Late Cretaceous flora of James Ross Island (Antarctica) – preliminary report

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Abstract

Fossil plants from Late Cretaceous strata (Hidden Lake Formation and Santa Marta Formation) of James Ross Basin exposed in the northern part of the James Ross Island are preliminary described. Both formations contain plant mega fossils, petrified wood, and charcoalified mesofossils. Fossil plants from the Hidden Lake Formation are represented by leaf impressions of pteridophytes (*Microphyllopteris*, *Delosorus*, *Lygodium*), conifers (*Elatocladus*, *Brachyphyllum*, *Pagiophyllum*, *Araucaria, Podozamites* vel *Lindleycladus*), Bennettitales vel Cycadales (*Zamites* vel *Dioonites* sp.) and angiosperms (*Cinnamomoides, Dicotylophyllum* ssp., *Proteophyllum, Juglandiphyllum* vel *Dicotylophyllum*). Fossil wood can be attributed to the very broadly defined morphogenus *Antarctoxylon* Poole & Cantrill.

Key words: flora, leaf impressions, pteridophytes, conifers, angiosperms, Late Cretaceous, James Ross Basin

Introduction

The James Ross Island displays large sequence of Jurassic – Cretaceous sediments of the back-arc James Ross Basin (*e.g.* del Valle et al. 1992, Svojtka et al. 2009), which are full of fossils (Crame et al. 1991). Leaf impressions of terrestrial flora and silicified wood are known beside the well-preserved marine fauna. Our latest field investigations revealed also occurrence of charcoalified meso fossils, which will be referred elsewhere.

The Cretaceous floras of Antarctica are known from several deglaciated places, usually islands and nunataks (Hill et Scriven 1995); *e.g.* Falcon-Lang et Cantrill (2000) described the Late Albian flora from the Alexander Island; Eklund et al. (2004) described the Late Cretaceous flora from the Table Nunatak; Rees et Smellie (1989), and Poole et Cantrill (2001) studied the Late Cretaceous flora of the Livingston Island. From all those floras it

Received April 25, 2012, *accepted* May 16, 2012.
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Acknowledgement: We are grateful to Radek Vodrážka (Czech Geological Survey) for his help in the field and for loaning the specimens from the Czech Geological Survey. He is also acknowledged for providing as with basic geological data. The fieldwork at the Czech Johann Gregor Mendel Antarctic Research Station, northern James Ross Island, and collection of fossils in the field was financially supported by the R & D project No. SPII 1a9/23/07 of the Ministry of the Environments of the Czech Republic to the Czech Geological Survey.

is clear that the Cretaceous high-latitude climate was much wormer than today (*e.g.* Huber 1998).

The Late Cretaceous flora of the Hidden Lake and the Santa Marta Formations has not yet been comprehensively described although there are several reports based on fossil plants (Hayes et al. 2006), wood (Poole et Cantrill 2006) and palynomorphs (Dettmann et Thompson 1987, Keating 1992). The aim of this report is to describe preliminarily leaf impressions and mobilize interest in detailed studies of the Late Cretaceous flora of James Ross Basin as a key flora for understanding the Cretaceous plant associations of Antarctica.

This report is based on the collections gathered during two austral summer seasons in December 2008 - March 2009 and January - March 2010 with the help of Radek Vodrážka (CGS), when being at the Czech Antarctic Johann Gregor Mendel Research Station (63° 48' 5.6" S, 57° 53' 5.6" W) situated on the northern coast of the James Ross Island. The excavation of the Santa Marta Formation flora was interrupted in the field by a snowstorm and has not been found again.

The fossil flora was collected from the Hidden Lake Formation (Coniacian) and the Santa Marta Formation (Coniacian - Campanian). Angiosperm leaves of the flora were mentioned for the first time in the analysis of palaeoclimate published by Hayes et al. (2006). They provided line drawings of major angiosperm leaf morphotypes without their descriptions and taxonomic identifications. Sedimentological and taphonomic conditions of the flora are rather unusual. Virtually the whole flora is preserved in marine sediments, fine-grained sandstones, siltstones and calcareous concretions being accompanied with rich marine fauna.

