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Stable isotope geochemistry of the lower Cambrian Sekwi Formation, Northwest Territories, Canada: Implications for ocean chemistry and secular curve generation

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Abstract

Three curves delineating $\delta^{13}C$ variations across the Early Cambrian Sekwi Formation carbonate ramp, Mackenzie Mountains, Northwest Territories, Canada, are incorporated into a biostratigraphic and sequence stratigraphic framework that provides a higher resolution temporal and spatial framework for the Sekwi Formation. The three $\delta^{13}C$ curves were correlated across a range of depositional environments, from tidal flat to deep subtidal on the Sekwi carbonate ramp. Eight $\delta^{13}C$ "cycles" in the curves (A–H) were correlated across the basin, complimenting the sequence stratigraphic framework. The most complete $\delta^{13}C$ curve from the Sekwi Formation correlates well with a composite Early Cambrian $\delta^{13}C$ curve from the Siberian Platform. However, the differing magnitude and absolute timing of some of the correlative isotopic excursions records the influence of regional tectonism, sea level changes, and diagenesis on the Sekwi ramp. Additionally, the Sekwi Formation $\delta^{13}C$ curve has more high-frequency variations than the Siberian curve, due in part to the higher sample density used to construct the Sekwi curve. The Early–Middle Cambrian boundary was not sampled in this study, but a large negative isotopic excursion in the very latest Early Cambrian coincides with a regional drowning that may be correlative throughout western Laurentia, but recognizing this event globally is problematic.

Keywords: Carbon-isotopes; Early Cambrian; Secular curves; Stable isotope chemostratigraphy

1. Introduction

The recognition of secular variations in carbon isotope ratios, preserved in marine carbonate strata, i.e. carbon isotope chemostratigraphy, is a powerful technique for correlating widely spaced stratigraphic successions, especially in Neoproterozoic to Cambrian age strata with poor or non-existent biostratigraphic control (e.g., Magaritz et al., 1991; Ripperdan, 1994; Corsetti and Kaufman, 1994; Kaufman and Knoll, 1995; Brasier et al., 1996; Brasier and Sukhov, 1998; Montañez et al., 2000). Additionally, these variations in $\delta^{13}C$ values can provide insights for understanding local, regional, and possibly global variations in weathering and carbon burial rates (e.g., Pelechaty et al., 1996a,b; Brasier and

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Sukhov, 1998; Saltzman et al., 1998, 2000; Immenhauser et al., 2003; Swart and Eberli, 2005). For example, large shifts (up to 5‰) in Early Cambrian rocks of Siberia were interpreted to record changes in the fraction of carbon buried as organic matter (Ripperdan, 1994; Brasier et al., 1994a,b; Brasier and Sukhov, 1998). However, the sequence stratigraphic controls and biostratigraphic resolution of these curves are poorly understood, particularly when they are derived from single measured sections that provide insufficient information about possible temporal and/or spatial variability of the isotopic record across a carbonate platform (e.g., Grant, 1992; Corsetti and Kaufman, 1994; Glumac and Walker, 1998; Saltzman et al., 2000).

Variations in δ^{13}C values of carbonates reflect changes in relative burial rates of organic carbon and carbonate carbon (Knoll et al., 1986; Kaufman and Knoll, 1995; Kump and Arthur, 1999). An increase in organic carbon burial can be produced by an increase in: 1) biological productivity; 2) stagnation of the basin (anoxic event); and 3) sedimentation rates that result in the preservation of organic matter (e.g. Derry et al., 1994; Brasier et al., 1994a; Weissert et al., 1998). Times of increased burial of organic carbon are characterized by positive δ^{13}C excursions, preserved in contemporaneous marine carbonates, resulting from the light ^{12}C-isotope being preferentially incorporated into buried organic carbon. Similarly, a decrease in organic carbon burial results in a negative δ^{13}C excursion. Possible explanations for secular variations in the δ^{13}C record include: 1) high biological productivity and preservation resulting in a positive δ^{13}C excursion; 2) reduced biological productivity during a mass extinction resulting in a negative δ^{13}C excursion; 3) sea-level driven changes in oceanic circulation patterns triggering changes in organic carbon burial rates and ocean anoxic events, and 4) changes in continental weathering patterns.

