Palaeogeography, Palaeoclimatology, Palaeoecology 413 (2014) 101–122

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

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

Cenomanian to Santonian radiolarian biostratigraphy, carbon isotope stratigraphy and paleoenvironments of the Sverdrup Basin, Ellef Ringnes Island, Nunavut, Canada

Adam T. Pugh [a,1], Claudia J. Schröder-Adams [a,*], Elizabeth S. Carter [b], Jens O. Herrle [c,f], Jennifer Galloway [d], James W. Haggart [e], Julie L. Andrews [a], K. Hatsukano [c]

[a] Department of Earth Sciences, Carleton University, Ottawa, Ontario K1S 5B6, Canada
[b] Department of Geology, Portland State University, Portland, OR 97207-0751, USA
[c] Institute of Geosciences, Goethe-University Frankfurt, D-60438 Frankfurt am Main, Germany
[d] Geological Survey of Canada, 3303-33 St. NW, Calgary, Alberta T2L 2A7, Canada
[e] Geological Survey of Canada, 1500-605 Robson Street, Vancouver, British Columbia V6B 5J3, Canada
[f] Biodiversity and Climate Research Centre (BIK-F) D-60325 Frankfurt am Main, Germany

ARTICLE INFO

Article history:
Received 26 August 2013
Received in revised form 11 June 2014
Accepted 16 June 2014
Available online 25 June 2014

Keywords:
Cretaceous
Radiolaria
Arctic
Sverdrup Basin
Paleoproductivity
Carbon isotope stratigraphy

ABSTRACT

An upper Albian to Santonian sedimentary record on Ellef Ringnes Island, Canadian Arctic Archipelago, records variable paleoenvironmental conditions within the Cretaceous Polar Sea and Sverdrup Basin. The upper Albian to lower Cenomanian uppermost Christopher and Hassel formations represent a regressive system tract from offshore to shoreface/terrestrial paleoenvironments. The upper Cenomanian to Santonian shales of the Kanguk Formation signify a distal offshore basin setting controlled by increased subsidence and high global sea levels. Siliceous pelagic faunas and floras dominate the basin and herein, three informal radiolarian partial range zones are proposed for the Polar Sea. Alternating diversity and abundance patterns are interpreted as a response to sea-level controlled productivity systems. Transgressive phases correspond to low diversity shallow dwelling radiolarian taxa with an expanded oxygen minimum zone (OMZ); regressive phases are coupled with radiolarian radiations of deeper dwelling species and a depressed OMZ. The upper Cenomanian to Turonian was marked by increased preservation of marine-type organic matter and organic carbon isotope excursions indicate the presence of the Oceanic Anoxic Event 2 (OAE 2) at the base of the Kanguk Formation. Rock Eval data suggest that an increasing terrestrial influence prevailed during the Coniacian to Campanian time covering the OAE 3. Benthic environments are dominated by anoxic conditions, as suggested by the near lack of benthic foraminifera and extensive intervals of fine platy shale lacking bioturbation. Only the upper Coniacian records a return to dysoxic benthic conditions. Radiolarian faunal comparisons to more southern localities suggest migration routes from the east through a narrow North Atlantic pathway and from the Pacific through the Alaskan–Asian Pathway.

1. Introduction

During the Cretaceous Period, the climate–ocean system was in flux due to increases in tectonism, global surface and deep-water temperature, atmospheric and oceanic CO_2 concentrations, and Oceanic Anoxic Events (OAEs) (e.g. Price, 1999; Leckie et al., 2002; Hay, 2011; Föllmi, 2012; Friedrich et al., 2012). Polar regions may have experienced ice-free summers during the mid-Cretaceous, resulting in increased sea levels and flooding of interior basins (e.g. Barron, 1983; Price, 1999; Huber et al., 2002). Resulting large variations in sea level caused significant paleogeographic changes (e.g. Jeletzky, 1970; Haq et al., 1987; Ziegler and Rowley, 1998; Miller et al., 2005).

Micropaleontological studies throughout the Cretaceous Polar Realm are sparse and limited biostratigraphic resolution to this date has precluded formal subdivision of the upper Cenomanian to Campanian aged Kanguk Formation. Carbon isotope stratigraphy is also lacking from the Cretaceous Sverdrup Basin. This study is part of a multi-fossil biostratigraphic, chemostratigraphic and paleoenvironmental analysis of the Cretaceous Arctic, and addresses radiolarian assemblages that have to our knowledge not been studied in detail in the Cretaceous Sverdrup Basin. Within Canada and especially within the Cretaceous, very few studies have attempted their use as pelagic biostratigraphic index fossils, although references to the presence of Radiolaria throughout the Sverdrup Basin and the Western Interior Sea have been noted for many years (e.g. Wall, 1975, 1983; Sliter, 1981;

* Corresponding author. Tel.: +1 613 520 2600x1852; fax: +1 613 520 5613.
E-mail address: Claudia.schroderadams@carleton.ca (C.J. Schröder-Adams).
[1] ConocoPhillips Canada, 401 9thAvenue SW, Calgary, Alberta, T2P 3C5, Canada.

http://dx.doi.org/10.1016/j.palaeo.2014.06.010
0031-0182/

Stelck et al., 2007; Haggart et al., 2013). Due to their generally poor preservation, these studies note their occurrence but lack thorough descriptions and biostratigraphic ranges. The Kanguk Formation on Ellef Ringnes Island yields a relatively rich radiolarian assemblage that allows to refine paleoceanographic and paleoenvironmental reconstructions of the Canadian Polar Sea. Thus, our objectives are as follows: a) provide a facies analysis in order to document the paleoenvironmental change from a deltaic Hassel Formation to a deep-water Kanguk Formation; b) document biostratigraphic ranges of radiolarians for the uppermost Cenomanian to Santonian interval within the Sverdrup Basin; c) correlate radiolarian faunal changes with other microfossil and macrofossil occurrences, global transgressive/regressive mega cycles as proposed by Gradstein et al. (2012) and geochemical data including a carbon isotope record to improve our understanding of the complex Cenomanian to Santonian paleoenvironmental history of the Sverdrup Basin, and the Polar Realm under greenhouse conditions as a whole.

