GS-6

HOW AN OROGEN BECAME A CRATON: THERMOCHRONOLOGY OF THE TRANS-HUDSON OROGEN, CANADA

by M. E. Bickford[1] , K. C. Condie[2] , M. Heizler[2], S. A. Kelley[2], and J. F. Lewry[3]

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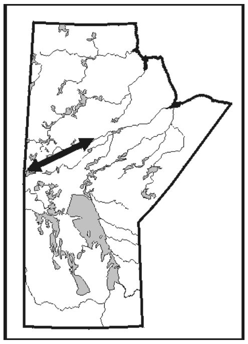

INTRODUCTION

A recently funded grant from the National Science Foundation of the United States supports a study of the thermal history of the Trans-Hudson Orogen. Collaborating scientists are Kent C. Condie, Matt Heizler, and Shari Kelley, all of New Mexico Institute of Technology, Socorro, New Mexico, and M. E. Bickford, Syracuse University, Syracuse, New York. The study, which will utilize the techniques of ^{40}Ar/^{39}Ar, U-Pb and apatite fission-track thermochronology, is designed to learn the details of the cooling history of the whole orogen, from its Archean hinterland in the Hearne Province, across the internides of the Reindeer Zone and into the Superior craton foreland. Specific questions being asked are:

1) How much time elapsed between terminal collision and the amalgamation of the several terranes into a single craton?
2) Was the cooling history the same across the whole orogen, or were there significant changes across internal terrane boundaries?
3) Which, if any, of the terranes have been re-activated at times later than the time of cratonization?
4) How far did the post-collisional cooling event extend into the bounding Archean cratons? In a related question, did the juvenile terranes of the internides have the same cooling history as the bounding Hearne and Superior cratons? and
5) Finally, what has been the low temperature cooling history, that is the history of cooling into the 200-100°C range? And how has this been related to Phanerozoic sedimentation and denudation?

ANALYTICAL TECHNIQUES

The high-temperature part of the cooling history will be investigated by Bickford and post-doctoral Research Associate Greg Wortman. They will study the U-Pb system in the accessory minerals monazite (blocking temperature about 730-640°C), sphene (blocking temperature about 670-500°C), rutile (blocking temperature about 420-380°C) and possibly apatite (blocking temperature about 300°C). The U-Pb study will employ careful petrographic analysis to determine sequences of mineral growth in the polymetamorphosed rocks of the orogen, and such techniques as cathodoluminescence and electron back-scatter images to look for zoning or domainal structure in the accessory minerals being analyzed.

The intermediate temperature portion of the cooling history will be investigated by Heizler, Condie, and M.S. student Stacey Perilli, using the techniques of ^{40}Ar/^{39}Ar thermochronology. They will measure the ^{40}Ar/^{39}Ar ages of hornblende (blocking temperature about 500°C), muscovite (blocking temperature 400-350°C), biotite (blocking temperature 350-275°C), and K-feldspar (blocking temperature 350-150°C). The Argon Laboratory at New Mexico Tech is equipped with a laser ablation device, which permits spot analyses of minerals, as well as standard incremental furnace heating.

Finally, Kelley will use apatite fission-track thermochronology to examine the lowest temperature (140-60°C) portion of the cooling history. She will use track-length analysis, as well as fission-track ages to model the complex low-temperature thermal histories related to Phanerozoic sedimentation and denudation. Her study will add to previous fission-track work in the southern Canadian Shield.

SAMPLING PROGRAM

Figure GS-6-1 is a generalized map of the Trans-Hudson Orogen on which we have plotted, in a generalized way, most of the localities at which we collected samples. Our general goals were to sample all the way across the orogen, being sure that we sampled each of the terranes within it. We collected a total of 110 samples, comprising plutons, pegmatites, and metasedimentary rocks. We did not sample metavolcanic rocks because we considered it unlikely that, other than zircon, they would yield the minerals we needed (as outlined above).

Many of the rocks collected are granodiorites and tonalites, for these normally contain hornblende, biotite, sphene, and K-feldspar. Additionally, we collected pegmatites to obtain both K-feldspar and muscovite. Although we collected both metagreywackes and meta-arkoses, we particularly concentrated on obtaining samples of relatively high-grade metapelites because these typically contain metamorphic monazite and rutile. Many of the best metapelite samples were collected from the Burntwood Group in the Kisseynew Domain, but we collected excellent samples from other terranes as well.

