Palaeogeography, Palaeoclimatology, Palaeoecology 402 (2014) 55–72

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

journal homepage: www.elsevier.com/locate/palaeo

Stratigraphy and vertebrate paleoecology of Upper Cretaceous–?lowest Paleogene strata on Vega Island, Antarctica

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ARTICLE INFO

Article history:
Received 24 October 2013
Received in revised form 18 February 2014
Accepted 3 March 2014
Available online 11 March 2014

Keywords:
Vertebrates
Stratigraphy
Antarctica
Paleoecology
Cretaceous
Vega Island

ABSTRACT

The Upper Cretaceous (Maastrichtian) Sandwich Bluff Member of the López de Bertodano Formation is well exposed on Vega Island in the James Ross Basin off the northeastern coast of the Antarctic Peninsula. Although this unit is one of the richest sources of end-Cretaceous vertebrate fossils in Antarctica, it is also one of the least sedimentologically and stratigraphically characterized units in the basin. New facies and stratigraphic analyses of the Sandwich Bluff Member and the underlying Cape Lamb Member of the Snow Hill Island Formation were performed in tandem with intensive prospecting for fossil vertebrates and stratigraphic assessment of historic paleontological localities on Vega Island. This effort has led to a revised stratigraphy for the Sandwich Bluff Member and the precise stratigraphic placement of important terrestrial and marine vertebrate fossil localities. Facies analysis reveals a fining and shallowing upward trend through the section that culminates in a newly recognized sequence boundary near the top of the Sandwich Bluff Member, followed by the deposition of a previously unrecognized, 6 m-thick, matrix-supported pebble–cobble conglomerate of probable alluvial origin. Immediately overlying this unit, well-developed *Thalassinoides* burrow networks in fine-grained transgressive sandstones and siltstones indicate a rapid return to marine conditions. A similar stratigraphic pattern is well documented at the top of the López de Bertodano Formation and the base of the overlying (Paleocene) Sobral Formation on Seymour Island in the southern part of the basin. Although no fossils were recovered to constrain the age of the upper 10–15 m of the succession on Vega Island that preserves the newly recognized upper sequence boundary, strata below this level can be confidently placed within the *Manumiella bertodano* interval zone, which extends to a short distance below the K–Pg boundary on Seymour Island. Hence, based on sequence stratigraphic and lithostratigraphic evidence, the uppermost 10–15 m of the succession on Vega Island may encompass the Cretaceous–Paleogene boundary together with a few meters of the Paleocene Sobral Formation.

1. Introduction

The James Ross Basin (JRB), located off the northeastern margin of the Antarctic Peninsula, provides the most extensive record of Upper Cretaceous strata exposed at present anywhere in Antarctica. Richly fossiliferous, predominantly nearshore shallow marine beds are exposed on James Ross, Vega, Seymour, Snow Hill, Cockburn, Humps, and a few other, smaller islands in the JRB. Sites in this archipelago collectively preserve over 2000 m of exposed Cretaceous strata that range in age from the Albian to the Maastrichtian. These units have yielded an exceptional marine invertebrate record plus a sparse but critical snapshot of Antarctic end-Mesozoic floras and vertebrate faunas (e.g., Olivero et al., 1986; Gasparini et al., 1987; Macellari, 1988; Pirrie, 1989; Zinsmeister et al., 1989; Crame et al., 1991; Olivero et al., 1991; Pirrie et al., 1991; Marenssi et al., 1992; Crame et al., 1996; Zinsmeister and Feldmann, 1996; Pirrie et al., 1997; Rich et al., 1999; Case et al., 2000; Olivero and Medina, 2000; Césari et al., 2001; Marenssi et al., 2001; Chatterjee, 2002; Francis and Poole, 2002; Crame et al., 2004; Clarke et al., 2005; Martin and Crame, 2006; Case et al., 2007; Cerda et al., 2012; Tobin et al., 2012; Bowman et al., 2013; Reguero et al., 2013, in press).

