

Cambridge University Press
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Randall J. Schaetzl & Michael L. Thompson
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Soils: Genesis and Geomorphology

Second Edition

In its first edition, *Soils: Genesis and Geomorphology* established itself as the leading textbook in the fields of pedology and soil geomorphology. Expanded and fully updated, this second edition maintains its highly organized and readable style. This edition is no small upgrade; it is a major revision. Suitable as a textbook and a research-grade reference, the book's introductory chapters in soil morphology, mineralogy, chemistry, physics, and organisms prepare the reader for the more advanced treatment that follows. This textbook devotes considerable space to discussions of soil parent materials and soil mixing (pedoturbation), along with dating and paleoenvironmental reconstruction techniques applicable to soils. Although introductions to U.S., Canadian, and international soil classification systems are included, theory and processes of soil genesis and geomorphology form the backbone of the book.

This thoroughly updated second edition has been revised, rewritten, and restructured to make topics flow more smoothly and read more easily, without sacrificing depth. Every figure has been revised, sharpened, and improved, and the glossary has been updated. The book now boasts an introductory chapter on soil chemistry, and new sections have been developed on soil descriptions, geoarchaeology, digital soil mapping, soil production functions, bombturbation, and the World Reference Base for Soil Resources. Replete with more than 550 high-quality figures and photos and a detailed glossary, this book will be invaluable for anyone studying soils, landforms, and landscape change anywhere on the globe.

RANDALL J. SCHAEZTL is a professor of geography and geosciences at Michigan State University. His research has been published in all the leading soils, geomorphology, and geography journals. He is the editor of the Soils section for the *International Encyclopedia of Geography* (Association of American Geographers) and a Fellow of the Geological Society of America. He is an expert in the soils and landforms of the Great Lakes region, and he is editor in chief of *Michigan Geography and Geology* (2012). His expertise on podzolization and pedoturbation has led him to publish numerous papers on these widespread soil processes.

MICHAEL L. THOMPSON is a professor of soil science at Iowa State University. For more than twenty years, he taught pedology and clay mineralogy courses, and for the past ten years, he has taught courses in soil chemistry. Thompson's research has dealt with paleosols, soil organic matter, and the fate of actinides, heavy metals, and organic contaminants in waste-amended soils. His research seeks to identify the chemical and physical conditions that favor stability, transformations, and movement of soil organic matter, anthropogenic contaminants, and clay minerals in soils. He is a Fellow of the Soil Science Society of America, the American Society of Agronomy, and the American Association for the Advancement of Science.

Praise for the Second Edition:

'Schaetzl and Thompson have done it. They took a book that was already unique among soil science books and made it better. This comprehensive textbook is a perfect read for soil scientists ... The book is the perfect teaching tool because the instructor who reads and uses it becomes so much more informed about pedology.... I enjoyed reading the first version so much I will buy a copy of the second edition for myself for professional and pleasure reading.'

- John M. Galbraith, Virginia Tech

'...the definitive textbook for those wishing to understand the complexity and beauty of soil genesis. The revised edition is a fantastic update, including rich additions of subject material and many new and/or improved figures. The well-organized text clearly conveys the importance of interdisciplinary research in understanding soil genesis through time, and it can be used for introductory and advanced courses ... well done authors!'

- Patrick Drohan, The Pennsylvania State University

'...a remarkably well-measured fresh cut across the disciplines of soil science, geology, and ecology. Neglected paths and boundaries between these disciplines finally get the light they deserve. This book is a rare success in the difficult act of balancing descriptive versus process-oriented perspectives on soils ... an approachable writing style and delightful figures and photos ... a deep treatment of the theory and history of studying soils, and it is encyclopedic in its geographical and temporal scopes.'

- Kyungsoo Yoo, University of Minnesota

'...a depiction of soils as a global system that links to - and interacts with - all other natural systems critical to human endeavors. The book is an asset to geomorphologists and pedologists alike.'

- Martha Cary (Missy) Eppes, University of North Carolina

'... this now classic textbook ... has been significantly updated, even including much about the on-going and important discussions about soils as human-natural systems. The book should be on the shelves of all environmental scientists and managers.'

- Daniel Richter, Duke University, author of *Understanding Soil Change*

'This book comprises the most important up-to-date theories and concepts of soil genesis ... very well written; you can feel that the authors are really fascinated by the world of soils, and their enthusiasm is infectious. And, what I think is extremely important ... this book imparts not only comprehensive knowledge on soils but also profound understanding of the geomorphological processes shaping landscapes and their interaction with soil formation.'

- Daniela Sauer, Dresden University of Technology

Praise for the First Edition:

'The writing is clear and concise, and the authors' enthusiasm for their subject material is obvious.... an excellent textbook for upper-level undergraduate and graduate level courses in soil geography, pedology, and geomorphology.'

- *The Canadian Geographer*

'... a big book in size, concept, and ideas.... lavishly illustrated ... Each section is often approached in quite fresh and new ways.... wonderful.'

- *Environmental Conservation*

'... a rare textbook: well-written, comprehensive, up-to-date, thought-provoking, and refreshingly opinionated.... well-suited for any course in pedology or soil geomorphology, whether it is taught in a geography, geology, or soil science program.'

- Joseph A. Mason, Department of Geography, University of Wisconsin-Madison

'... an excellent summary of pedogenic theory and should occupy the shelves of all pedologists and students of soil science.'

