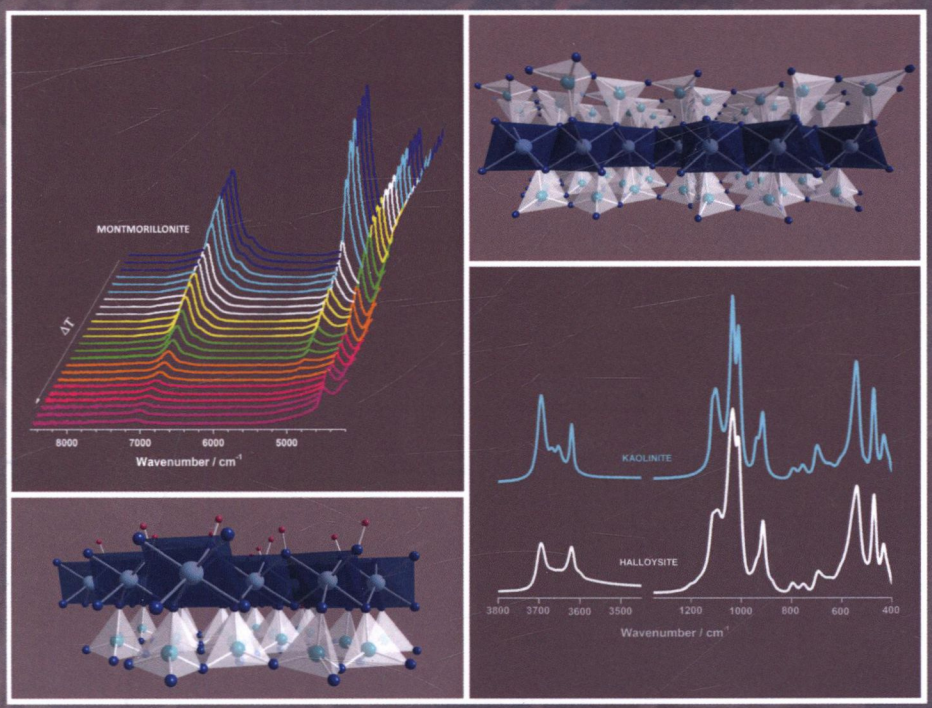
ELSEVIER
DEVELOPMENTS IN **CLAY SCIENCE** 8
SERIES EDITOR: F. BERGAYA

INFRARED AND RAMAN SPECTROSCOPIES OF CLAY MINERALS

EDITED BY
W. P. GATES, J.T. KLOPROGGE,
J. MADEJOVÁ, AND F. BERGAYA



DEVELOPMENTS IN CLAY SCIENCE 8
SERIES EDITOR: F. BERGAYA

INFRARED AND RAMAN SPECTROSCOPIES OF CLAY MINERALS

EDITED BY
W. P. GATES, J.T. KLOPROGGE,
J. MADEJOVÁ, AND F. BERGAYA

An up-to-date systematic review of spectroscopic theory, methods, and techniques for the study of clay minerals by infrared and Raman spectroscopies.

- Includes a systematic review of spectroscopic methods
- Covers the theory of infrared and Raman spectroscopies and instrumentation
- Features a series of chapters, each covering either a particular technique or an application

Infrared and Raman Spectroscopies of Clay Minerals, Volume 8 in the Developments in Clay Science series, is an up-to-date overview of the spectroscopic techniques used in the study of clay minerals. The methods include infrared spectroscopy, covering near-IR (NIR), mid-IR (MIR), far-IR (FIR) and IR emission spectroscopy (IES), as well as FT-Raman spectroscopy and Raman microscopy. This book complements the succinct introductions to these methods described in the original *Handbook of Clay Science (Volumes 1, 1st Edition and 5B, 2nd Edition)*, offering greater depth and featuring the most important literature since the development and application of these techniques to clay science. No other book covers such a wide variety of vibrational spectroscopic techniques in a single volume for clay and soil scientists.

W. P. Gates, Institute for Frontier Materials, Deakin University, Victoria, Australia

J. T. Kloprogge, Department of Chemistry, College of Arts and Sciences, University of the Philippines Visayas, Miagao, Philippines

J. Madejová, Slovak Academy of Sciences, Institute of Inorganic Chemistry, Bratislava, Slovakia

F. Bergaya, CNRS, Interfaces, Confinement, Matériaux et Nanostructures (ICMN) Orléans, France

GEOLOGY

ISBN 978-0-08-100355-8

9 780081 003558

ELSEVIER

elsevier.com/books-and-journals

8

EDITED BY

GATES
KLOPROGGE
MADEJOVÁ
BERGAYA

INFRARED AND RAMAN SPECTROSCOPY OF CLAY MINERALS

ELSEVIER

Developments in Clay Science

Volume 8

Infrared and Raman Spectroscopies of Clay Minerals

Edited by

W.P. Gates
Institute for Frontier Materials, Deakin University, Victoria, Australia

J.T. Kloprogge
Department of Chemistry, College of Arts and Sciences University of the Philippines, Visayas, Miagao, Iloilo, Philippines

J. Madejová
Slovak Academy of Sciences, Institute of Inorganic Chemistry, Bratislava, Slovakia

F. Bergaya
CNRS, Interfaces, Confinement, Matériaux et Nanostructures (ICMN) Orléans, France

Elsevier
Radarweg 29, PO Box 211, 1000 AE Amsterdam, Netherlands
The Boulevard, Langford Lane, Kidlington, Oxford OX5 1GB, United Kingdom
50 Hampshire Street, 5th Floor, Cambridge, MA 02139, United States

Notices

Knowledge and best practice in this field are constantly changing. As new research and experience broaden our understanding, changes in research methods, professional practices, or medical treatment may become necessary.

