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Palynofacies as indicators of paleoenvironmental changes in a Cretaceous succession from the Larsen Basin, James Ross Island, Antarctica

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ABSTRACT

In order to reconstruct the paleoenvironment of one of the most extensive marine Cretaceous successions in the Southern Hemisphere, palynofacies analyses were conducted on 83 samples from the Whisky Bay (Albian–Turonian), Hidden Lake (Coniacian) and Santa Marta (Santonian–Campanian) formations in the Larsen Basin, James Ross Island, Antarctica. Categories of particulate organic matter were counted and investigated by cluster analysis. The trends and parameters of palynofacies constituents were used to reconstruction paleoenvironments based on the existing sedimentological interpretation. The stratigraphic distribution of the four identified palynofacies associations (A–D) reflects a continuous terrestrial influx throughout the succession. From base to top, a conspicuous increase in woody elements, especially non-opaque particles, is observed. This increase in continental elements occurs despite the presence of marine elements. This finding corroborates the sedimentological interpretation of a deeper water paleoenvironment during deposition of the Whisky Bay Formation and initiation of a shallowing-upward trend in the Hidden Lake Formation, culminating with shallow marine shelf environment of the Santa Marta Formation.

1. Introduction

Palynofacies analysis is an interdisciplinary approach toward paleoenvironmental reconstruction. Rather than limiting the investigation to palynomorphs in palynological residue, the entire organic content is investigated. Particulate organic matter is viewed as a sedimentary component that reflects the original conditions of the source area and in the depositional environment. The composition and proportion of sedimentary organic matter deposited in marine paleoenvironments are directly related to sea level, as shown by many authors (e.g., Gorin and Steffen, 1991; Tyson, 1995; Bombardiere and Gorin, 2000; Oboh-Ikuenobe et al., 2005).

The Larsen Basin contains one of the most extensive marine Cretaceous successions in the Southern Hemisphere (Francis et al., 2006). The outcrops of the Albian–Campanian deposits analyzed in this study are located on northern James Ross Island (Fig. 1) and include three formations: Whisky Bay (Albian–Turonian), Hidden Lake (Coniacian) and Santa Marta (Santonian–Campanian). On the basis of the stratigraphic distribution of sedimentary organic matter, we report a long-term regression trend related to changes in relative sea level and, hence, variations in local paleoenvironments.

2. Geological setting

The Larsen Basin is a major sedimentary basin on the eastern side of the Antarctic Peninsula (Fig. 1). This basin was developed in a back-arc setting with respect to a volcanic arc formed by subduction of a proto-Pacific oceanic crust beneath Gondwana (Macdonald et al., 1988; Hathway, 2000). The opening of the Weddell Sea may have been responsible for oblique extension along the eastern margin of the Antarctic Peninsula volcanic arc and may have influenced the evolution of back-arc sedimentary basins from the Late Jurassic to the Late Cretaceous (Storey and Nell, 1988; Storey et al., 1996). The Larsen Basin subsidence began in Jurassic times as a result of continental rifting during the early stages of the breakup of Gondwana, and its sediment fill was wholly derived from the volcanic arc. The northern part of the Larsen Basin was defined as the James Ross Sub-basin by Del Valle and Fourcade (1992). The volcano-sedimentary sequences are best exposed on and around James Ross Island (Fig. 1), where a nearly complete Aptian–Eocene succession crops out.

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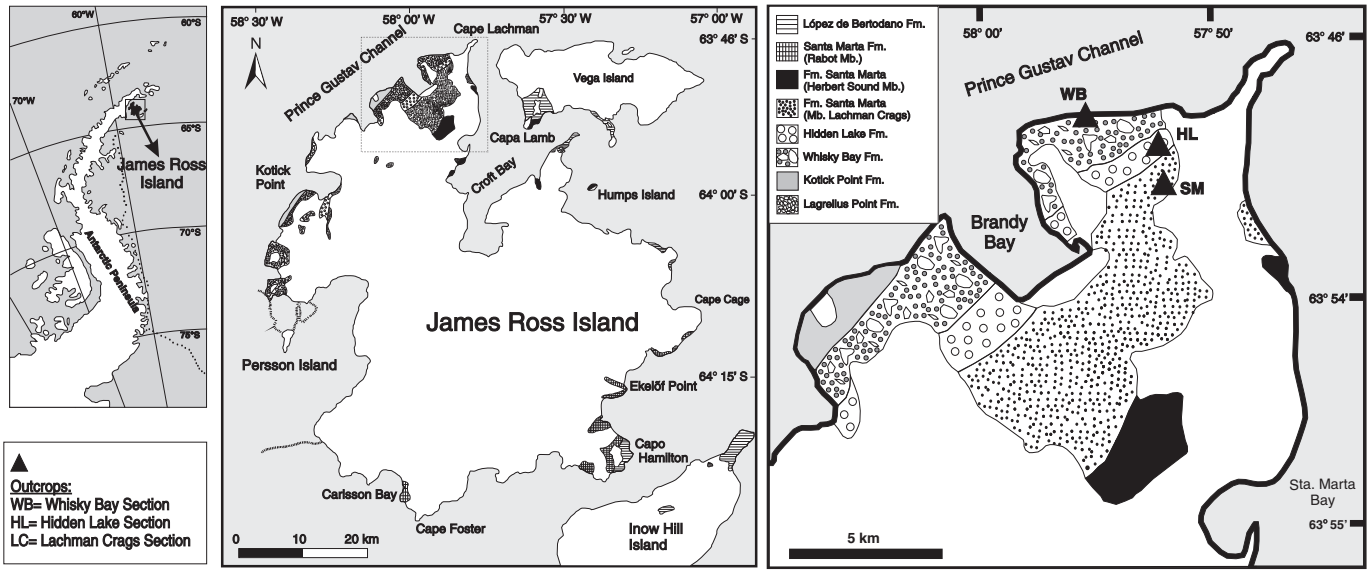

