Predicting the Existence of a Plateau in the Canadian Cordillera using Thermochronometry

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Introduction

The Canadian Cordillera is part of the North American Cordillera, which extends from Alaska to Mexico along the western margin of North America. The development of the Canadian Cordillera is thought to be the result of continuous accretion, during the Mesozoic, along the western margin of Canada, with the final "push" occurring in the Late Cretaceous and leading to the formation of the Rocky Mountains. Some authors have suggested that the landscape during the Late Cretaceous was a broad, elevated, low relief plateau, with as much as 12 km of crust overlying the present day erosional surface (Osborn et al, 2005; Yorath and Gadd, 1995). These authors propose that the eastern edge of the plateau extended above the present day Foothills of the Rockies. We hypothesize that, if the plateau existed, it must also have extended west, back to the coast belt, in order to explain the deformation along the plateau's eastern margin, ~1000 km from an accreting body to the west. Our initial results utilized six samples that were collected from the Neoproterozoic Miette Gp., Mississippian Banff Fm. (bentonite unit), Jurassic - L. Cretaceous Nikanassin Fm. and the U. Cretaceous Brazeau Fm. at exposures along the Miette and Athabasca river valleys. These samples were collected for fission track thermochronometry during the 1990s and were reutilized to conduct an exploratory (U-Th)/He low temperature thermochronology study. The basic aim of this ongoing study is to evaluate this hypothetical Canadian plateau and its post-Laramide destruction by erosion and extension may have produced the present day geology and geography of Canadian Cordillera and Rockies.

Methods

The evolution of the Cordillera and Rockies is studied using a combination of (U-Th)/He (He method; using apatite, zircon, and monazite), and fission track (FT methods; apatite and zircon) thermochronology to develop cooling histories showing when and how fast rocks in the cordillera cooled from 200˚C to 40˚C. To do this we collected samples along transect across the Cordillera, perpendicular to strike. The transect focuses on granitic intrusions and sandstone units exposed in accessible areas. At each study site we sampled from the base of the exposure to the summit of the range, collecting one sample every ~200 m, vertically. By assuming a normal geothermal gradient and with the closure temperatures and cooling rates of both apatite and zircon grains we can predict the depth to which they were once buried. From these relationships as well as external geologic constraints, exhumation and erosion can be extracted. The horizontal spacing between study sites is fairly large (50 to 100 km) because of the great length of the transect and the desire to obtain an orogen-wide signal.

Results

Our Initial results obtained 16 cooling ages from six of the samples collected in the Athabasca River valley. Samples J91-2 and J91-5 are from the middle Miette Gp. J91-2 produced three (U-Th)/He ages; 22.1 Ma, 32.6 Ma, 20.5 Ma. Sample J91-5 had one (U-Th)/He age of 2.5 Ma. Sample J91-4 is from the lower Miette Gp. The sample produced one (U-Th)/He age of 10.7 Ma. Sample J91-1 from the Banff Fm. produced five (U-Th)/He ages of 137.0 Ma, 132.1 Ma, 80.5 Ma, 61.7 Ma and 77.3 Ma. Sample J91-9 (Nikanassin Fm.)

returned one age of 118.3 Ma. Sample J91-18 (Brazeau Fm.) returned five ages of 43.0, 36.2, 45.9, 47.9, and 34.1 Ma. Additional fission track data are available for four Foothills samples from Upper Cretaceous (J91-17 (65.8±7.0 Ma), J91-16 (72.8±7.2 Ma), J91-14 (65.0±6.1 Ma) and Lower Cretaceous (J91-8 (62.8±12.2 Ma) rocks.

Discussion

The young ages from J91-5 and J91-4 may be misleading due to small sample populations; with more ages it is possible that these samples would give an average age that falls in the early Miocene (e.g. J91-2). This would be consistent with final erosional cooling in the lower to mid Miocene in the Main Ranges. We tentatively interpret the ages from sample J91-1 to indicate that this sample spent a long time in the He partial retention zone resulting in partial resetting and leading to a large cooling age range. For example, it has been shown that apatites with significant radiation damage are more retentive of He (higher closure temperature) than apatites with minimal radiation damage. In this case the sample apatite population may include a mix of metamict and undamaged apatites; a long residence time in the partial retention zone would result in the undamaged apatite being reset while the metamict, (more retentive) apatites would remain un-reset. For the Foothills samples we combine the (U-Th)/He data from J91-18 with the fission track data from that sample as well as additional fission track data from samples J91-17, J91-16 and J91-14. We tentatively interpret these ages to record erosional cooling in the Foothills during Late Cretaceous-Paleocene time (62.8 to 72.8 Ma).

J91-9 with an age of 118.3 ± 7.1 Ma comes from the Lower Nikanassin Fm. (125-146 Ma). We suspect that this sample also experienced a long residence time in the partial retention zone (as we have interpreted for J91-1). This is because a nearby fission track age for sample (J91-8) from the Cadomin Formation (up-section from the Nikanassin) is 62.8±12 Ma, which is inconsistent with normal top down cooling (the structurally and stratigraphically higher sample should be older not younger). This suggests that this single analysis does not represent the full distribution of cooling ages for the sample and further analyses will reveal a broader spread in ages.

These preliminary data suggest that shortening related uplift and exhumation in the Front Ranges was under way prior to the Early Cretaceous, and that cooling was slow throughout the Cretaceous. During the latest Cretaceous to early Tertiary, final erosional exhumation took place in the Foothills. In contrast, in the Main Ranges final cooling was much later (Oligo-Miocene), possibly reflecting regional extension to the west at this time.

Future work

These preliminary ages are part of regional analysis of the exhumational history across the Canadian Rockies and Canadian Cordillera. Our research will provide the first test of the hypothetical Canadian plateau, a fundamental morpho-tectonic feature that preceded the formation of the present-day Canadian Rockies and Cordillera.

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