- *Vadose Zone Journal*

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Soils

Genesis and Geomorphology

Second Edition

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Michigan State University

and

Michael L. Thompson
Iowa State University



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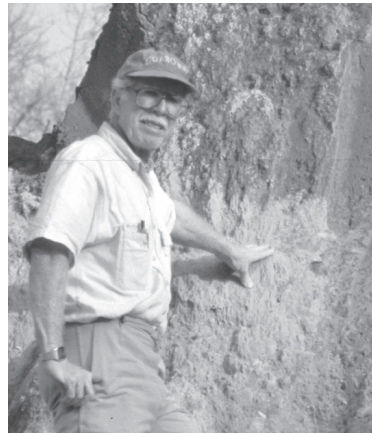
Dedication

We dedicate this volume to those who have inspired us to write it – through their lifelong scholarship, insatiable curiosity about the world around them, and their willingness to share it ... innovative thinkers who have made many, including us, stop and think about the world through different intellectual “filters”... scholars who make soils fun and exciting, but mostly, genuinely good people who inspired everyone around them to be better.



Francis D. Hole in 1978
(1932–2002)

Photo courtesy Univ. of Wisconsin,
Photo Media Center



Donald L. Johnson in 2009
(1934–2013)

Photo by RJS



Peter W. Birkeland in 1997
(1934–)

Photo by D Muhs

A New Psalm (inspired by Psalm 19)

The earth beneath the feet of all runners and walkers
 Declares the glory of God, our cherisher!
 The roots of trees and grasses, the mole
 And all organisms in the rich realm of darkness ...
 These are God's handiwork.
 Our life in the realm of sunlight
 Is upheld by the vital earth. God made it so.
 All creatures that live on the land depend on the soil,
 Which is like a strong parent,
 Providing for all peoples and
 All creatures that live above the waters.
 Praise be to the holy ground that is softly under our feet;
 Praise be to God who has blessed the living carpet
 That He has spread for our walking,
 In the days of our living in the flesh,
 And into which our rich residues will return.

Francis D. Hole, TNS

(For years, Dr. Hole had appended the honorary title, “TNS – temporarily not soil,” to his name, a sign of a bond that ties us all together, and of his love for the soil. We are proud to carry that notion forward.)

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Preface

This book is about pedogenesis and soil geography. To some, this is a difficult and challenging area of study, because a geographic approach to soils requires synthesis of the many physical, chemical, and biological systems that have interacted to form the soils that blanket most landscapes. Plus, these landscapes change through time. Our purpose in writing this book is to assert that only through a study of the spatial interactions of soils *on landscapes* can soil and landscape evolution be resolved and understood.

This book can be used in courses on soil geography, soil genesis, pedology, and soil geomorphology. Our assumption is that the readers have had some background in the natural sciences and are eager to learn more about soils. We do not assume, nor does the reader need, a substantial background in soils to read and comprehend this book. Difficult as the task may seem, our goal was to write a soils text that could serve both as an initial soils text and as a cutting-edge resource book of research grade.

Our emphasis, beyond that of pedogenesis and soil geography, is deliberately intended to be broad and comprehensive. Other similar books (Daniels and Hammer 1992, Gerrard 1992, Birkeland 1999) focus more on geomorphology and the initial geologic setting as a guiding framework for the understanding of soil landscape evolution. We emphasize these issues in later chapters. Fanning and Fanning (1989) and Buol *et al.* (2011) focus on soil genesis while emphasizing classification. Our book tries to walk the middle ground amid these approaches to the study of soils.

This book relies heavily on concepts and imagery – mental and graphical – to convey ideas. We have compiled a suite of figures, images, and graphics that, in and of themselves, convey messages that cannot be put into words. Throughout the text we include brief “out-takes” on soil landscapes from around the world. We call these excursions “Landscapes,” and hope that they convey, with pictures and graphics, what would otherwise take many hundreds of words to explain.

We believe in the necessity and importance of soil classification; we define, explain, and use its terminology in the book, but we do not focus on it. Because we feel that one of the best ways to “learn” and use taxonomy is to exam-

ine it in the context of landscapes, we include taxonomic information within many of the “Landscapes” excursions.

Soils research is exciting. It is enlightening to see and read about cutting-edge research. Therefore, we have spent considerable effort linking this book and its concepts to the literature. We are proud of the extensive literature listed herein. We have tried to cite many of the major works in the field, both the classic ones and the recent state-of-the-art papers. If we have missed something, we urge our readers to call it to our attention; we will be receptive. Where possible, we have tried to cite mainly papers and studies that are readily accessible in major academic libraries. That is, we have steered clear of obscure papers or those in the gray literature, as well as theses and dissertations, unless we felt that they were essential reading. The end result is a book that relies heavily on work published in national and international scholarly journals and books. If you wish to have a digital copy of our References section entries, just e-mail us (soils@msu.edu, mlthomps@iastate.edu) and ask.

The Glossary is rich in terms, many of which are only marginally touched upon in the text. Our philosophy with regard to the Glossary was simple: If the reader might need to know a term to understand something in the book, include it in the Glossary and define it clearly. The Glossary adds length to the book but makes it more “readable.”

Our goal for this second edition was to update the book – with respect to concepts, theoretical advances, and the literature – without necessarily making it longer. We have added a chapter on soil chemistry as well as new sections on digital soil mapping, soils and archaeology, and the World Reference Base for Soil Resources, among others.

We are constantly striving to make the book more readable and comprehensive. We encourage you, the reader, to help us. For example, if you wish any topics to be added to the Glossary or the body of the book, contact us with your request. More importantly, alert us to your papers, send reprints and citations, e-mail or write to inform us of new findings or breakthroughs; we will include them as best we can. Contact us with your perceptions of the book, positive or otherwise. Help us make this book better and we promise to continue to work hard toward this goal.

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