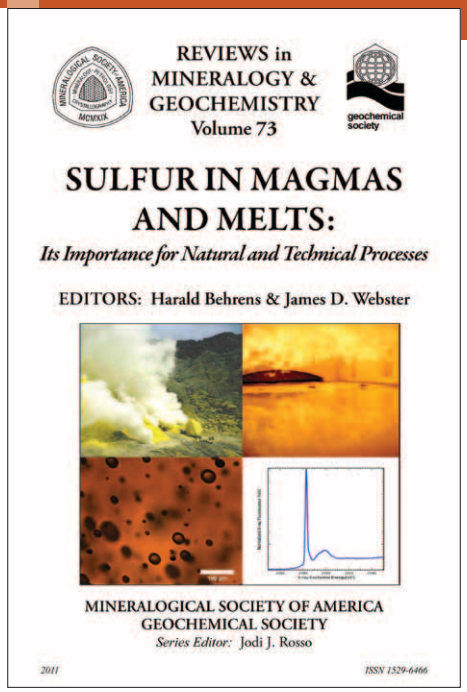
SULFUR IN MAGMAS AND MELTS: ITS IMPORTANCE FOR NATURAL AND TECHNICAL PROCESSES



Published by the Mineralogical Society of America and the Geochemical Society, volume 73 of the Reviews in Mineralogy & Geochemistry series, *Sulfur in Magmas and Melts: Its Importance for Natural and Technical Processes*, is an excellent reference volume and will be, for many people and for many years to come, the starting point for understanding the role of sulfur in melts. Edited by Harald Behrens and Jim Webster, this soft-cover, 578-page book consists of 15 chapters divided into 4 sections. The table of contents and an overview of each chapter are available online at www.minsocam.org/MSA/RIM/Rim73.html.

The editors state that the purpose of the volume is "to summarize the current state of research concerning sulfur in melts." To accomplish this, they looked beyond the geosciences to the broader field of sulfur in melts, regardless of the type of melt. The potential benefit is that by looking beyond geosciences and into other areas (materials science and, in particular, the glass industry) geoscientists may gain a different perspective. Readers working in materials science may also benefit by looking at the problem from the perspective of geoscientists (especially regarding high-pressure processes). The emphasis, nonetheless, is on geosciences. Only 3 of the 15 chapters are devoted to industrial applications: two deal with industrial glasses (fining and color), and one treats steel desulfurization. Of the remaining chapters, several contributions go beyond sulfur in melts. These chapters may not be obvious from the title but help make this volume a valuable reference encompassing a variety of topics related to sulfur.

The first section of the book (Analytical and Spectroscopic Methods) consists of two chapters. Chapter 2 summarizes analytical techniques for measuring the sulfur (S) content in glasses, whole rocks, minerals, and fluid inclusions and is an excellent starting point for evaluating the most appropriate techniques to use. Readers will appreciate the tables that summarize, for example, the type of sample required, detection limits, and limitations of each technique. Chapter 3 is dedicated to S speciation in glasses (as a proxy for S speciation in melts). Four techniques are discussed in detail (EPMA, XANES, NMR, and Raman spectroscopy), and the emphasis is on the first two, mostly because they are more mature and because the current level of development of NMR and Raman spectroscopy is limited.

The second section (Physical and Chemical Properties of Sulfur-Bearing Silicate Melts) contains 5 chapters and is the most technical section. Chapter 4, devoted to S diffusion, mostly compares S diffusion to diffusion of other volatiles. The data compilation (as appendices), discussion, and summary combine to make a good review chapter. Chapter 5 will be of interest to most geoscientists: it deals, in part, with Fe^{3+} and S^{2-}, and changes in oxygen fugacity in silicate melts. Chapters 6 and 7 deal with one of the core topics of the book: controls on the S content in silicate melts. Chapter 6 deals mostly with low-pressure experiments, whereas chapter 7 presents an extensive discussion of the thermodynamics related to the S content in silicate melts. Software complementing this chapter is available from the RiMG website.

The third section (Constraints from Natural and Experimental Systems) also contains 5 chapters. Chapter 8 discusses the S budget in magmas and volcanic S emissions, including the excess-sulfur (excess-volatile) problem. Chapter 9 deals with the challenge of understanding S in the context of other volatile species (O, H, C, Cl), and how this knowledge can be used to monitor volcanic degassing. Chapter 10 is a dense but uncluttered review of S-bearing minerals, including minerals containing S as an essential component (sulfides, sulfates) and as a minor constituent (apatite, silvialite, haüyne, etc.). It includes the most essential phase diagrams and a brief discussion of the importance of these minerals for unraveling magmatic processes. Chapter 11 discusses aspects such as the role of S in melts during core–mantle separation and in extraterrestrial bodies like Io (one of Jupiter's moons and the most volcanically active body in the Solar System). Chapter 12 explains how sulfur is used to remove bubbles (fining) during glass manufacturing.

The last section (Natural and Technical Applications) contains four chapters. Chapter 13 is dedicated to degassing in volcanoes (including monitoring eruptions, sulfur release during passive degassing, massive release during catastrophic eruptions, and short-term climate change). Chapter 14 deals with the use of S isotopes and is an excellent introduction to those unfamiliar with isotopes. Chapter 15 is a technical one and discusses the process of desulfurization and how to control the very small amounts of S needed in steel. Chapter 16 summarizes our current understanding of the role of S in the origin of ore deposits, with a focus on porphyry and orthomagmatic deposits. It includes summaries and discussions on metal partitioning between sulfide and silicate melts and models of sulfur content at sulfide saturation.

The volume is well edited (although chapters 13 and 14 are listed backwards on the back cover). A minor problem is the use of inappropriate terminology, such as "sulfur solubility" and "solubility of sulfur," although this is mostly an inherited problem from the peer-reviewed literature. One of the chapters provides a much-needed discussion on terminology, but it states that "the solubility of sulfur" can be defined as "the equilibrium concentration of S in a phase under a given set of thermodynamic parameters and coexisting phases." However, one could argue that *concentration* should be the term used in such cases and that *solubility* should be used in reference to a saturating phase (as defined by the IUPAC), which would remove unnecessary ambiguity. Almost all chapters have excellent tables, summarizing key information and providing all the references needed to pursue further research. Some chapters go beyond summarizing the current state of knowledge and provide some reflections regarding where more research is needed (something that perhaps all review chapters should have).

Who should read this book? Geochemists and graduate students working with sulfur in magmatic systems and silicate melts in general, analysts wishing to optimize S analysis in a variety of phases, people involved in the manufacturing of technical glasses, and, in general, anybody with interest in the role of S in high-temperature processes. In conclusion, this is a superb reference for anything and everything related to sulfur and an excellent companion to other RiMG volumes.

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