Among the most significant terrestrial vertebrate discoveries from the Upper Cretaceous of the JRB are birds and non-avian dinosaurs (e.g., Chatterjee, 1989; Case et al., 2000; Chatterjee, 2002; Novas et al.,

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http://dx.doi.org/10.1016/j.palaeo.2014.03.005
0031-0182/

2002; Clarke et al., 2005; Case et al., 2007; Tambussi and Acosta Hospitaleche, 2007; Reguero et al., 2013, in press). Although scattered remains of these groups have been found throughout the basin (Gasparini et al., 1987, 1996; Reguero and Gasparini, 2006; Reguero et al., in press), arguably the most productive and important locality for Antarctic Cretaceous dinosaurs (including birds) has been the area encompassing Cape Lamb and Sandwich Bluff on the western half of Vega Island (Hooker et al., 1991; Thomson and Hooker, 1991; Milner et al., 1992; Noriega and Tambussi, 1995; Case and Tambussi, 1999; Case et al., 2000; Case, 2001; Case et al., 2001; Cordes, 2001, 2002; Case et al., 2003; Clarke et al., 2005; Case et al., 2006; Chatterjee et al., 2006; Tambussi and Acosta Hospitaleche, 2007; Reguero et al., 2013, in press). A considerable number of these discoveries are derived from an isolated exposure of the Sandwich Bluff Member of the López de Bertodano Formation that forms the top of the exposed Cretaceous section on the island (Noriega and Tambussi, 1995; Case et al., 2000; Case, 2001; Case et al., 2001, 2003; Clarke et al., 2005; Case et al., 2006; Tambussi and Acosta Hospitaleche, 2007; Reguero et al., in press). Exposed almost exclusively along the flanks of Sandwich Bluff (Figs. 1–2), this section has been proposed to comprise marine and possibly terrestrial facies (Olivero, 2012); however, it is among the least-studied of all stratigraphic units in the JRB.

Previous investigations (Pirrie et al., 1991; Marenssi et al., 2001; Crame et al., 2004) have provided a basic stratigraphic and sedimentological framework for the Sandwich Bluff Member. Nevertheless, the limited understanding of the stratigraphy and depositional setting of this unit is problematic in light of the fact that its fossil vertebrate assemblage includes some of the most evolutionarily and paleobiogeographically significant non-avian dinosaur and bird remains yet recovered from the Cretaceous of Antarctica. Foremost among these are an isolated tooth of a hadrosaurid ornithopod dinosaur (Case et al., 2000) and the only described partial skeleton of the anseriform bird *Vegavis iaai* (Noriega and Tambussi, 1995; Clarke et al., 2005). Both of these records are important in that they document the presence of these clades in the Antarctic during the Cretaceous; moreover, the hadrosaurid tooth constitutes compelling evidence for Late Cretaceous terrestrial vertebrate dispersal from South America to Antarctica (Case et al., 2000). *Vegavis* is also of paramount importance in that it is the only unquestioned representative of an extant (i.e., crown) avian lineage (Anseriformes, e.g., ducks and geese) yet known from pre-Cenozoic strata anywhere in the world. Its latest Cretaceous occurrence helps to establish that the diversification of Neornithes—the group that includes all modern birds—was underway by this time (Clarke et al., 2005).

The growing significance of the vertebrate fauna of the Sandwich Bluff Member, along with a relative scarcity of high-resolution stratigraphic, taphonomic, and paleoenvironmental information from this unit (Pirrie et al., 1991; Marenssi et al., 2001), prompted the review and investigation reported herein. The results of this study provide a refined stratigraphic framework for Cretaceous deposits on Vega Island. Furthermore, the review and synthesis of the sedimentological and paleontological data shed critical light on paleoecosystems that developed along a polar Gondwanan coastline near the close of the Mesozoic.