Geological setting

Fossil plants preserved in major part as leaf impressions come from near-shore marine sediments of the James Ross Basin, northern part of the larger Larsen Basin (Elliot 1988, Macdonald et Butterworth 1990, del Valle et al. 1992, Hathway 2000). The Hidden Lake Formation of the Gustav Group is dated as Coniacian (McArthur et al. 2000, Riding et Crame 2002). It consists of 300 – 400 m of volcanoclastic conglomerates, sandstones and mudstones, which were deposited in relatively deep marine environment (Crame et al. 2006, Whitham et al. 2006). Sr isotope data suggest early- to mid-Coniacian age for the Hidden Lake Formation (McArthur et al. 2000, Riding et Crame 2002). The Santa Marta Formation of the Marambio Group conformably overlying the Hidden Lake Formation consists of more than 1000 m of silty and muddy sandstones and marls with concretionary beds. It was deposited mostly in shallow-marine low-energy shelf environment (Crame et al. 1991). The majority of fossil plants are found in the Lachman Crags Member of Santa Marta Formation, which is formed by sandstones and mudstones (Crame et al. 1991). Less frequently, fossil plants are recorded in the Herbert Sound Member of Santa Marta Formation, a sequence of monotonous sandstone-dominated lithologies (Crame et al. 1991). Sr isotope data suggests late Coniacian to late Campanian age for the Santa Marta Formation (McArthur et al. 2000).

Material and methods

The fossil flora, which is described in this paper, is preserved in two preservation modes: as mega fossils leaf impressions and as permineralized woods. The fossil plant mega fossils originating from the Hidden Lake Formation were collected in the north western part of the James Ross Island north of the Crame Col. The plant mega fossils from the Santa Marta Formation were collected in the vicinity of the Lachman Crags Member type section, on western slopes of Lachman Crags, but also from both sides of the Crame Col. Special care was given to document each sample in the field, including using the so-called "reference points" to which GPS coordinates and lithological/stratigraphical data were attributed. The studied material is stored in major part in the Czech Geological Survey, Prague and the Natural History Museum, Buenos Aires; several specimens are housed in the National Museum, Prague.

The plant mega fossils were sampled in the field and cut into small hand specimens by diamond saw to be suitable for transport. They were preliminary documented by digital camera Canon 300D and later studied under Olympus SZX 12 binocular microscope. Carbonate concretions were bulk macerated directly in place by 70% hydrochloride acid and neutralized in water.

Systematics

The Late Cretaceous floras of the James Ross Island are quite diversified consisting of pteridophytes, cycads/bennettits, conifers and diversified angiosperms.

Pteridophytes

Recorded ferns show similarities to the Matoniaceae (*Delosorus* sp.), Schizaeaceae (*cf. Lygodium* sp.), Gleicheniaceae (*Microphyllopteris* sp.) and perhaps Maratiaceae (pinnules with synangia). Several species of *Cladophlebis* with prevailing *Cladophlebis antarctica* Nathorst occur. The most common species among ferns is *Microphyllopteris* sp. (Pl. 1, Fig. 1). It is preserved as fragments of bipinnate fronds. This fern shows affinity to Gleicheniaceae or perhaps Lophosoriaceae, but without reproductive organs the identification remains doubtful.

Another common fern is *Delosorus* sp. It is preserved as fragmented pinnulae, pinnate or bipinnate fronds. Secondary pinnae consist of small triangular slightly decurrent pinnulae. Records of this fern in meso fossil material (umbrella shaped indusia) from the Santa Marta Formation confirm that it belongs to the Matoniaceae. One exceptionally well-preserved specimen belongs to *Lygodium* sp. (Pl. 1, Fig. 2). It is represented by a fragment of pinnate frond consisting of one lanceolate terminal pinnula and one shorter lateral pinnula of similar shape. It shows pinnate venation with forking secondaries.

Isolate pinnules of *Dicksonia* vel *Maratia* occur in a layer rich in charcoal. It is represented by fragments of ovate pinnules with dentate margin and pinnate venation showing secondary veins forked in basal parts. In some cases elongate synangia are preserved in marginal parts of the pinnulae.

