees and Smellie, 1989).

The palynological record from the Hannah Point samples is dominated by Pteridophyta (*Gleicheniidites senonicus, G. circinidites, Cyathidites minor, Dictyophyllidites* sp.) and tricolpate pollen grains of a Magnoliophyta: *cf. Tricolpites pachyexinus*. There is a low frequency of *Podocarpidites marwickii* and epiphyllous fungal spores. A Late Cretaceous age, but later than the suggested Williams Point palynoflora age, is suggested.

Conclusion

It is concluded that the Pteridophyta-Pinophtya palynological associations found in moraine deposits at Cape Shirreff (Type A) are correlated with the palynoflora found at Byers Peninsula, interpreted to be Early Cretaceous in age (probably Aptian-Albian. The palynological association from Williams Point and Hannah Point samples is characterized by Pteridophyta, Pinophyta and Magnoliophyta with a probable Late Cretaceous age; the palynomorph assemblage of Hannah Point being later than the one observed from Williams Point. Whereas the macroflora record of

the Punta Hannah sequence suggests a Santonian-Campanian age. The palynological association Type B from Cape Shirreff is characterized by a subantarctic flora dominated by *Nothofagidites,* typical of a cold temperate and humid climate, with a probable Late Cretaceous-Paleogene age.

There are correlation studies between the Cretaceous sediments of the Byers Peninsula and Cretaceous formations in southern Chile and Argentina (e.g., Archangelsky and Césari, 2004; Troncoso et al., 2002). The palynological correlation between Cretaceous-Paleogene sequences from Antarctica and Patagonia contribute to the better understanding of the evolution of the southern Pacific Gondwana margin.

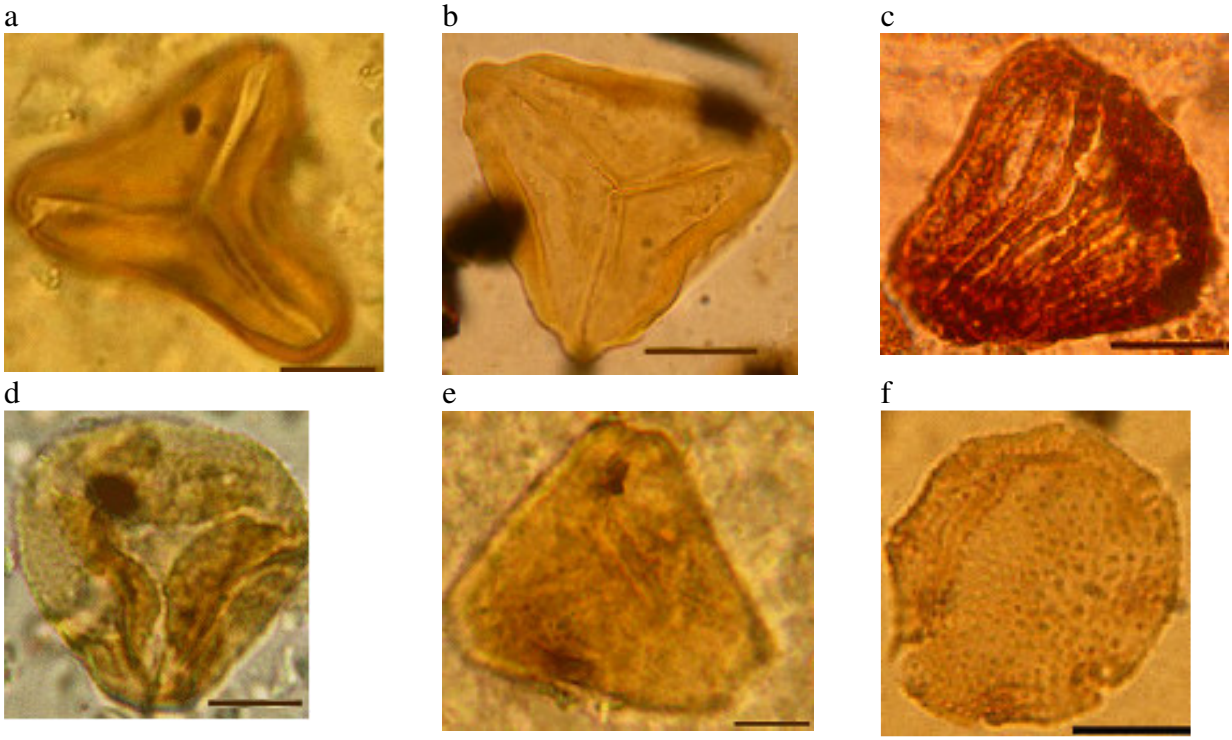

Figure 2. Photomicrographs of palynomorphs (10 µm scale bar). a, *Gleicheniidites concavisporites* (Rouse) Srivastava (Shirreff Cape); b, *Clavifera triplex* Bolkhovitina (Byers Peninsula); c, *Cicatricosisporites australiensis* (Cookson) Potonié (Byers Peninsula); d, *Microcachrydites antarcticus* Cookson (Williams Point); e, *Proteacidites parvus* Cookson (Williams Point); f, *Nothofagidites deminutus* Cookson (Shirreff Cape).

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