We have already begun processing our samples and should have preliminary results in a few months. To show how these thermochronometric systems work, we present the preliminary data below (Fig. GS-6-2). This curve was done as an adjunct to our NSF proposal to show reviewers that we could get useful data. The data were obtained as follows: (1) monazite U-Pb data are from the Ph.D. dissertation of Suzanne E. Orrell in the Black Birch Lake area in the Hearne Province; (2) hornblende ^{40}Ar/^{39}Ar data are from samples of Archean rocks exposed in the Iskwatikan window of the Glennie Domain; (3) rutile U-Pb data are from Orrell's thesis in the Black Birch Lake area; (4) biotite ^{40}Ar/^{39}Ar data are from a "Hudsonian" orogenic pluton from the La Ronge Domain; (5) K-feldspar ^{40}Ar/^{39}Ar data are from an Archean rock in the Iskwatikan window of the Glennie Domain; and finally (6) apatite fission-track data are from samples from both the Glennie and la Ronge domains. Clearly, these data are a hodge-podge from samples across the western part of the orogen. However, they show what can be done. We expect to obtain comparable cooling curves from a large number of samples, collected in groups in closely-spaced arrays, within numerous parts of the orogen.

ACKNOWLEDGMENTS

Our collecting was directed by our Canadian collaborators. John F. Lewry, University of Regina, accompanied us throughout our traverse and was particularly helpful in directing collecting in the Glennie Domain, the Hanson Lake Block, and Saskatchewan parts of the Kisseynew Domain. Earlier Lewry worked with Bickford in collecting in the La Ronge Domain, the Rottenstone Domain (tonalite-migmatite belt), the Wathaman batholith and at selected sites in the Mudjatik Domain of the Hearne Province. Mr. Hai Tran, a doctoral student of Lewry's at the University of Regina, will also collect 10 samples for us in the Wollaston Belt and in the central Mudjatik Domain. In Manitoba, in the Flin Flon, Snow Lake, and Kisseynew Domains, we were directed by Eric Syme and Alan Bailes of the Manitoba Geological Services Branch. Finally, Timothy Corkery of the Manitoba Geological Services Branch directed our collecting in the Thompson Belt.

We also wish to express thanks to Gary Delaney of the Saskatchewan Survey, Eric Syme of the Manitoba Geological Services Branch, and Steve Lucas and Richard Stern of the Geological Survey of Canada, for providing us with up-to-date maps. Both surveys also facilitated shipping of our samples, for which we are grateful.

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[1] Department of Earth Sciences, Syracuse University, Syracuse, NY 13244 USA

[2] Department of Earth and Environmental Sciences, New Mexico Institute of Technology, Socorro, NM 87801 USA

[3] Department of Geology, University of Regina, Regina, Saskatchewan S4S 0A7 Canada

