Preface

Earth is a very small part of a vast universe, but it is our home. Like Goldilocks, on Earth we enjoy just the right combination of conditions and ingredients necessary to maintain life and support our modern society. The science of geology is particularly important in our quest for understanding how planet Earth works.

Media reports keep us aware of the geological forces at work on our planet. News stories graphically portray the violent force of a volcanic eruption, the devastation generated by a strong earthquake, and the large numbers left homeless by landslides and flooding. Such events, and many others as well, are destructive to life and property, and we must be better able to understand and deal with them. To comprehend and prepare for such events requires an awareness of how science is done and the scientific principles that influence our planet, its rocks, mountains, atmosphere, and oceans.

Geology can also yield clues to help us understand, prevent, and repair environmental problems. Just as an auto mechanic must have a good working knowledge of the interactions among the parts in a car in order to fix it, the knowledge of our planet is critical to our well being and, indeed, vital to our survival.

The Canadian edition of *Earth: An Introduction to Physical Geology* is a university-level text that is intended to be a meaningful, non-technical primer for students taking their first course in geology. In addition to being informative and up-to-date, a major goal of *Earth* is to meet the need of students for a readable and user-friendly text, a book that is an effective resource for learning the basic principles and concepts of geology.

Distinguishing Features

Readability

The language of the book is straightforward and written to be understood by the layperson. Clear, readable discussions with a minimum of technical language are the rule. The frequent headings and subheadings help students follow discussions and identify the important ideas presented in each chapter. Large portions of the text were substantially rewritten in an effort to make the material less repetitive, more understandable, and more relevant to a Canadian audience.

Illustrations and Photographs

Geology is a highly visual science. Therefore, photographs and artwork are a very important part of an introductory book. *Earth* contains hundreds of photographs, of which over 100 are new to the Canadian edition. These have been carefully selected to aid understanding, add realism, and contribute a Canadian perspective to geological concepts.

The illustrations in *Earth* are renowned for their quality. The original art program was carried out by Dennis Tasa, a gifted artist and respected geological illustrator. The Canadian edition also features many pieces of new or substantially redesigned line art. The new art illustrates ideas and concepts more clearly and realistically than ever before. Most of the new illustrations produced for the Canadian edition were custom-designed by Cam Tsujita, with the help of the outstanding graphics team at Pearson Education Canada.

Focus on Learning

When a chapter has been completed, three useful devices help students review. First, the Chapter Summary recaps all the major points. Next is a checklist of Key Terms with page references. Learning the language of geology helps students learn the material. This is followed by Review Questions that help students examine their knowledge of significant facts and ideas. Each chapter closes with a reminder to visit the Companion Website for *Earth* (**http://www.pearson.ca/tarbuck**). It contains many excellent opportunities for review and exploration.

Earth as a System

An important occurrence in modern science, particularly in geology, has been the realization that Earth is a giant multidimensional system. Our planet consists of many distinct but interacting parts. The Earth system responds to changes in any of its constituent parts, often in ways that are neither obvious nor immediately apparent. Although it is not possible to study the entire system at once, it is possible to develop an awareness and appreciation for the concept and for many of the system's important interrelationships. Therefore, the theme of "Earth as a System," recurs at appropriate places throughout the book. It is a thread that weaves through the chapters and helps tie them together.

New and revised special-interest boxes relate to "Earth as a System." To remind the reader of this important theme, the small icon you see at the beginning of this section is used to mark these boxes.

People and the Environment

Because knowledge about our planet and how it works is necessary to our survival and well-being, the treatment of environmental issues plays an important part

of *Earth*. Such discussions serve to illustrate the relevance and application of geological knowledge. This theme is given considerable prominence in the Canadian edition. The text integrates a great deal of information about the relationship between people and the natural environment and explores applications of geology to understanding and solving problems that arise from these interactions. In addition to many basic text discussions, several of the text's special-interest boxes involve the "People and the Environment" theme and are quickly recognized by the distinctive icon you see at the beginning of this section.

Canadian Profile

Many of the people, places, issues, and ideas that play pivotal roles in understanding physical geology also happen to originate in Canada. Of course, this theme pervades the Canadian edition, but we have also highlighted certain topics for discussion in special-interest boxes in almost every chapter. You can identify these in the text by the small icon you see at the beginning of this paragraph.

Maintaining a Focus on Basic Principles and Instructor Flexibility

The main focus of the Canadian edition is to foster a basic understanding of physical geology. As much as possible, we have attempted to provide the reader with a sense of the observational techniques and reasoning processes that constitute the discipline of geology.

The organization of the text remains intentionally traditional. Following the overview of geology in the introductory chapter, we turn to a discussion of Earth materials and the related processes of volcanism and weathering. Next a discussion of a most basic topic, geologic time, is followed by an examination of the geological work of gravity, water, wind and ice in modifying and sculpting landscapes. After this look at external processes, we examine Earth's internal structure and the processes that deform rocks and give rise to mountains. Finally, the text concludes with an important chapter on resources and a step beyond the physical confines of our planet to view Earth in larger-scale context of the solar system. This particular organization was selected largely to accommodate the study of minerals and rocks in the laboratory, which usually comes early in an introductory-level geology course.

