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North Atlantic climatic events recorded in Aptian Naskapi Member cores, Scotian Basin

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ABSTRACT

Early Aptian black laminated organic mudstones, including the Selli Level, are recognized over large areas of Tethys and western European basins. This interval was investigated in a 75 m-thick continuously cored section of varicoloured shale in the lower Naskapi Member from the Panuke B-90 well in the Scotian Basin, offshore eastern Canada. This study complements the palaeogeographic range of correlatable Selli black shales and provides information on their relationship to sea-level change and palaeoclimate. Total organic carbon (TOC) was measured on 127 discrete samples, chemical environmental proxies (Th/K, Mn/Ti, K/Ti, Th/Ti, V/Ti) were measured with a portable X-ray fluorescence (pXRF) spectrometer, and colour parameters L*a*b* were measured by spectrophotometer. Several black shale levels are recognized and correlated with similar shales in Europe between the Barremian–Aptian boundary and the Selli Level. The Th/K ratio proxy for hinterland humid or arid climate conditions shows no systematic variation with black shale levels. Several sea-level lowstands are inferred from condensed sandy intervals with some brackish water biota and tidal sedimentary structures. Black shale intervals are found in highstand intervals, with no systematic relationship to inferred transgressions. The formation of black shales is related to palaeoceanographic changes that may be driven by conditions remote from the Scotian Basin.

1. Introduction

The Early Cretaceous was a period when the breakup of Pangaea accelerated, resulting in increases in ocean floor spreading and both terrestrial and marine volcanic activity. Climatic changes, on a million-year scale, are interpreted from the sedimentary record (Föllmi, 2012), and fluctuate between arid or normal greenhouse and humid or intensified greenhouse conditions in the western Tethyan region. Such climatic fluctuations allowed for the preservation of dark, laminated organic-rich muds (LOM), which occur as discrete layers in outer shelf, slope and basinal sediments. During the humid periods, dys- and anaerobic conditions in deeper ocean waters developed, resulting in deposition of black shales, such as the Selli Level in the Early Aptian in the Tethys Basin (Föllmi, 2012). Such episodes of environmental change often resulted in extensive LOM intervals, known as oceanic anoxic events (OAE), throughout the Cretaceous of western Tethys and its marginal seas (Arthur et al., 1990; Erba, 1994; Erba et al., 2010). These episodes also led to a decrease of carbonate nannofossils and the increase of phytoplankton production, resulting from an increase in weathering, erosion, run-off rates and elevated nutrient levels from continents into oceans (Weissert and Erba, 2004).

The Scotian Basin developed at the northwestern margin of the opening North Atlantic Ocean in the Jurassic and by the Early Cretaceous was equivalent in palaeolatitude to western Europe, including the Tethys and Lower Saxony basins, showing similar palaeoclimatic events such as the Aptian Selli Event (Weston et al., 2012; Gould et al., 2014). Zhang et al. (2014), using bulk-sediment geochemical data, showed evidence of greater weathering and humid climate in the Valanginian to Aptian in the hinterland of the Scotian Basin. Gould et al. (2014) correlated warm humid intervals from European sections in Late Hauterivian, Early Aptian and Late Aptian to the Scotian Basin, using spectral gamma log data to assess the weathering of illite to kaolinite.

This study investigates whether LOM intervals in a continuously cored section of the Early Aptian at the Panuke B-90 well can be used to refine stratigraphic correlation with western European sections. Shales were analyzed by portable X-ray fluorescence (pXRF) for selected elements and by spectrophotometry for colour. The specific

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objectives of this study were to: (i) examine and evaluate the limitation and significance of pXRF and colour spectrophotometry on in-situ core and powdered cutting samples, (ii) refine Early Aptian stratigraphic correlation of the Panuke B-90 well with sections in Europe; (iii) establish depositional environment of sediments, interpret them in terms of sea level fluctuations, identify thus Early Aptian climatic and palaeoceanographic events in the Scotian Basin and correlate them with similar events in western Europe; and (iv) test hypotheses of climate or sea level control of LOM intervals.

2. Geological setting

The Scotian Basin is a Mesozoic–Cenozoic passive margin basin on the Atlantic margin of south-eastern Canada (Fig. 1A; Wade and MacLean, 1990). It was initiated during the rifting of Pangaea and the opening of the North Atlantic Ocean in the Triassic and earliest Jurassic (Withjack et al., 2009). Following the rifting, the basin received abundant sand in the Late Jurassic to Early Cretaceous. The resulting deltaic deposits comprise the Mississauga and Logan Canyon formations, which are composed of deltaic, fluvial, and nearshore sandstones, with the shaly Naskapi Member at the base of the Logan Canyon Formation (Fig. 1B; Wade and MacLean, 1990).

