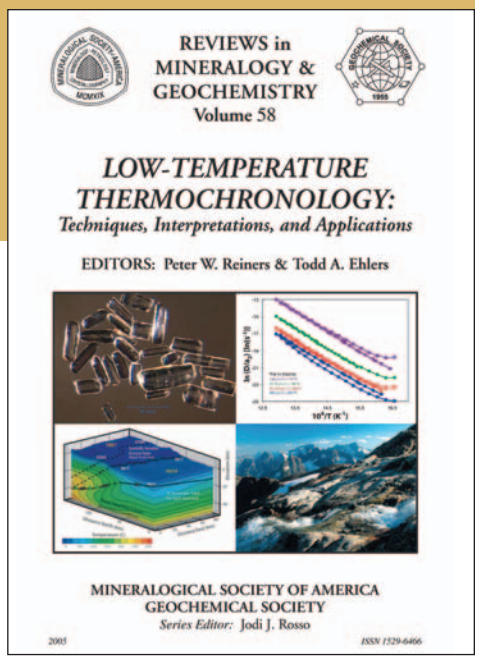
Low-Temperature Thermochronology: Techniques, Interpretations, and Applications[1]



Thermochronology, the study of the thermal histories of geological materials and systems, is a tool employed by an ever-increasing number and variety of geoscientists. Thermochronologic data and interpretations have significantly impacted the study of tectonics, landscape development, erosion and sediment transport, sedimentary basin evolution, ore genesis, and even meteoritics, and novel applications and techniques of thermochronology are still being developed. Thus, the field of thermochronology has applications crosscutting many disciplines. "Low-Temperature Thermochronology: Techniques, Interpretations, and Applications," edited by Peter W. Reiners and Todd A. Ehlers—volume number 58 in the long-running *Reviews in Mineralogy & Geochemistry* series—is a timely book that should be of interest and utility to a broad geoscience audience. Indeed, as the editors state in their preface, "this volume will likewise encourage continued innovation and discoveries in [the field of thermochronology] that synergizes the work and imagination of geochemists, geodynamicists, tectonicists, geomorphologists, and others." Students and professionals in any of these disciplines are likely to gain something from understanding thermochronology and hence will benefit from this book.

The book begins with a concise and well-written review of the past, present, and future of thermochronology (chapter 1). The next several chapters represent a series of "how to" guides that will be of use to students and experts. They review the state-of-the-art theoretical underpinnings, analytical approaches, and key uncertainties remaining to be resolved in thermochronologic measurements. Chapters 2 to 4 concern fission-track analysis, an established technique which remains indispensable, not only for its place in the historical context of modern thermochronology, but also as a valuable tool to unravel complex thermal histories by exploiting our understanding of track annealing (also see chapter 11). Chapter 5 reviews the fundamentals of thermochronometers based on noble gases (i.e. K/Ar, ^{40}Ar/^{39}Ar, and U–Th/He). While most published U–Th/He thermochronometric data come from apatites, chapter 6 describes the more recently popularized zircon U–Th/He thermochronometer. Chapter 7 describes an emerging methodology named "^{4}He/^{3}He thermochronology" by the authors of this chapter, who developed it. Broadly analogous to the ^{40}Ar/^{39}Ar geo-thermochronometer, ^{4}He/^{3}He thermochronology exploits a nuclear irradiation process to produce a uniform distribution of ^{3}He within a host mineral. Subsequent thermal-release patterns during degassing experiments inform the scientist of both the diffusion kinetics for the grain of interest (via ^{3}He) and the initial spatial distribution of radiogenic ^{4}He. Both pieces of information are valuable in thermochronologic interpretations. This chapter demonstrates the fact that thermochronology is still a developing field. Indeed, this volume is particularly timely because it catches the development of thermochronology *not* at a time of scientific stagnation, but rather during a time of innovation and growth.