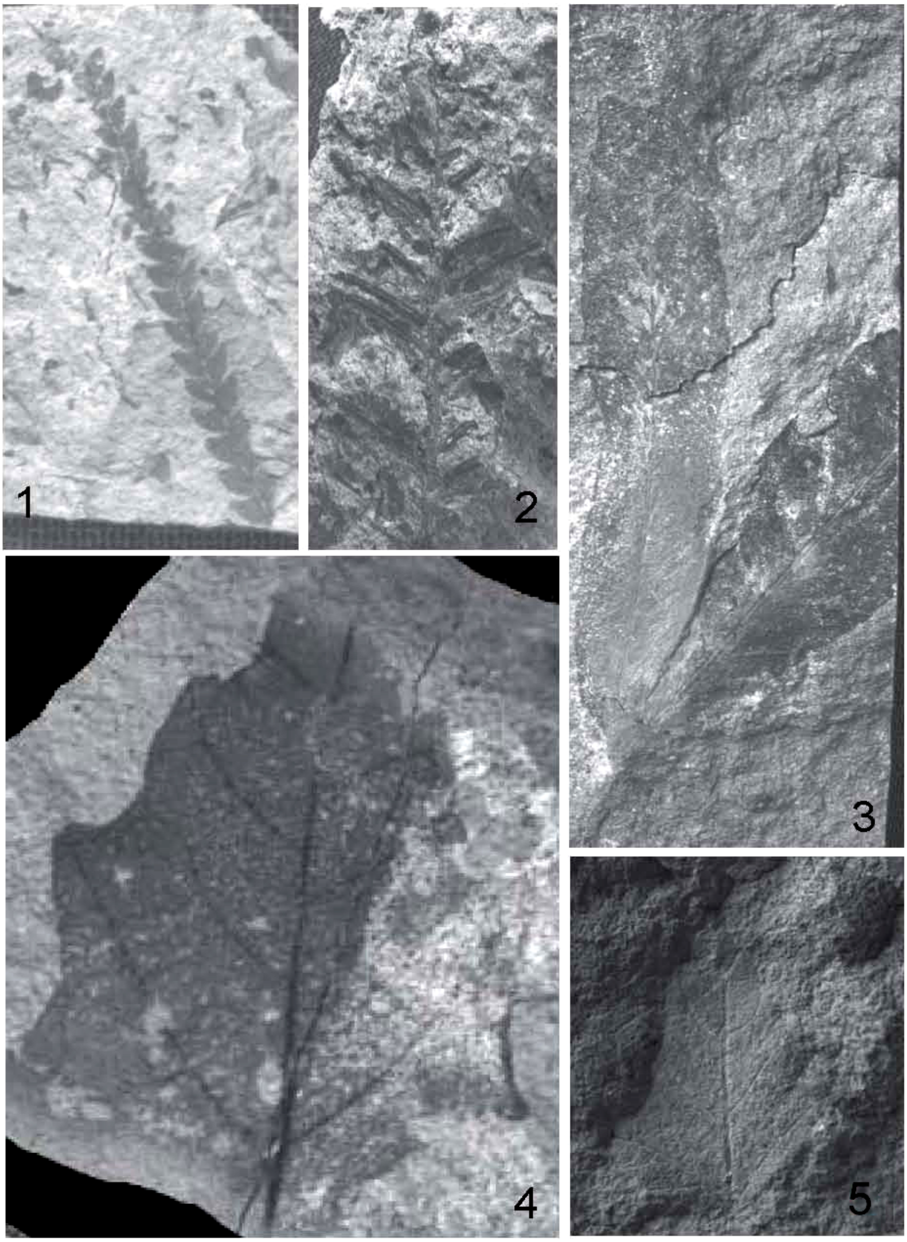

Plate 1. Explanation to the plate. Flora of the Hidden Lake Formation. Fig. 1 - *Microphyllopteris* sp., x 1; Fig. 2 - *Elatocladus* cf. *heterophylla* Halle, x 1.2; Fig. 3 - *Lygodium* sp., x 0.9; Fig. 4 - *Dicotylophyllum* sp. 2, x 1; Fig. 5 - *Dicotylophyllum* sp. 3, x 1.

Bennettitales vel Cycadales

Zamites vel *Dioonites* sp.

Entire-margined phylomes representing probably isolated pinnules of larger fronds of cycads or bennettits. They are parallel veined showing veins of the same thickness and running usually parallel to the phylum margins, sometimes anastomosing. Remarks: Without studying their cuticle, it remains open if the remains represent cycads or bennettits. Representatives of both groups are common in Cretaceous times.

