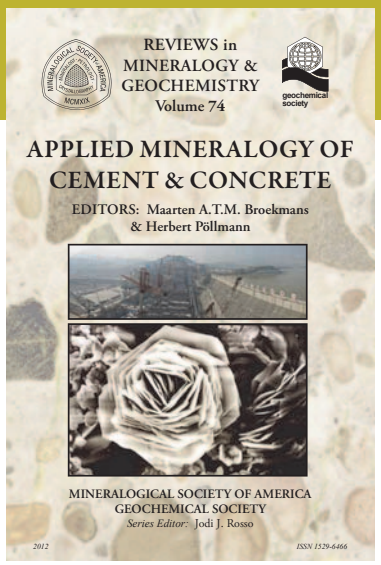
APPLIED MINERALOGY OF CEMENT AND CONCRETE[1]



Cements and concretes are among the most widely used materials, and they have had a significant impact on modern human activities and the environment. Ordinary Portland cement is the essential binder in modern concrete, and together with other cement types, it represents a fundamental and cheap commodity for the development of society's infrastructure around the world. Concrete is second only to water in terms of the total volume of raw material consumed annually. It is well known that cement production generates a substantial amount of CO_2, such that the cement industry produces approximately 5% of current, global, man-made CO_2 emissions. It is expected that the increasing global population, the economic growth of developing countries, and a need for climate change mitigation and adaptation measures will boost the future demand for cement. The lack of a real alternative to concrete as a major construction material at a global scale is a challenging issue for the whole planet. Therefore, it is appropriate that the geosciences, and specifically mineralogy and geochemistry, provide a conceptual framework for understanding the problems involved and propose possible solutions. The need for replacing Portland cement–based concrete by alternative formulations with acceptable engineering performance, long-term durability, environmental compatibility, and sustainable production ought to be a fundamental driving force in geoscience research. Given these premises, a volume devoted to the mineralogy of building materials fills an existing gap in the Reviews in Mineralogy & Geochemistry (RiMG) series.

Based on a project conceived in 2006 and approved by MSA Council in 2009, RiMG volume 74 is the product of the short course entitled Applied Mineralogy of Cement and Concrete, which was sponsored by the Mineralogical Society of America and the Geochemical Society and held in Trondheim, Norway, in July 2011, prior to the 10th International Congress for Applied Mineralogy, and again in June 2012, after the International Congress on the Durability of Concrete. The short courses were organized by the editors of RiMG volume 74, Maarten A. T. M. Broekmans, Geological Survey of Norway, Trondheim, Norway, and Herbert Pöllmann, Martin Luther Universität, Halle (Saale), Germany.

Chapter 1, by Herbert Pöllmann, provides an in-depth description of calcium aluminate cements (CAC), including their manufacture, phase diagrams, hydration reactions, and the effects of admixtures and impurities. The wide variety of phase compositions and crystal structures possibly occurring in CACs and their hydration products are listed and depicted. Notwithstanding the fact that CACs are only used in small-scale, specialized applications due to their relatively high cost (H. Justnes, the same volume), the extensive and authoritative review by Pöllmann stands as a state-of-the-art reference for a readership ranging from students to the advanced researcher.

In chapter 2, Harald Justnes presents a critical overview of low-CO_2 calcium oxide sources alternative to calcium carbonate currently used in the production of Portland cement. The pressure to make the production of concrete more sustainable, or "greener," is considerable and increasing. Pure Portland cement will have to be replaced by more complex binary, tertiary, or even quaternary binders, including other types of cementitious materials. This short contribution by the chief scientist at a large independent research organization in Scandinavia has the merit of providing a realistic Earth sciences viewpoint on the sustainability of concrete production.

Paul Stutzman of NIST has long contributed to the development of optical and electron microscopy techniques and standards for studying and quantifying clinker phases in Portland cements. The practical advice in chapter 3 is the result of his long experience in the field. Newer and promising X-ray computed tomography methods aimed at investigating undisturbed sample volumes are briefly mentioned.

Chapter 4, by Roger Meier, Jennifer Anderson, and Sabine Verryn, reflects the great attention given nowadays by manufacturers of analytical equipment, in particular X-ray diffraction instrumentation, to the cement industry. Automated XRD measurements and Rietveld analysis have been successfully applied to the online, continuous monitoring of the cement-production workflow.

In chapter 5, Miguel Aranda, Ángeles de la Torre, and Laura Leòn-Reina provide a complete and authoritative introduction to Rietveld quantitative phase analysis as applied to ordinary Portland cements and their hydration processes. Tables 1 to 3, listing the most common phases occurring in ordinary Portland cements, along with their ICSD and PDF codes, make a very useful and reliable reference for beginners in the Rietveld analysis of cement materials. The chapter is bound to be a reliable and important reference in the future.

The comprehensive and in-depth review of supplementary cementitious materials compiled by Ruben Snellings, Gilles Mertens, and Jan Elsen in chapter 6 complements chapter 2 in convincingly showing that the performance, durability, and sustainability of concrete can be improved by mastering the wide assortment of geological and by-product materials that can be blended with Portland cements. The subject is well covered and thoroughly discussed.

The book closes with chapter 7, by Maarten Broekmans. It treats deleterious reactions of aggregate with alkalis in concrete and deals with several topics possibly related to the main subject. A merit of this chapter is that it shows that the recognition of deleterious processes in concrete requires a combination of techniques.

As pointed out in the volume preface, the applied mineralogy of cements and concrete is a steadily growing field. The selection of a limited number of topics to be covered in a single volume is therefore unavoidable. Unlike a comprehensive textbook, RiMG volume 74 provides a collection of contributions from a competent group of authors. Any reader acquainted with the basics of cements and concrete will find most of the chapters very useful in terms of the depth of coverage and the extensively cited literature. However, in the absence of general guidelines and an appropriate introduction, the beginner might find it difficult to place the chapters in an appropriate context. For example, the notation of cement's chemistry is formally given on page 84 even though it is used earlier. Ordinary Portland cement is properly introduced only in chapter 3, although a discussion of this universally used material could have been given in an introductory chapter. Furthermore, modern methods used in cement and concrete research, such as advanced imaging techniques and computer modeling, are almost completely ignored, apart from a few sparse citations (end of chapter 3); they deserve a more complete coverage.

Applied Mineralogy of Cement and Concrete will be a useful reference for a wide readership in cementing materials. Some of the chapters, especially chapters 1, 5, and 6, will be comprehensive and authoritative sources for those interested in the specific topics. RiMG volume 74 maintains the tradition and standard of the Reviews in Mineralogy & Geochemistry series.

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1 Broekmans MATM, Pöllmann H (eds) Applied Mineralogy of Cement and Concrete. Reviews in Mineralogy & Geochemistry 74, Mineralogical Society of America, i-x + 364 pages, ISBN 978-0-939950-88-1, US$40