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Link between long-lasting evaporitic basins and the development of thick and massive phreatic calcrete hardpans in the Mississippian Windsor and Percé groups of eastern Canada

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Abstract

Part of the Viséan (upper Mississippian) succession in the upper Paleozoic Maritimes Basin of eastern Canada is overprinted by massive phreatic calcrete hardpans that can exceed 10 m in thickness and that are characterized by the thorough mineral replacement of most of their host sediment by calcite, similar to those that are currently forming around salt lakes in Quaternary sediments of central Australia. The precise timing and paleogeography of this Carboniferous event was until now poorly known, but lateral correlations over a large study area indicate that phreatic calcretization occurred in the vicinity of large evaporitic basins following a marine transgression and regression cycle in Chadian to Holkerian times. This relation confirms that the previously proposed model for modern analogs in central Australia, which states a genetic link between the salt lakes and the thick and massive phreatic calcrete hardpans, can be applied to ancient environments, and that such occurrences may be used to infer the former presence of an evaporitic basin in their vicinity. Finally, our relatively large dataset indicates that the stable isotopes of carbon and oxygen are successful in differentiating ancient marine carbonates from ancient phreatic calcretes.

Keywords: Phreatic calcrete hardpans; Groundwater; Mississippian; Stable isotopes; La Coulée Calcrete; Percé Group

1. Introduction

Thick and massive phreatic calcrete hardpans such as those reported in Quaternary sediments of central Australia, which result from thorough mineral replacement along the entire thickness of an aquifer, have been associated with the mixing zone between a fresh groundwater discharge and the salty groundwater that surrounds evaporitic basins in arid environments (Mann and Horwitz, 1979; Arakel and McConchie, 1982; Jacobson et al., 1988; Arakel et al., 1989). The mixing generates an increase in alkalinity within the fresh groundwater discharge, which creates a significant increase in silica solubility paired with a substantial decrease in calcium carbonate solubility, thus favouring replacement of silicate minerals by calcite (Arakel and McConchie, 1982). However, a possible analog in Portugal (Pimentel et al., 1996) was more recently reinterpreted as a palustrine carbonate, potentially casting doubt on the Australian model (Pimentel and Alsonso-Zarza, 1999; Alonso-Zarza, 2003). Moreover,

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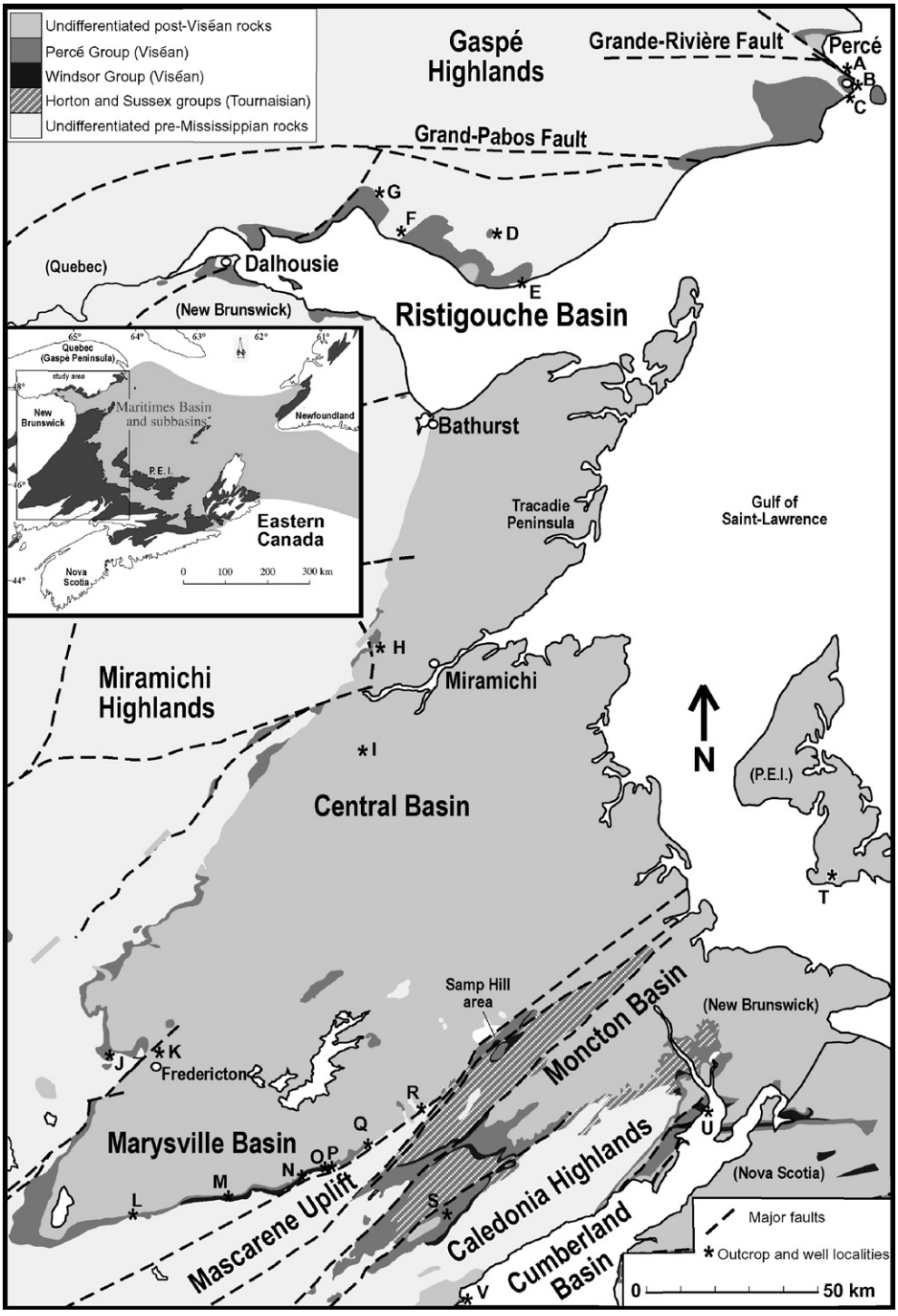

Fig. 1. Simplified post-Acadian (post-Middle Devonian) geology of the study area (modified from the New Brunswick Department of Natural Resources and Energy, 2000). Localities A: Cannes-de Roches; B: La Coulée Creek; C: Percé-Beach; D: Saint-Elzéar; E: New-Carlisle; F: Black Cape; G: Saint-Jules; H: Sevogle; I: Blackville; J: Mactaquac Dam; K: Killarney; L: Shin Creek; M: Irving Brook; N: Hampstead; O: Albright Brook west; P: Albright Brook east; Q: Stewarton; R: Snider Mountain; S: Salt Springs; T: Wellington; U: Hopewell Cape; V: Quaco Head. Inset: location of the study area within eastern Canada (Dark grey: onshore extent of upper Paleozoic rocks; light grey: offshore extent of upper Paleozoic rocks; modified from Gibling et al., 1992). P.E.I. is an acronym for the Province of Prince Edward Island.