2. Geologic background

The James Ross Basin extends several hundred km into the Weddell Sea (del Valle et al., 1992; Hathway, 2000). Cretaceous–Paleogene (K–Pg) exposures in the JRB are limited to a handful of ice-free areas, principally on James Ross, Seymour, Snow Hill, Vega, and a few other, smaller islands (Fig. 1). The JRB developed as a back-arc basin along

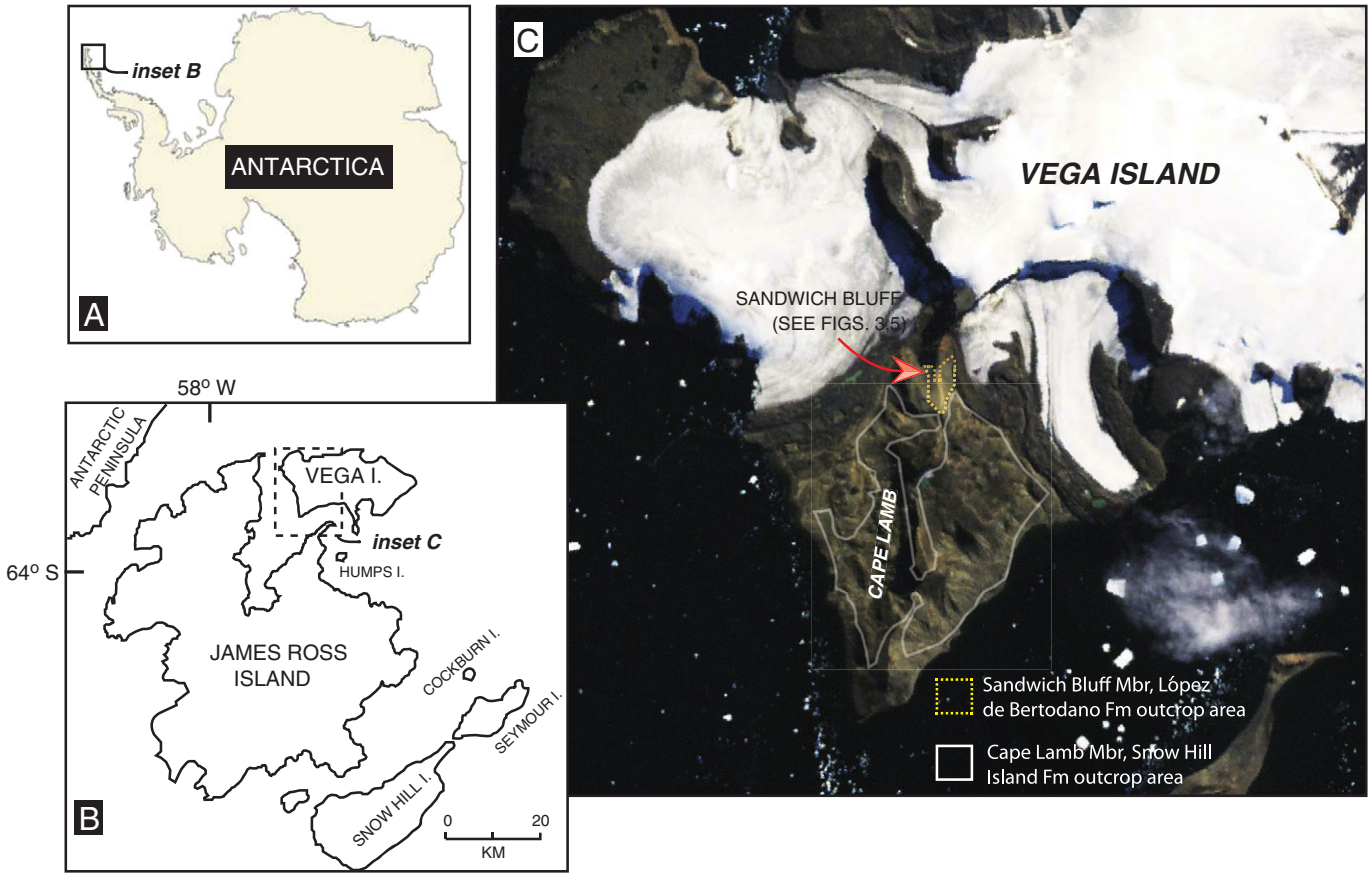

Fig. 1. Location of study area. A) Map of Antarctica showing location of northern Antarctic Peninsula and adjacent James Ross Island Group (box). B) Map of James Ross Island Group showing location of western Vega Island (and northern Naze peninsula of James Ross Island) (box). C) NASA LandSat image of western Vega Island (and northern Naze peninsula) showing outcrop distribution of studied Upper Cretaceous units. Abbreviations: Fm, Formation; I, island; Mbr, Member.