During deposition of Naskapi Member, the rivers draining Labrador that transported the sands to the deltaic deposits of the Missisauga and Logan Canyon formations were blocked by uplift of the Meguma Terrane and the extrusion of basalts and were diverted south-westwards to the Bay of Fundy (Piper et al., 2011). The Naskapi Member is a several hundred metre thick varicoloured shale unit with a lower sedimentation rate than the rest of the Logan Canyon Formation (Wade and MacLean, 1990).

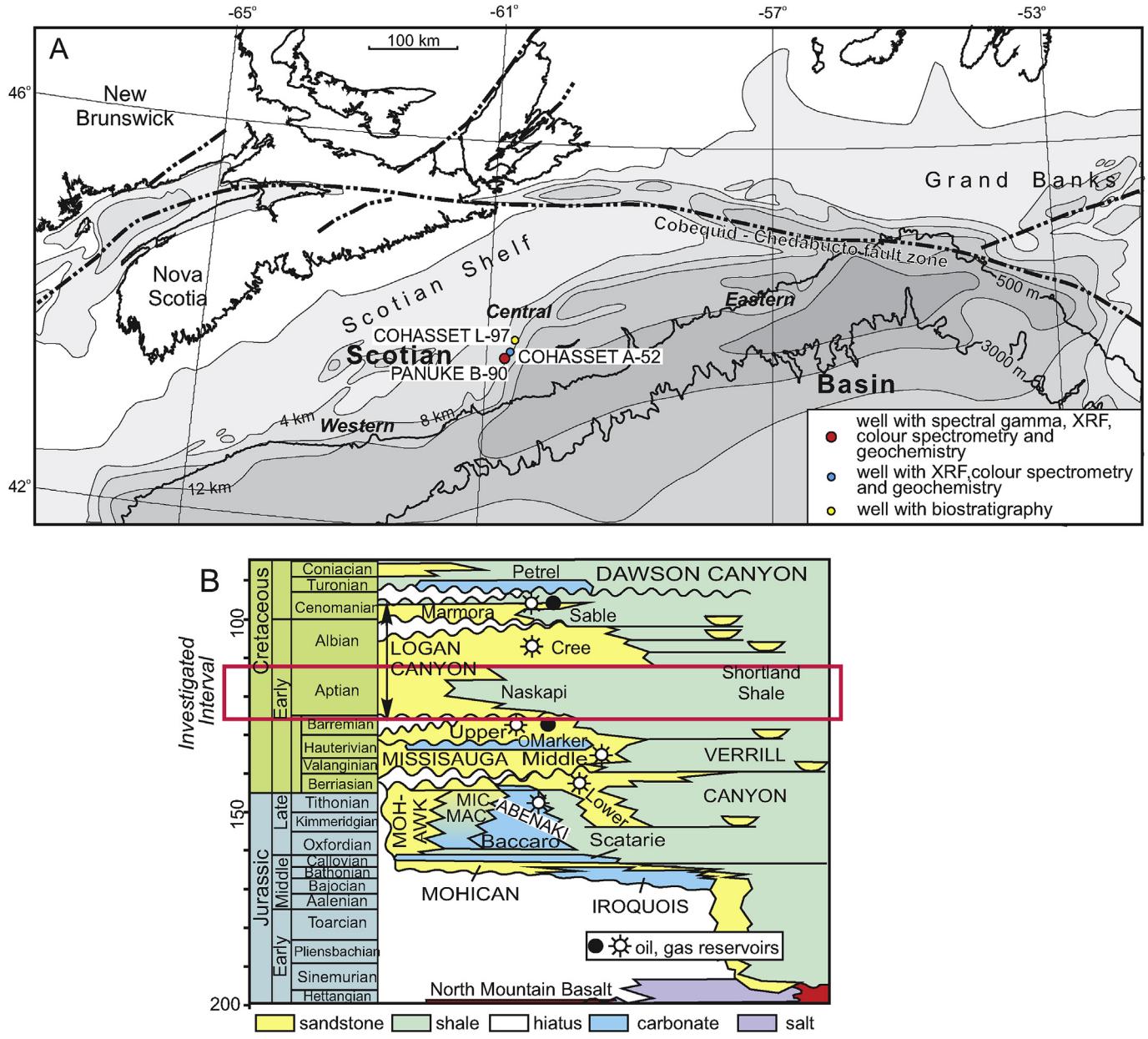

Fig. 1. (A) Map of the Scotian Basin showing location of wells examined in this study and generalized basin isopachs (modified from Wade and MacLean, 1990). (B) Lower Jurassic–Upper Cretaceous stratigraphic summary of the Scotian Basin (modified from Weston et al., 2012). Red box highlights the stratigraphic interval in this study. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)