Calcium Carbonate

From the Cretaceous Period into the 21st Century

Edited by F. Wolfgang Tegethoff

in collaboration with Johannes Rohleder and Evelyn Kroker

Cover illustration: Scanning electron microscope image of a coccolith.

A CIP catalogue record for this book is available from the Library of Congress, Washington D.C., USA

Die Deutsche Bibliothek – CIP-Einheitsaufnahme

Calcium carbonate : from the Cretaceous Period into the 21st century / ed. by F. Wolfgang Tegethoff.
In collab. with Johannes Rohleder and Evelyn Kroker. - Basel ; Boston ; Berlin : Birkhäuser, 2001
Dt. Ausg. u.d.T.: Calciumcarbonat
ISBN 978-3-0348-9490-6 ISBN 978-3-0348-8245-3 (eBook)
DOI 10.1007/978-3-0348-8245-3

This work is subject to copyright. All rights are reserved, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, re-use of illustrations, recitation, broadcasting, reproduction on microfilms or in other ways, and storage in data banks. For any kind of use, permission of the copyright owner must be obtained.

The use of registered names, trademarks etc. in this publication, even if not identified as such, does not imply that they are exempt from the relevant protective laws and regulations or free for general use.

The publisher and editor can give no guarantee for the information on dosage and administration contained in this publication. The respective user must check its accuracy by consulting other sources of reference in each individual case.

© 2001 Springer Basel AG

Originally published by Birkhäuser Verlag in 2001

Softcover reprint of the hardcover 1st edition 2001

Printed on Biberist Furiso, calcium carbonate matt art paper (115 g/m²)