Propelled in large part by modern U–Th/He thermochronology, the last 10 years have seen the emerging field of "tectonic geomorphology" burgeon into one of the most active areas of geoscience research. The development of this subdiscipline has been exciting as it has brought together tectonics and geomorphology, which had previously been treated as quite separate entities, by quite separate groups of geoscientists, despite what surely have always been obvious relationships. Innovations in low-temperature thermochronology have provided the cement that binds the study of tectonics and geomorphology more closely together. Indeed, previous distinctions between crustal-scale tectonics and surface processes are becoming blurred as geoscientists using modern thermochronology as a unifying tool encompass and appreciate some of the most exciting questions of both disciplines. It is no surprise, then, to find that many of this book's chapters are devoted to applications spanning the tectonic geomorphology continuum. Chapters 8 and 9 describe methods and applications of detrital thermochronology aimed at reconstructing regional patterns and processes of exhumation and erosion, with a focus on fission track zircon and ^{40}Ar/^{39}Ar techniques, respectively. Chapter 12 describes applications resulting in the reconstruction of crustal thermal histories. Chapter 13 covers the thermochronologic expression of landscape development. Chapter 16 discusses thermochronologic applications that lead to understanding extensional tectonic regimes. Chapters 17 and 20 delve into applications of modern thermochronology that permit quantifying and visualizing exhumation and denudation at the Earth's surface. The book also highlights some of the other diverse applications of thermochronology, including hydrothermal ore formation (chapter 18), evolution of sedimentary basins (chapter 19), and the long-term history of meteorites and the solar system (chapter 21).

Finally, this book presents powerful computational and rigorous modeling approaches to extract thermal histories from thermochronologic data. Beginning with chapters 10 and 11, authors present forward and inverse modeling techniques based on fission-track and noble gas thermochronometers. Chapter 14 discusses the modeling of thermochronologic data that have been sampled in three dimensions. Chapter 15 describes modeling approaches that permit the extraction of continuous thermal histories from closure profiles (i.e. based on the patterns of thermal release of radiogenic gases from host minerals). This chapter includes a discussion of the "multi-domain diffusion model," which has been popularized (and debated) in large part based on its applications to ^{40}Ar release from potassium feldspars. The book's final chapter (chapter 22) represents perhaps the most useful take-home toolbox for any reader who wishes to employ thermochronologic data in their own work. This chapter, cowritten by many of the book's contributors, includes background information, some instruction, and most importantly directions for web-based access to a number of powerful computational tools for thermochronologic interpretation. Too often, computer codes are inaccessible to the community at large, and thus the advances and innovations in rigorous quantitative analysis and modeling are limited to those familiar with, and with access to, existing programs. The combined work of the editors and authors in compiling this chapter—and this book—will go a long way towards unifying, informing, and expanding the growing thermochronologic community.

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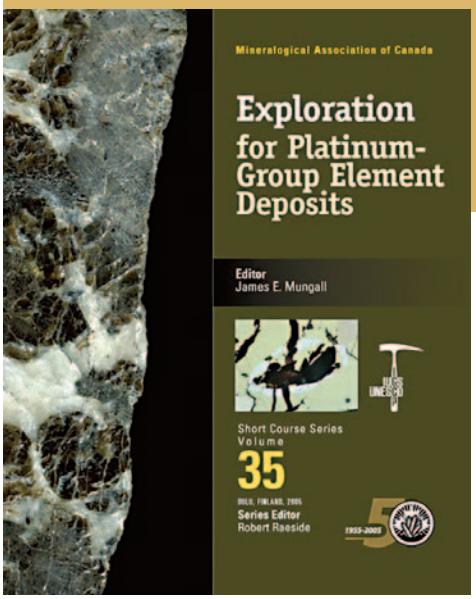
[1] Reiner PW, Ehlers TA, editors (2005) Low-Temperature Thermochronology: Techniques, Interpretations, and Applications. Reviews in Mineralogy & Geochemistry 58, Mineralogical Society of America, 622 pp, ISBN 0-939950-70-7, US$40, 25% discount for MSA and GS members



Exploration for Platinum-Group Element Deposits[1]

This ambitious volume was produced in time for a two-day short course in Oulu, Finland, held prior to the 10th International Platinum Symposium, August 8–11, 2005, and in conjunction with the activities of IGCP Project 479, sponsored by UNESCO. It consists of an introduction by the editor Jim Mungall and 22 chapters by an international group of authors from academic and mining company affiliations.