Practitioners and researchers must always rely on their own experience and knowledge in evaluating and using any information, methods, compounds, or experiments described herein. In using such information or methods they should be mindful of their own safety and the safety of others, including parties for whom they have a professional responsibility.

To the fullest extent of the law, neither the Publisher nor the authors, contributors, or editors, assume any liability for any injury and/or damage to persons or property as a matter of products liability, negligence or otherwise, or from any use or operation of any methods, products, instructions, or ideas contained in the material herein.

ISBN: 978-0-08-100355-8
ISSN: 1572-4352

Publisher: Candice Janco
Acquisition Editor: Amy Shapiro
Editorial Project Manager: Tasha Frank
Production Project Manager: Maria Bernard
Designer: Victoria Pearson

Typeset by SPi Global, India

Developments in Clay Science

Volume 8

Infrared and Raman Spectroscopies of Clay Minerals

Dedication

In loving memory of my son Andrew Olav Kloprogge

Feb. 2000–May 2016
J.T. Kloprogge

Contributors

D. Bain, Middleton Steading, North Deeside Road, Cults, Aberdeen, AB15 9PL, United Kingdom; derekcbain@gmail.com

E. Balan, Sorbonne Universités, Paris, France; etienne.balan@impmc.jussieu.fr

F. Bergaya, CNRS, Interfaces, Confinement, Matériaux et Nanostructures (ICMN) Orléans, France; f.bergaya@cnrs-orleans.fr

J.L. Bishop, SETI Institute, Mountain View, CA, United States; jbishop@seti.org

J. Carter, Institut d'Astrophysique Spatiale, CNRS, University de Paris - Sud, Orsay, France; john.carter@ias.u-psud.fr

G.D. Chryssikos, National Hellenic Research Foundation, Athens, Greece; gdchryss@eie.gr

W.P. Gates, Institute for Frontier Materials, Deakin University, Melbourn, Victoria, Australia; will.gates@deakin.edu.au

H.P. He, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou, China; hehp@gig.ac.cn

C.T. Johnston, Purdue University, West Lafayette, IN, United States; clays@purdue.edu

J.T. Kloprogge, Department of Chemistry, College of Arts and Sciences University of the Philippines, Visayas, Miagao, Iloilo, Philippines; t.kloprogge@qut.edu.au

J. Madejová, Institute of Inorganic Chemistry, Slovak Academy of Sciences, Bratislava, Slovakia; jana.madejova@savba.sk

J.R. Michalski, Department of Earth Sciences and Laboratory for Space Research, University of Hong Kong, Hong Kong, China; jmichal@hku.hk

S. Petit, Institut de Chimie des Milieux et Matériaux de Poitiers, Université de Poitiers, Poitiers, France; sabine.petit@univ-poitiers.fr

H. Pálková, Institute of Inorganic Chemistry, Slovak Academy of Sciences, Bratislava, Slovakia; uachpalk@savba.sk

J. Zhu, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou, China; zhujx@gig.ac.cn

Acknowledgements

(1) *Faïza Bergaya* acknowledges her co-editors for accepting this non-trivial task and for the heavy work they provided during these past 2 years. The author is particularly thankful to Jana Madejová for her enthusiastic participation as co-author of several chapters, and as co-editor of the book. The author also extends her gratitude to Helena Pálková, for help with the conception and development of the cover. She also expresses her thanks to Will Gates who acted as co-author of several chapters and also, later during its final stages, as first main editor of this book. His help in sharing this last responsibility of managing this book was particularly invaluable. A special thought should be addressed to Theo Kloprogge who, despite a personal setback (a sad event that happened while editing this book), continued to be active writing important chapters for this book. Both Faïza and Will are very grateful for his effort and valuable contributions.

(2) *Will P. Gates* thanks the co-editors for asking him to join the team and his co-authors for three of the chapters. As co-author of Chapter 7, he acknowledges that some of the data were collected at the Australian Synchrotron during commissioning of the far-IR beamline. The authors of this chapter acknowledge *D. Appadoo* and *J.D. Cashion* for their able assistance in collecting the data displayed in Fig. 7.9.

(3) *Jana Madejová* acknowledges her co-authors for three chapters of this book, and *P. Komadel*, for many years of close collaboration in the IR study of clays and clay minerals.

(4) *Theo Klopproge* extends his thanks, first of all, to *Faïza Bergaya* for making a long-held dream come true after his forced retirement from the Queensland University of Technology. He specially acknowledges the co-editors for their tremendous help and support in what was for him personally an extremely difficult year. Finally, Theo wants to thank, in particular, *Will Gates* as he took over so much of the work of the main editor in getting this book to the finish line.

(5) All four co-editors express their thanks to the external authors and co-authors of the different chapters of this volume for their useful and timely contributions which made this book possible. Last but not least, several anonymous reviewers are thanked for their precious help in improving the scientific quality of this book. The hard work of the authors and reviewers has resulted in a hopefully excellent addendum to Farmer's book.

(6) Co-author of Chapter 4, *Georgios Chryssikos*, thanks *V. Gionis* (NHRF) for many years of close collaboration in the study of clays, and *G. Kacandes* (Geohellas S.A.) and *M. Stefanakis* (S&B Industrial Minerals, now Imerys) for setting the challenge and providing the means.

(7) The authors of Chapter 14, *Janice Bishop*, *Joseph Michalski* and *John Carter* are grateful to *R.E. Arvidson* and *J.J. Wray* for their helpful comments that greatly improved this chapter.

Contents