Realizing that some instructors prefer to structure their courses differently, each chapter is self-contained, so that chapters may be taught in a different sequence. Thus, the instructor who wishes to discuss earthquakes, plate tectonics and mountain building prior to dealing with erosional processes may do so without difficulty. We also chose to introduce the principles of plate tectonics as part of the first chapter so that this important and basic theory could be incorporated in appropriate places throughout the text.

More About the Canadian Edition

The Canadian edition of *Earth* represents a robust revision of its U.S. predecessor. Every part of the book was examined carefully with the goals of keeping topics current, addressing Canadian perspectives and issues, and improving the clarity of text discussions.

Here are some examples of what is new in the Canadian edition of *Earth:*

- Over 200 new photos, maps, and illustrations.
- Canadian examples used judiciously throughout, while retaining the best of the U.S. and international examples.
- New or substantially revised "People and the Environment" boxes, including features on: "Asbestos: What Are the Risks?" (Ch. 2) and "Return to the Dustbowl?" (Ch. 5).
- New or substantially revised "Understanding Earth" boxes, including features on: "A Closer Look at Facies" (Ch. 6) and "Index Fossils and Ecology of Organisms" (Ch. 8).
- New to the Canadian edition, the "Canadian Profile" box focuses on notable geologists, geological features, and geological events that are unique to Canada. Topics include: "Sir William Logan: Canada's Premier Geologist" (Ch. 1); "The Burgess Shale" (Ch. 6); "The Walkerton Tragedy: Geology Forms the Link" (Ch. 11); "Snowball Earth: Canadian Cryospheric Controversy" (Ch. 12); "The Okanagan Valley: A Canadian Desert" (Ch. 13); "Earthquakes in Canada" (Ch. 16); "LITHOPROBE: Probing the Depths of Canada" (Ch. 17); "Canadian Research on Earth's Four Cylinder Engine" (Ch. 17); "The Grand Banks Earthquake and Turbidity Current" (Ch. 18); "John Tuzo Wilson: Canada's Sponsor of Plate Tectonics" (Ch. 19); "Some Important Events in the History of Canada's Petroleum Industry" (Ch. 21); and "Fall and Recovery of the Tagish Lake Meteorite: A Messenger from the Early Solar System" (Ch. 22)
- Chapter 5, Weathering and Soil, includes coverage of the Canadian Soils Classification System, as well as a section on paleosols.

- Chapter 7, Metamorphism and Metamorphic Rocks, has been effectively rewritten and condensed to communicate more clearly the processes and products of metamorphism. Concepts are progressively built on one another, culminating in the concept of metamorphic facies and the significance of this concept with respect to plate tectonic processes.
- Chapter 10, Running Water, has been reformatted for a more logical flow of concepts, and now includes a Canadian-based account of the Red River Flood of 1997 as well as some interesting facts about the history of the Niagara River. In addition, examples of ancient river deposits are provided to give the reader a sense of how processes observed in modern rivers are used to interpret features of ancient river systems.
- Chapter 13, Deserts and Winds, now also includes information on polar deserts.
- Chapter 14, Shorelines, has been substantially revised, with greater emphasis on depositional features of coastlines and the sedimentary characteristics of ancient shoreline deposits.
- Chapter 20, Mountain Building and the Evolution of Continents, has been extensively rewritten to allow the step-by-step explanation of how, where, and why mountain building occurs, with the concept of isostasy as a common thread. This approach allows the reader to then understand mountain building episodes in the context of the Wilson Cycle, a concept given less prominence in U.S. editions of this text.
- Chapter 21, Mineral and Energy Resources, bears little resemblance to its U.S. counterpart. Substantial changes were made to this chapter to provide better explanations of how the many types of mineral and fossil fuel deposits came to be, to highlight environmental issues surrounding the extraction and use of natural resources, and more importantly, to make the chapter more relevant to Canadian issues. We view this chapter as perhaps the most important of all the chapters in this text, and much effort was concentrated in its revision. All the maps and most of the figures in this chapter are new and are focused on Canada.

The Teaching and Learning Package

We have prepared an excellent supplements package to accompany the text. This package includes the traditional supplements that students and professors have come to expect from authors and publishers, as well as some new kinds of supplements that involve electronic media.

For the Student

Geode III CD-ROM. Each copy of *Earth*, Canadian Edition, comes with GEODe III, by Ed Tarbuck, Fred Lutgens, and Dennis Tasa of Tasa Graphic Arts, Inc. GEODe III is a dynamic program that reinforces key concepts by using animations, tutorials, and interactive exercises. This new version has been updated and reorganized to provide content that more closely correlates to the text's content. A special GEODe III icon appears throughout the book wherever a text discussion has a corresponding GEODe III activity. This special offering gives students two valuable products (GEODe III and the textbook) for the price of one.