Fig. 1. Location map showing the studied outcrops of the formation sampled.

2.1. Lithostratigraphy

In the northern part of James Ross Island, the Cretaceous succession is represented by the Gustav Group and by the basal strata of the Marambio Group (Fig. 2). The marine sediments of the Gustav Group are exposed within this marginal flexured zone along the northwestern coast of James Ross Island. The volcano-sedimentary successions included in the Gustav Group (Fig. 2) were deposited in a deep marine setting and represent proximal submarine-fan and slope-apron depositional systems (Ineson, 1989).

The Marambio Group is 2.5 km thick and is exposed over the largest part of the James Ross Basin. This group comprises a variety of fine- to medium-grained sandstones, siltstones and silty mudstones, with minor coarser-grained intervals, coquinas and other shell beds (Crame et al., 2006). Pirrie et al. (1997) subdivided the Marambio Group into three formations: the Santa Marta, Snow Hill Island and López de Bertodano formations. The Marambio Group was deposited from inner- to outer-shelf settings (Macellari, 1988; Pirrie, 1989; Pirrie et al., 1991; Scasso et al., 1991; Olivero, 2011). According to Olivero (2011), this group represents the construction of a prograding shelf.

2.1.1. Whisky Bay Formation

The Whisky Bay Formation is an extremely variable unit, exhibiting rapid changes in lateral facies and a variation in total thickness from 720 to 950 m. This formation comprises clast-supported conglomerates and pebbly sandstones, interbedded with finer-grained sandstones and silty mudstones. It is interpreted as a slope-apron and submarine fan deposit (Ineson, 1989; Buatois and López-Angriman, 1992; Riding and Crame, 2002). This unit is subdivided into three members: Bibby Point, Lewis Hill and Brandy Bay. According to Riding and Crame (2002), it is not possible to demonstrate precise lateral equivalence between these units because of the high lateral variability of the Whisky Bay Formation.

The Bibby Point Member is composed of dark green channelized and graded pebble conglomerates interbedded with pebbly sandstones, sandstones and scarce mudstones. Macrofauna and palynological data indicate a mid-late Albian age range (Ineson et al., 1986; Riding and Crame, 2002). The Lewis Hill Member has middle-late Albian age affinities based on macrofossils, and the record of Australasian flora affinities indicates a latest Albian age (Morgan, 1980; Riding and Crame, 2002). The Lewis Hill Member is dominated by cobble conglomerates with minor intercalated pebbly sandstones and mudstones (Crame et al.,

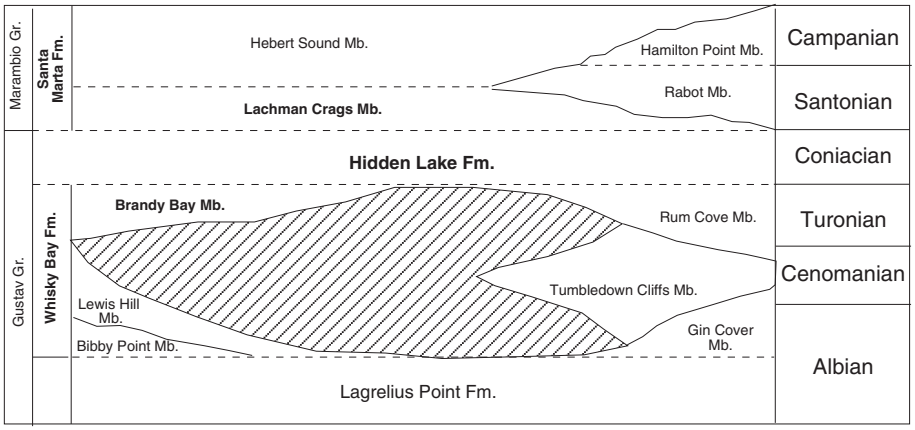

Fig. 2. Lithostratigraphic scheme of the Cretaceous sedimentary strata on the James Ross Island (adapted from Pirrie et al., 1997; Crame et al., 2006). The names in bold letters indicate the studied formations and members. Hatched area = erosional hiatus.