The volume succeeds in its goal of wanting "to bridge the gap between academic research and modern exploration practice," and the contributions have been critically reviewed prior to editing. It is divided into five sections, beginning with "Geochemistry of Platinum-Group Elements," which consists of two chapters: one dealing mainly with geological and geochemical controls and mantle melting, and the other with aqueous geochemistry in specific environments. The next two sections are devoted to descriptive platinum-group element ore deposit models, of which the first contains five chapters on precious-metal-dominant deposits. The PGE deposit types are stratiform deposits in layered intrusions, deposits at the margins of layered intrusions, the supergene environment of a stratiform intrusion, placers associated with Alaskan-type complexes, and a group of hydrothermal and supergene deposits. The third section contains three chapters on base-metal-dominant PGE deposits; the first presents a refined classification of two Sudbury-area deposits; the second concerns conduits of magmatic ore deposits; and the third discusses the PGE potential of porphyry deposits. The fourth section entitled "Exploration Methods" begins with a chapter on economic and geological considerations. This is followed by three chapters discussing geophysical, geochemical, and lithogeochemical exploration methods. The final section contains seven case histories and ends with a brief six-page summary of the distribution and classification of Ni–Cu–Cr–PGE mineralization types. The case histories deal with exploration strategies and results from a variety of deposits: Fedorov-Panov layered mafic intrusion (Kola Peninsula), Nickel Rim South (Sudbury), Lac des Iles intrusive complex (Ontario), Hartley Platinum mine (Zimbabwe), Platinova Reef (Skaergaard intrusion), and Sukhoi Log (Eastern Siberia).

The volume includes a useful index and an appendix of 14 pages of color illustrations. The quality of the line drawings and photomicrographs is fair to good for this type of volume, where costs are held down by using matt instead of glossy paper. I found very few typos (e.g. Laflamme, p. 483). The volume is accompanied by a CD containing the full text, all color illustrations, spreadsheet, and color poster of PGE deposits.

Most of the authors are well known for their past and continuing contributions to the field. By providing up-to-date information, they have produced credible snapshots of their respective specialty. With the current upswing in the price of platinum, this volume is a timely source of valuable information for a wide audience, ranging from exploration geologists, geophysicists, and geochemists to senior undergraduate students in geological sciences. All chapters are well referenced with up-to-date citations, including papers in press; an unfortunate exception is the last chapter, which provides a classification of PGE mineralization types. I am unable to judge the quality of the review in many of the specialized papers. However, I found much new and valuable information that either has not yet been published or is not published in the form presented (e.g. placers associated with Alaskan-type complexes, the PGE potential of porphyry deposits, and on hydrothermal and supergene deposits). However, the last-mentioned summary is restricted to mineralization in certain environments and does not include some deposits with a hydrothermal component, such as Salt Chuck, Coldwell, New Rambler, and Rathbun Lake. Also noted is the very small starting weight (43 g) of a detailed mineral separation scheme described on page 475. The results from this study could well benefit from more critical assessment and review.

In conclusion, the volume is a valuable, timely, and affordable contribution to the PGE literature and should be obtained by all those working in the field of PGE, not just explorationists. It is a worthy addition to the short course volumes of the Mineralogical Association of Canada.

Louis J. Cabri
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Cabri Consulting Inc.

[1] Mungall JE, editor (2005) Exploration for Platinum-Group Element Deposits. Mineralogical Association of Canada Short Course Volume 35, 526 pp, plus CD. US$55 (outside Canada); CDN$55 (in Canada); reduced price for members

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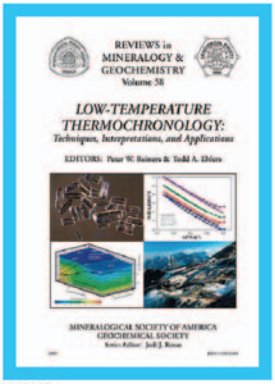
Low-Temperature Thermochronology: Techniques, Interpretations, and Applications

22 chapters covering many of the important modern aspects of thermochronology, including historical perspective, analytical techniques, kinetics and calibrations, modeling approaches, and interpretational methods. Volume 58 2005 Peter W. Reiners & Todd A. Ehlers, editors. i-xxii and 620 pp. ISBN 093995070-7. US$40



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