An exhumation history of Hall Peninsula, Baffin Island derived from low-T thermochronometry and 3D thermokinematic modeling

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1. Introduction

Eastern Canadian Arctic Rim

The eastern Canadian Arctic Rim (ECAR) is a rugged, shieldfolded terrain, spanning from southwestern Ellesmere Island to northern Labrador (Fig. 1). While much of the relief along the ECAR may be related to isostatic uplift and erosion during and after lifting between Canada and Greenland, there has recently been renewed interest over understanding of crustal margin evolution and the processes responsible for the development of the northern Canadian margin.

Unlike the rapid expansions indicated in the southern ECAR (Tingmiat Mountains) and most of the interior, the ELR has experienced a slower rate of uplift, 25–40 Ma ago. This relative stability of the ELR may be due to the late development of the redox boundary in the Arctic Ocean and the concurrent periods of glacial activity across the northern Canadian and Greenland shelves.

2. Objectives

Short-term: In the assessment of potential 14C dates for future 10Be thermochronology studies, the zircon (U-Th)/He system (ZHe) can be used to assess the effective concentration of parent radionuclides (eU, where eU = U/238U + 235U). The ZHe system is also useful for the assessment of effective cooling of the parent mineral and improve the fit of the modeled histories. Therefore, apatite grains from three samples have been strategically selected for fission-track analysis to help constrain the 10Be thermochronology.

Long-term: In the assessment of potential 14C dates for future 10Be thermochronology studies, the zircon (U-Th)/He system (ZHe) can be used to assess the effective concentration of parent radionuclides (eU, where eU = U/238U + 235U). The ZHe system is also useful for the assessment of effective cooling of the parent mineral and improve the fit of the modeled histories. Therefore, apatite grains from three samples have been strategically selected for fission-track analysis to help constrain the 10Be thermochronology.

3. Methodology

Overview of Apatite (U-Th)/He Thermochronology

The (U-Th)/He thermochronology method is based on the thermally controlled emission of radioactive daughter atoms by an α-emitter within a mineral lattice (e.g., Ibarra, 2003). This method relies on the understanding that (1) the lineshape may exhibit nonlinearities due to recoil, (2) the effective cooling rate of the mineral, and (3) the effective cooling rates of the mineral are different.

4. Results

Measured Heages

In total, 26 samples have been analyzed by (U-Th)/He thermochronology, with 13 by 10Be thermochronology, and 12 by (Zn-Sb) thermochronology (ZHe) (Table 1). Most samples yielded 1–7 year-old data, confirming that the samples were not heated to above 150 °C in the past 10,000 years.

In both the AHe and ZHe data, measured Heages exhibit a significant degree of scatter across each of the samples (Fig. 3). This scatter in space is likely to have originated in the spatial distribution of cooling ages from the various parent minerals.

Preliminary HeResults

The authors’ understanding of HeFTy was greatly improved by insightful discussion with R. Ketcham and I. Coutland. The support received through the NSERC Discovery Grant and the NSERC Northern Research Supplement to J. Gosse was greatly appreciated. Additional support from a Shell Partnership with CNGO was greatly appreciated. The authors gratefully thank the Canada-Nunavut Geoscience Office (CNGO) for logistical and field support during the 2012 Hall Peninsula field season, as well as the support received from other samples by applying a radiation damage correction to the measured and calculated ages. Additional support from the NSERC Discovery Grant and the NSERC Northern Research Supplement to J. Gosse was greatly appreciated. The authors gratefully thank the Canada-Nunavut Geoscience Office (CNGO) for logistical and field support during the 2012 Hall Peninsula field season, as well as the support received from other samples by applying a radiation damage correction to the measured and calculated ages.

5. Discussion

Radiation Damage

Three data sets that the rocks in Hall Peninsula have experienced a history of profound exhumation (Fig. 4), with cooling ages ranging from 250 Ma for Thermal Emission Spectrometer (Ae) and 400 Ma for Thermal Emission Spectrometer (Ap). However, positive relationships in the Ae data (Fig. 3, upper right) and negative relationships in the Ap data (Fig. 3, lower right) within 1σ of the global reference data set (Ap, where eU = 1–2), suggest a strong influence of radiation damage on Ae diffusional losses, consistent with a correction in the AHe model. The authors’ understanding of HeFTy was greatly improved by insightful discussion with R. Ketcham and I. Coutland. The support received through the NSERC Discovery Grant and the NSERC Northern Research Supplement to J. Gosse was greatly appreciated. The authors gratefully thank the Canada-Nunavut Geoscience Office (CNGO) for logistical and field support during the 2012 Hall Peninsula field season, as well as the support received from other samples by applying a radiation damage correction to the measured and calculated ages. Additional support from the NSERC Discovery Grant and the NSERC Northern Research Supplement to J. Gosse was greatly appreciated. The authors gratefully thank the Canada-Nunavut Geoscience Office (CNGO) for logistical and field support during the 2012 Hall Peninsula field season, as well as the support received from other samples by applying a radiation damage correction to the measured and calculated ages.

6. Future work

AHe Age Correlation

The potential lack of effective radiation damage in the Ae data (Fig. 3) suggests a stronger influence of radiation damage on AHe diffusional losses. However, a significant amount of variation between the aliquots from the same sample suggests that this is not the case. Additional support from the NSERC Discovery Grant and the NSERC Northern Research Supplement to J. Gosse was greatly appreciated. The authors gratefully thank the Canada-Nunavut Geoscience Office (CNGO) for logistical and field support during the 2012 Hall Peninsula field season, as well as the support received from other samples by applying a radiation damage correction to the measured and calculated ages.