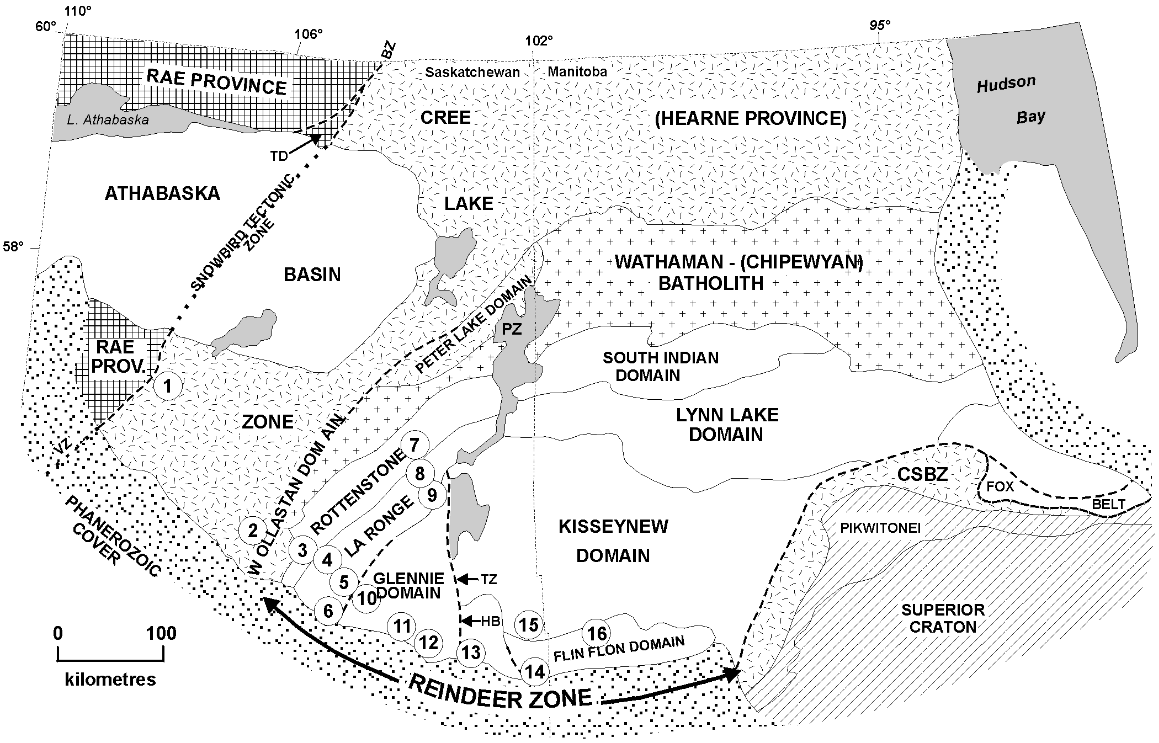

Figure GS-6-1: Map showing the main subdivisions and structural elements of the Trans-Hudson Orogen in northern Saskatchewan and Manitoba. Ensialic blocks are patterned; largely juvenile arc-related terranes are not. C-SBZ, Churchill-Superior Boundary Zone; HB, Hanson Lake Block; TZ, Tabbernor faults zone; VZ, Virgin River shear zone; BZ, Black Lake fault zone; TD, Tantato domain. Numbered points show generalized sample distribution (several samples: 1) Black Birch Lake area; 2) Sandfly Lake area; 3) Black Bear Island Lake area; 4) Nipew Lake region; 5) Nemeiben Lake area; 6) English River pluton; 7) Davin Lake complex; 8) Brindson pluton; 9) Star Lake pluton; 10) selected sites along the Churchill River in eastern Glennie Domain; 11) Oskikebuk granodiorite; 12) Deschambault Narrows tonalite; 13) Jan Lake granite; 14) Johnson Lake granodiorite; 15) Reynard Lake pluton; 16) selected sites in the Flin Flon domain, Thompson Nickel Belt and northeastern Kisseynew domain.

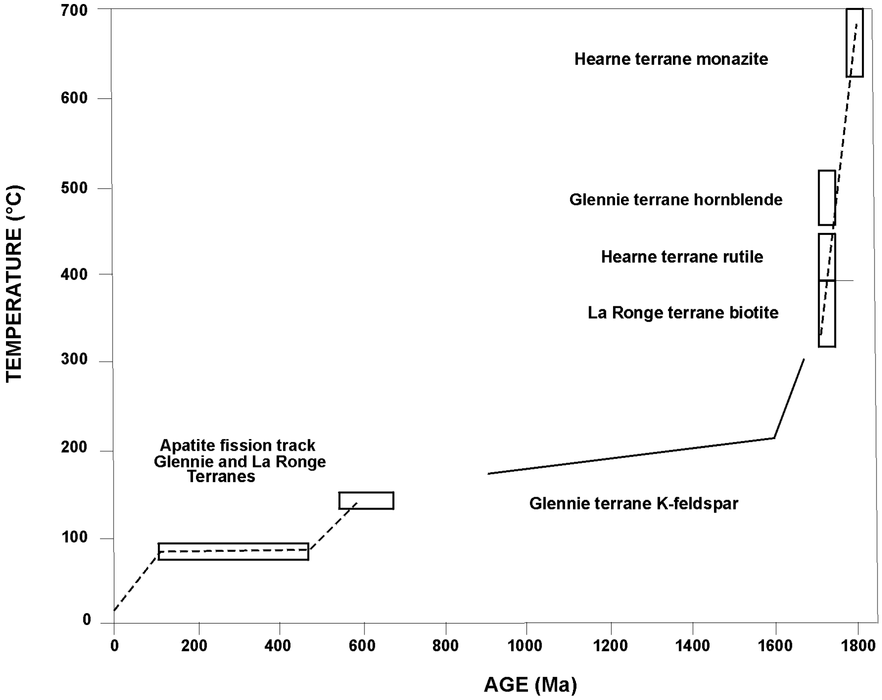

Figure GS-6-2: Combined cooling history for samples from within the Trans-Hudson Orogen. U-Pb (monazite and rutile) and argon (hornblende and biotite) data reveal a pronounced cooling event at ca. 1.8-1.75 Ga. The K-feldspar suggests this cooling continued until about ca. 1.6 Ga and then apparently slowed considerably as the crust thermally stabilized. Fission track results record the Phanerozoic history.