2. Geological setting

This study addresses Upper Cretaceous strata at Hoodoo Dome (Fig. 1), an anhydrite diapir, on Ellef Ringnes Island nearly centered within the Sverdrup Basin in the Canadian High Arctic. Most topography

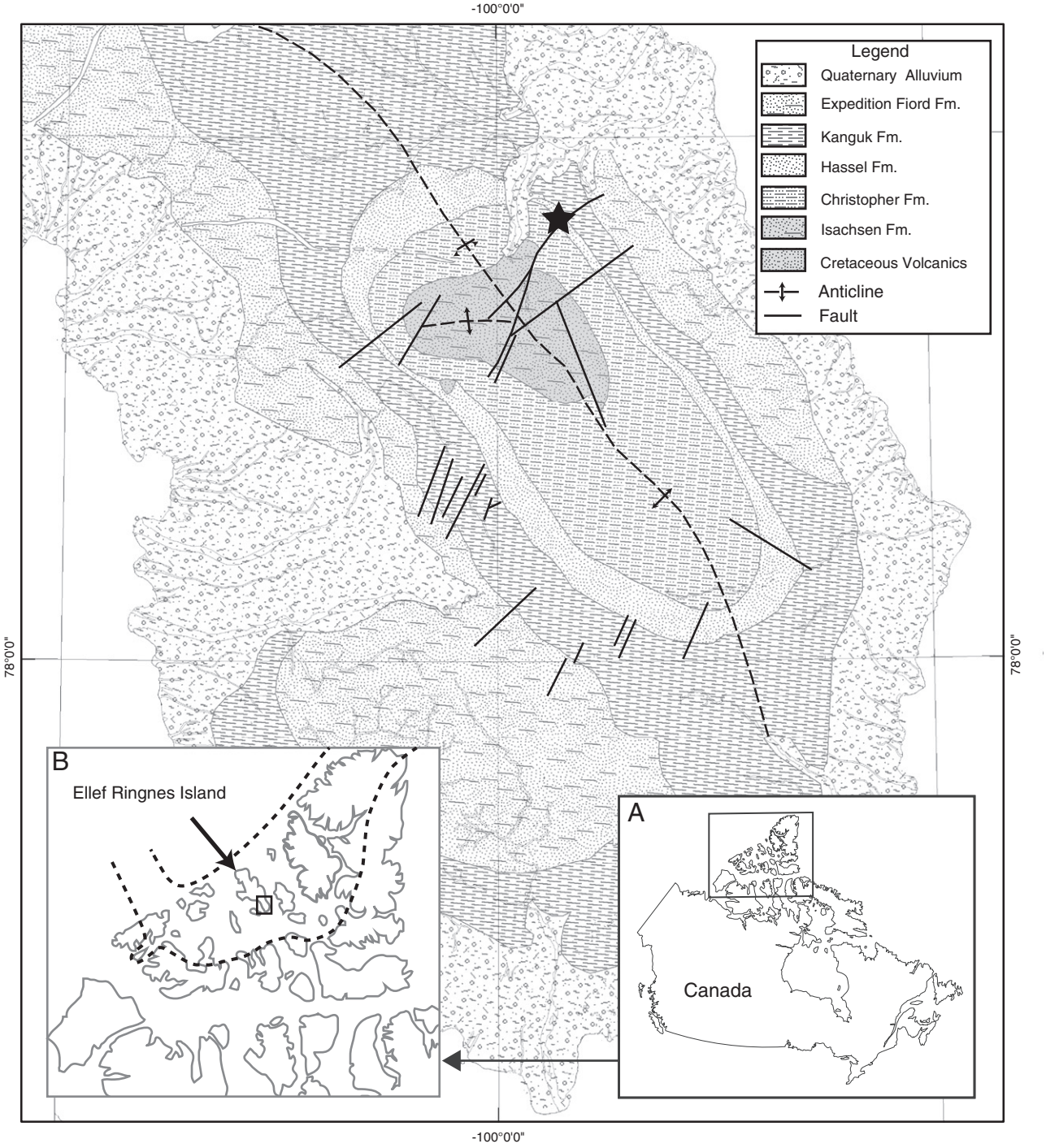

Fig. 1. Geologic map of Hoodoo Dome on Ellef Ringnes Island, redrafted from Stott (1969). Inset A shows the position of the Queen Elizabeth Islands in northern Canada and the outline of inset B; inset B shows the location of Hoodoo Dome relative to the Canadian Arctic Archipelago and the outline of the Sverdrup Basin indicated by dashed lines. Star marks study locality. Modified after Embry and Beauchamp (2008).