This paper presents an integrated carbon isotope chemostratigraphic, biostratigraphic, and sequence stratigraphic framework for Early Cambrian Sekwi Formation of the Mackenzie Mountains, Northwest Territories, Canada. Detailed carbon isotopic curves from three measured sections of the Sekwi Formation, each up to 1 km thick, are correlated along a dip profile. The new integrated framework provides a much higher resolution temporal and spatial framework compared to the traditional, three trilobite biozones of the Early Cambrian Sekwi Formation. This new framework also provides a

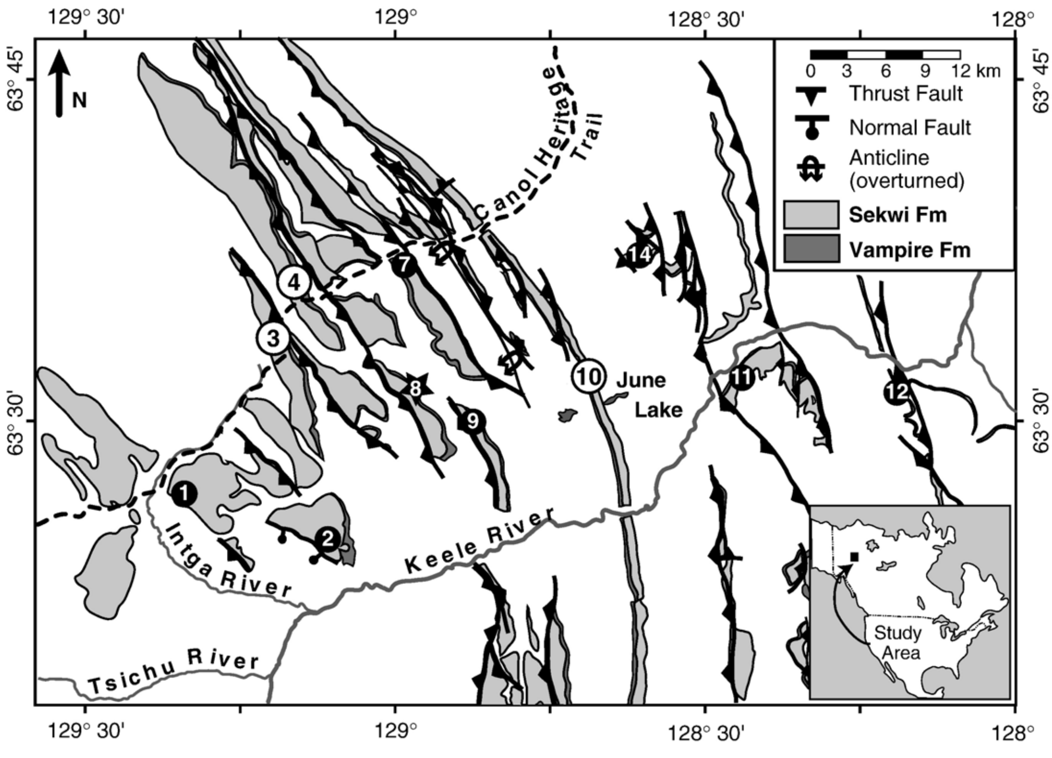

Fig. 1. Simplified geologic map of a portion of the Sekwi Mountain map area (modified from Blusson, 1971) depicting outcrops of the Vampire and Sekwi formations as well as locations of measured sections (black circles) and the three Sections, 3, 4, and 10, sampled for geochemistry (white circles). Star denotes measured section of Krause (1979). Inset map shows the approximate location of the study area.