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New constraints on the Late Jurassic paleogeography and thermal history of the Flemish Pass basin

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Introduction

The Flemish Pass basin is located ~500 km east of St. John's, Newfoundland, and formed during Triassic to Cretaceous rift development that led to the opening of the North Atlantic Ocean. The Flemish Pass basin contains syn-rift, Upper Jurassic to Lower Cretaceous strata and a series of oil discoveries have been within Tithonian incised valley to deltaic successions in the Bay du Nord and other project areas. Previous depositional and detrital zircon provenance studies of the northern Flemish Pass basin suggest these Tithonian strata were fed by WNW-directed river systems with headwaters in Flemish Cap, Beothuk Knoll, and other adjacent highlands (Fig. 1, Beicep-Franlab, 2015, Beranek et al., 2022). However, the identities and geographic distribution of potential parent rock sources within these regions remain elusive.

Methods

We applied a multi-method approach that combined fission-track dating, U-Pb dating, and trace element geochemical analysis of hundreds of individual detrital apatite grains from Tithonian successions in the Bay du Nord, Harpoon, and Mizzen discoveries. Apatite geochemistry allows the discrimination of igneous and metamorphic source rock lithologies. When combined with U-Pb age, these geochemical proxies provide useful provenance information that identify sediment source regions which are often indistinguishable using detrital zircon U-Pb methods. The apatite fission-track system is sensitive to temperatures ranging 60–120ºC and provides information on the post-depositional burial and thermal history of the Flemish Pass basin. Specifically, the shortening of fission-track lengths within apatite crystals constrains how long a rock sample spent within the temperature sensitivity window.

Results and preliminary observations

We present new detrital apatite fission-track age, U-Pb age, and trace element geochemical results for 24 samples of Tithonian strata from the Bay du Nord, Harpoon, and Mizzen discovery areas (Fig. 1). U-Pb age and trace element studies were conducted on each apatite grain (n=1039) and over half of those grains (n=546) were also dated using the fission-track method and the remaining used for measuring track lengths (n=493). Neoproterozoic to Mesozoic apatite grains from igneous parent rocks occurred in varying abundances and lithologies between the discovery areas. However, Jurassic apatite grains, present in Tithonian strata from all sample sites, showed mafic igneous source lithologies that are consistent with Late Jurassic mafic intrusive and volcanic rock units observed on the Newfoundland margin.

Detrital apatite grains derived from low- to medium-grade metamorphic parent rocks provided specific insights into sediment source areas. When compared between the discovery areas, two distinct source signatures for Tithonian strata were identified. Detrital apatite grains in Bay du Nord discovery area strata, which is the southernmost sample site, mostly yield

Mesoproterozoic metamorphic ages compared to Ediacaran to Cambrian metamorphic ages in the Mizzen discovery area which is the northernmost sample site (Fig. 1). Tithonian strata from the Harpoon discovery area, located geographically in-between the other two sample sites, have a bimodal distribution with detrital apatite U-Pb peaks with both Mesoproterozoic and Ediacaran to Cambrian metamorphic age populations (Fig. 1). The metamorphic apatite U-Pb populations distinguish northern and southern source regions within the Flemish Cap that were tapped by multiple drainage systems feeding sediments into the basin during the Late Jurassic.

The apatite fission-track results provided insights into the Late Jurassic and younger thermal histories of the Flemish Pass basin. Detrital apatite fission-track ages ranged from Neoproterozoic to Cenozoic and indicate that the samples were partially reset and experienced temperatures between 60–120°C since deposition in the Tithonian. The degree of resetting, measured by the shortening of fission-track lengths during reheating, increased with increasing borehole temperatures. These results indicate that Tithonian strata likely did not reach temperatures over 60°C until burial in the Cenozoic with samples currently residing at or close to their maximum burial temperature.

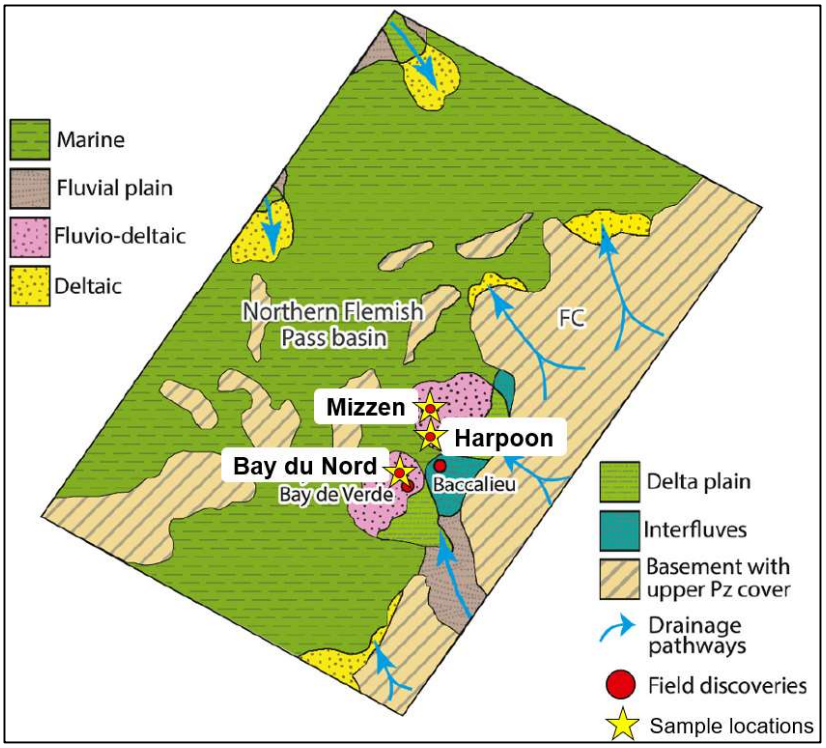


Figure 1: Proposed Late Jurassic paleogeography of the Northern Flemish Pass basin modified from Beicip-Franlab (2015) and Beranek et al. (2022).

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