Conifers

Conifers are usually preserved as twigs or cone scales (*Araucaria*). Among leaf impressions the most common is *Pagiophyllum*. There are two *Pagiophyllum* types, one *Brachyphyllum*-type, one *Elatocladus*-types and *Podozamites* vel *Lindleycladus* sp. Fragments of twigs *Elatocladus* cf. *heterophylla* Halle are common in particular parts of the Hidden Lake Formation. Each leaf shows contracted base and centrally placed vein (Pl. 1, Fig. 3). Two types of *Pagiophyllum* were recorded. One s-shaped triangular in cross-section (*Geinitzia* type), the second *Pagiophyllum* sp. 2 showing fragments of twigs with helically arranged leaves. Isolated parallel veined leaves of deltoid shape with auriculate base and acute apex are determined as cf. *Araucaria* sp. A fragment of a *Brachyphyllum* twig with helically and densely arranged leaves was recovered. Each leaf is slightly decurrent, ovoid in cross-section, slightly curved upwards with blunt apex.

Angiosperms

Prevailing part of the angiosperm remains consitsts of leaf impressions and their fragments. Hayes et al. (2006) was able to determine 41 morphotypes. However, none was described in binominal taxonomy. We have recorded 27 leaf morphotypes in the flora of the Hidden Lake Formation. In the Santa Marta Formation, we have recorded 11 leaf morphotypes. Also the systematic identification of the present leaf impressions is problematic except of entire-margined tri-veined leaves identified as *Cinnamomoides* Seward belonging to Laurales. Other leaf remains are identified as morpho-genera *Dicotylophyllum, Juglandiphyllum* or *Proteophyllum*.

The dicotyledon leaves are frequently asymmetrical indicating that they formed originally compound leaves. The leaves are usually fragmentary arguing for longer distance transport.

The most common leaf is represented by *Dicotylophyllum* sp. 1 showing large simple, oblong-elliptic entire-margined leaves with pinnate brochidodromous to camptodromous venation. *Cinnamomoides* shows large, simple, unlobed, oblong-elliptic, symmetric, entire-margined leaves. Venation palmately-pinnate, with well pronounced two basal secondary veins, brochidodromous. More than 5 pairs of secondary veins emerge from the midvein, secondary veins opposite in lower and middle parts of the leaf. The veins are simple or forking once, curving upwards and forming loops close to the leaf margin. Tertiary veins are thin, straight or slightly curved, percurrent. Another entire margined leaf is *Juglandiphyllum* vel *Dicotylophyllum* sp. showing small, simple, obovate leaves. It has pinnate brochidodromous to campto-dromous venation with secondary veins curving upwards, connecting with the upper secondary vein, forming loops close to the leaf margin, or forming, together with tertiary veins, a series of small loops near the leaf margin.

There are several leaves with dentate margin present in the flora. The most common type is *Dicotylophyllum* sp. 2 (Pl. 1, Fig.4) showing simple, lanceolate leaves with craspedododromous venation. *Dicotylophyllum* sp. 3 (Pl. 1, Fig. 5) exhibits small, trilobate, often asymmetric leaves. Its two small lateral lobes are triangular, with acute apices. Venation is palmately-pinnate, brochidodromous with basal veins emerging from leaf base.

Fossil wood

Almost 350 specimens of fossil wood were collected during the field season in January–February 2010. They originate from the vicinity of the Brandy Bay, as well as from the area between Johann Gregor Mendel Station and the Crame Col in the northern James Ross Island. Sampled specimens cover Whisky Bay and Hidden Lake Formations of the Gustav Group and the lower part of the Santa Marta Formation of the Marambio Group. As a result, they represent a very complete, stratigraphically well-defined and geologically characterized source of information, mainly with respect to the time interval Cenomanian–Turonian, which is otherwise rather poorly documented (compare Tab. 1 in Cantrill et Poole 2005). The preservation of the woods is rather unsuitable for any detailed systematic study. However, we can confirm that they all belong to conifers. One sample (No. CGS A.061F.W2C) from the upper part of the Hidden Lake Formation, Coniacian in age, represents an angiosperm. The wood is diffuse-porous with wide rays and scalariform perforation plates in vessels. It can be attributed to the very broadly defined morphogenus *Antarctoxylon* Poole & Cantrill as a new species.

Conclusions

The volcanoclastic Late Cretaceous marine sediments of James Ross Basin although developed in marine environment preserve information about terrestrial ecosystems, particularly about diversified plant assemblages. Plant mega fossils of these formations provide important insights in terrestrial ecosystems of the Antarctic Peninsula and surrounding area and can considerably increase our understanding of the Cretaceous Antar-ctica environment.

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