Companion Web Site. This site, created specifically for the text, contains numerous review exercises (from which students get immediate feedback), exercises to expand one's understanding of geology, and resources for further exploration. It provides an excellent platform from which to start using the Internet for the study of geology. Please visit the site at **http://www.pearson.ca/tarbuck.**

For the Professor

Instructor's Resource CD-ROM. This valuable aid provides quick and easy access to a wealth of valuable teaching tools, including the following:

- Instructor's Manual
- Test Generator. Averages more than 100 multiple-choice, true/false, and short-answer questions per chapter.
- Customizable PowerPoint® lecture presentations with Digital Image Gallery
- The Prentice Hall Geoscience Animations. A library of more than 30 Flash animations for physical geography, meteorology, physical geology, and Earth sciences. Created through a unique collaboration among four of Prentice Hall's leading geoscience authors, these animations make visual and accessible some key physical processes

Acknowledgments

Writing or revising a textbook requires the talents and cooperation of many individuals. When first approached by Pearson Education Canada with the prospect of adapting *Earth* for Canadian use, I jumped at the chance, partly because I was well aware of the quality of previous editions. Edward J. Tarbuck, Frederick K. Lutgens, and their U.S. publishing team have indeed set a high standard for university-level geology textbooks and I am honoured to have been involved in the production of the Canadian edition. The excellent graphics and user-friendly explanations of geological processes provided an excellent framework on which to build the current text.

I am indebted to many friends and colleagues who enthusiastically contributed material to the Canadian edition of *Earth*. I am also deeply thankful to the many professors who influenced my academic philosophy during my academic career and enhanced my interests beyond my own area of expertise in paleontology. Dr. Steve Hicock, a glacial geologist at the University of Western Ontario, is an individual who I particularly respect as a teacher. For this reason, I asked Steve for suggestions on how to adapt Chapter 12 (Glaciers and Glaciation) to better reflect the diversity of glacial features in Canada. The result is a product of Steve's enthusiasm for the project, and nearly all the improvements made to the chapter I owe to him.

Many other colleagues generously contributed material for the new "Canadian Profile" boxes found throughout the textbook. Many thanks are extended to these individuals:

Glen Caldwell
Rick Cheel
Claudia Cochrane
Matt Devereux
David Eaton
Alessandro Forte
Brian Hart
Steve Hicock
Phil McCausland
Mike Powell
Rob Schincariol
Gordon Southam
Gordon Winder
Grant Young

Several colleagues and other individuals were also very generous in providing new photographs for this edition of *Earth* and in many cases allowed me to use multiple images in their personal collections. I would particularly like to thank Catherine Hickson, Steve Hicock, Bob Hodder, Alfred Lenz, Mike Schering, Kristin Singh, Guy Plint, Denis Tetreault, and Grant Young for their cooperation in this regard. Although too numerous to mention here, several other people contributed individual images that enhance the tangibility of the concepts covered in the textbook, and I am grateful for their permission to showcase their photographic work.

Any project of this scale requires the work of many individuals to ensure that all of the logistical tasks are accomplished. David Dillon, Pamela A. Lowe, Matt Devereux, Bob Hodder, Erica Tsujita, and Anna Sergueeva were particularly helpful in ensuring that quality of this textbook reached a consistently high standard through their assistance in initial editorial work and in the acquisition of some of the photo permissions.

Special thanks go to those colleagues who prepared in-depth reviews for the Canadian edition. Their critical comments and thoughtful input helped guide our work and clearly strengthened the text. I wish to thank:

Kevin Ansdell, University of Saskatchewan
Dileep Athaide, Capilano College
S.A. Balzer, University of Alberta
Elliott Burden, Memorial University
Mary Lou Bevier, University of British Columbia
Ward Chesworth, University of Guelph
Rick Cheel, Brock University
Brewster Conant, Wilfrid Laurier University
Christopher Collom, Mount Royal College
Jaroslav Dostal, Saint Mary's University
Wayne Haglund, Mount Royal College
Charles Henderson, University of Calgary
S.R. Hicock, University of Western Ontario
Ian Hutcheon, University of Calgary
Joyce Lundberg, Carleton University
Anne Marie Ryan, Dalhousie University
Robert J. Ryan, Dalhousie University
Stuart Sutherland, University of British Columbia

I also want to acknowledge the team of professionals at Pearson Education Canada. Thanks are due to my Acquisitions Editors: Leslie Carson, who brought me on board, and Kelly Torrance, for her help in bringing this textbook to fruition. An enormous thanks is awarded to Paul Donnelly, Senior Development Editor, who did a remarkable job of coordinating this very ambitious endeavour and kept the project on an even keel at all times, even when it felt like the boat was tipping. On a personal level, I also thank Paul for his patience with my inexperience as a textbook author, for absorbing my frequent bouts of frustration that accompanied the writing of the text, and for tolerating my bad jokes. I'd also like to express my gratitude to the Production team, led by Judith Scott and Janette Lush, for their outstanding work.

Lastly, heartfelt thanks are extended to my wife Erica Tsujita, and my two sons Jeremy and Casey, who persevered through my long work hours and frequent absences from home during the preparation of this textbook. It is their love and support that keeps me going during these crazy periods of my life. Hang in there — I'll be home soon!

Cam Tsujita