

Cold Aqueous Planetary Geochemistry with FREZCHEM

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Cold Aqueous Planetary Geochemistry with FREZCHEM

From Modeling to the Search for Life
at the Limits

With 58 Figures and 33 Tables

 Springer

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Cover illustration: The cover art shows an eroding ancient Martian shoreline with sedimentary rock outcrops and ice remnants of a former lake, including rock deposits similar to those now being explored by the Mars Opportunity rover. The ancient lake is shown in the cutaway cross section at bottom right as it once may have been, with an ice-covered liquid brine lake and bubbles associated with gas hydrates and/or life.

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G.M.M. dedicates this book to his parents,
Maurice L. Marion and Lilianne Nadon Marion,
and to his wife, Dawn C. Hammond.

J.S.K. dedicates this book to Bé, Van,
Christopher, Dianna, and Isaiah, and his parents,
and to those who hold the world in their hearts.

Preface

This book focuses primarily on the FREZCHEM model, which was explicitly developed to quantify aqueous electrolyte properties at subzero ($< 0\text{ }^{\circ}\text{C}$) temperatures. The foundations of this model are based on chemical thermodynamic principles. Professionals and students that will find this book especially useful include geochemists interested in cold aqueous processes, geochemical modelers, cold planetary scientists, astrobiologists, physicochemists, and chemical engineers.

The original version of the model dealt with chloride and sulfate chemistries and was written when the senior author worked at the Cold Regions Research and Engineering Laboratory (U.S. Army Corps of Engineers) in Hanover, New Hampshire. Subsequent versions with new chemistries were largely funded by NASA for applications to cold Solar System bodies such as Mars and Europa.

Over the years, a number of individuals have contributed to developing the model, helped correct FORTRAN coding problems by using the model and providing feedback, collaborated on associated projects and papers, and reviewed associated papers. Those that have contributed, directly and indirectly, to model parameterization include Donald G. Archer, Peter Brimblecombe, Kenneth S. Carslaw, Simon L. Clegg, Anthony J. Gow, Steven A. Grant, David L. Hogenboom, Jeffrey S. Kargel, Boris S. Krungalz, Mikhail V. Mironenko, Nancy Møller, Christophe Monnin, John W. Morse, Ronald J. Spencer, Nicolaus J. Tosca, and John H. Weare. Users of the model that have provided feedback include Rich Anouar, Charles Barnhart, Craig Brown, David Catling, Peter Croot, Megan Elwood Madden, Qi Fu, Robert Gärtner, Mats Granskog, Birgit Hagedorn, Christopher Hall, Wouter Heijlen, Steve Jepson, Lars Kaleschke, Edwin Kite, Claudine Lee, Pawel M. Lesniak, Anna Markiwiu, Nathalie Maurer, Christopher P. McKay, Jill Mikucki, Lisa Miller, Mikhail V. Mironenko, Samuel Morin, Todd Nichols, Christopher Omelon, Stathys Papadimitriou, Jean-Marie Perrier, Venasan Pillay, Volker Rath, Bernhardt Saini-Eidukat, William Seyfried, Douglas Sheppard, Mark Skidmore, Ronald S. Sletten, Alexander Sokolov, Steven Vance, Yongliang Xiong, Min Zhang, and Mikhail Zolotov. Collaborators on associated projects and papers include Jay Arnone, David C. Catling, Hajo Eicken, Ronald E. Farren, Rainer Feistel, Christian H. Fritsen, Eric Gaidos, Steven A. Grant,

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Giles M. Marion
Jeffrey S. Kargel

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