U-Pb Geochronology and U-Th/He Thermochronology Applied to the Clastic Strata of the Franklinian Basin, Canadian Arctic Islands

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Abstract

Detrital zircon U-Pb ages and detrital zircon/apatite U-Th/He ages collected from Neoproterozoic to Late Devonian clastic strata of the Franklinian Basin clarifies the depositional and thermal history of these sediments and provides new information about potential source areas. Nearly 1800 detrital zircon U-Pb geochronologic ages (20 samples) and 80 detrital zircon/apatite U-Th/He thermochronologic ages (10 samples) collected from a broad geographic (latitudinal range 82° N to 75° N; longitudinal range- 69° W to 120° W) and stratigraphic (9 formations) range provide new insight into the major tectonic influences on the northern margin of Laurentia and enable improved reconstructions of basin paleogeography over this time interval. The scope of this endeavor far exceeds all previous geochronologic and thermochronologic studies in the Franklinian Basin.

Introduction

Course grain clastic deposits of the Franklinian Basin have three primary depositional intervals: (1) Neoproterozoic and Cambrian shelf and slope deposits (2) Lower Silurian to Lower Devonian deep-water turbidites and (3) Middle to Upper Devonian fluvial and deltaic deposits. The Middle to Upper Devonian fluvial and deltaic deposits can be further divided into the Hecla, Beverly Inlet, and Parry Islands sequences. The formations sampled from these intervals are as follows: (1) Neoproterozoic Kennedy Channel Formation; (2) Cambrian Archer Fiord Formation; (3) Silurian Danish River Formation; (4) Devonian Bird Fiord Formation; (5) Devonian Strathcona Fiord Formation; (6) Devonian Hecla Bay Formation; (7) Devonian Fram Formation; (8) Devonian Beverly Inlet Formation; and (9) Devonian Parry Islands Formation. All formations were analyzed for detrital zircon U/Pb geochronology, but only Middle to Upper Devonian deposits were analyzed for U-Th/He thermochronology.

Detrital Zircon Geochronology

Detrital zircon provenance studies entail the determination of U-Pb ages of 100 to 120 individual grains from each sample, and the correlation of these grain populations to specific sediment source areas. The detrital zircon U-Pb ages demonstrate the Franklinian Basin succession is composed of strata with three distinctly different provenance signatures. Samples collected from the Neoproterozoic Kennedy Channel and Cambrian Archer Fjord formations include prominent populations of Paleoproterozoic and Neoarchean detrital zircons, and lack grains younger than the Paleoproterozoic. By the time the Silurian Danish River Formation was deposited and until the Late Devonian Beverly Inlet Formation was deposited the population of detrital zircon ages encompasses the Devonian and Mesoproterozoic, yet the samples continue to contain large populations of Paleoproterozoic ages. A dominant population of Late Devonian to Neoproterozoic detrital zircon with secondary populations of Mesoproterozoic to Mesoarchean detrital zircon in the Upper Devonian Parry Islands Formation suggests a shift in sediment source relative to the underlying sedimentary units.

Detrital Zircon/Apatite Thermochronology

Detrital zircon/apatite U-Th/He thermochronologic studies identify the cooling ages of 6 to 10 grains from each sample, which provides a thermal/uplift history for that sample. Helium is produced within apatite and zircon grains during alpha decay from uranium and thorium isotopes, however the helium generated is only retained within that grain at temperatures cooler than ~70-80° C (apatite) and ~175-190° C (zircon). By measuring the U/Th-He concentrations within each apatite/zircon an age is determined for when that grain was uplifted to the cooling temperature. Detrital zircon samples from the Hecla Bay Formation and the Parry Islands Formation indicate they were uplifted in the Middle to Late Silurian. Assuming a thermal gradient of ~25°C for the majority of the Franklinian Basin these ages indicate that the samples have not been buried below 6-7 km since deposition, hence the cooling ages indicated uplift from their respective source areas. Detrital apatite samples from the Bird Fiord, Strathcona Fiord, Hecla Bay, and Parry Islands Formations are somewhat more diffuse, however all grain ages are younger than Carboniferous indicating they have been reset since deposition in the Devonian and thus record their most recent uplift histories.

Conclusions

The detrital zircon U-Pb ages and detrital zircon/apatite U-Th/He ages of Franklinian strata shed light on the provenance of the sediments and thermal evolution of the basin. The detrital zircon U-Pb age populations clearly demonstrate three distinctly different sediment sources for the samples collected from the Franklinian Basin. The detrital zircon U-Th/He age populations indicate the primary source areas for the Devonian clastic deposits were uplifted in the Middle to Late Silurian. The detrital apatite U-Th/He age populations indicate sediments within the Franklinian basin were buried at least 2-3 km before being uplifted during or after the Carboniferous. In addition, because detrital zircon and apatite is often recycled from older strata into younger deposits, these data provide the basis for understanding the sedimentary provenance and tectonic evolution of overlying units, including those in the oil and gas rich Sverdrup basin.

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