Layout: Karina Schwunk, Essen

ISBN 978-3-0348-9490-6

Index

FOREWORD

VIII

I. GEOLOGY OF CALCIUM CARBONATE

1

by Jacques Geysant

1. Features and characteristics of calcium carbonate

2

1.1 Calcium carbonate – a special compound

2

1.2 The crystal forms of calcium carbonate – mineralogy

9

2. The limestones – development and classification

15

2.1 Sedimentation

16

2.2 Diagenesis – from sediment to rock

23

2.3 Classification of the limestones

24

2.4 Metamorphism – from limestone to marble

26

2.5 Carbonatites – extraordinary limestones

29

3. Limestone deposits

31

3.1 Recognition of limestones

31

3.2 Distribution on the Earth's surface

33

3.3 Limestone deposits in the geological ages

36

3.4 CaCO_3 cycle

42

3.5 Industrially exploitable CaCO_3 deposits

44

II. THE CULTURAL HISTORY OF LIMESTONE

53

by Johannes Rohleder

1. The history of chalk

55

2. Marble and limestone

69

2.1 Quarrying stones

70

2.2 Transport, organisation and trade

80

2.3 The uses

97

III. CALCIUM CARBONATE – A MODERN RESOURCE

137

1. The beginnings: Calcium carbonate in glazing putty and rubber

138

by Johannes Rohleder

1.1 A chalk industry is born

139

1.2 Rubber and glazing putty

142

1.3 From chalk to calcium carbonate

156

2. Calcium carbonate – pigment and filler

160

by Eberhard Huwald

2.1 Properties and effects of a filler

164

2.2 Chalk, limestone, marble, PCC – common features and differences

165

2.2.1 Chalk

167

2.2.2 Limestone and marble

167

2.2.3 PCC

168

2.2.4 Areas of application

168

3. From rock to filler	170
by Eberhard Huwald	
3.1 Prospecting	171
3.2 Quarrying	172
3.2.1 Chalk	172
3.2.2 Limestone and marble	173
3.3 Mineral dressing	178
3.3.1 Production of the pre-ground product	180
3.3.2 Production of fillers	184
3.3.3 Other processes	190
3.3.4 Production of PCC	190
3.3.5 Storage and packing	191
3.4 Logistics - the route to the customer	193
 IV. CALCIUM CARBONATE AND ITS INDUSTRIAL APPLICATION	 197
1. Paper	198
by Christian Naydowski	
1.1 Calcium carbonate as filler	199
1.1.1 Paper manufacturing	200
1.1.2 The role of fillers in paper	201
1.1.3 Uncoated filled papers	204
1.1.4 Neutral paper manufacturing with calcium carbonate	207
1.2 Calcium carbonate as coating pigment	215
1.2.1 Upgrading of paper and cardboard	215
1.2.2 Coated paper qualities	218
1.2.3 Pigment properties for paper coatings	220
1.3 Industrial use of calcium carbonate in the paper industry	236
 2. Plastics	 238
by Peter Heß	
2.1 The Plastics Market	240
2.2 Fillers and Reinforcing Agents	242
2.3 Calcium Carbonate as Plastics Fillers	249
2.3.1 Calcium Carbonate in Thermoplastics	250
2.3.2 Calcium Carbonate in Thermosets	255
2.3.3 Calcium Carbonate in Elastomers	257
2.3.4 Calcium Carbonate in Adhesives and Sealants	258
2.4 Recent Developments	259
 3. Surface Coatings	 260
by Dieter Strauch	
3.1 Building blocks for surface coatings	262
3.2 Extenders in surface coatings – functions and properties	264
3.3 The use of calcium carbonates in selected coating systems	268
3.4 Trends	274
 4. Calcium Carbonate – A Versatile Mineral	 275
by Ralph Kuhlmann	
4.1 The use of calcium and magnesium carbonate in agriculture	275
4.1.1 The influence of lime treatment on the soil	279
4.1.2 The influence of lime treatment on the plant	284
4.1.3 Lime fertilizer and its conversion	290

4.2 The use of calcium and magnesium carbonate for forestry	291
4.3 Lime fertilizers and their application in Europe	294
4.4 Calcium carbonate in the feeding of livestock	295
4.5 Calcium carbonate for environmental protection	296
4.5.1 Flue-gas cleaning	296
4.5.2 Drinking water processing	297
4.5.3 Neutralisation of over-acidified water	300
4.6 Calcium carbonate – Everyday products by Johannes Rohleder	301
ANNEX	313
Bibliography	314
Definitions and Measurement Methods	319
Identification of successful processing	319
Measurement Methods	321
Glossar	325
Selection of major standards	329
Register	330
Geography	330
People and Companies	330
Technical Terms	331
Index of important addresses and institutions	336
Index of illustrations	341

Foreword

Anyone who takes the trouble to look up all the entries that have been filed under “Calcium Carbonate” in a university library will be surprised – if not overwhelmed – by the enormous amount of literature that is concerned in one way or another with this subject. Most of the corresponding books and journals can be assigned to the realms of chemistry, but they also include technical, geological and mineralogical literature. A continued search will eventually unearth works on the history of the arts and architecture. This is because calcium carbonate minerals, be they in the form of chalk, limestone or marble, symbolize defining moments in the history of our culture – the first prehistoric cave drawings in simple coloured chalk, the gigantic limestone blocks used to build the Egyptian pyramids and the marble statues of Michelangelo and Bernini.

This great diversity of what, at first sight, may appear to be only a simple chemical compound makes it rather difficult to explain to a layman what our company is producing and how the product should be defined. This task is much easier if you produce cars or furniture since only experts from different disciplines can associate certain concepts with calcium carbonate. The geologist and mineralogist will envision limestone and chalk or the different forms of marble. The engineer concerned with processing and application technologies will be familiar with the mineral's complicated crystalline properties, while the artist or art historian will think of the flawless “statuario” from the Carrara marble quarries that is sculptured into products that beautify our world.

The different terms and definitions are as numerous as the multitude of “aesthetic” and “useful” items that can be produced from CaCO_3 – the chemical formula of calcium carbonate. Moreover, such a diversity and profusion invariably tends to be bewildering rather than clarifying.

This book sets out to overcome this confusing array by indicating the multifarious interdependencies that exist in the world of calcium carbonate – its geology and the his-

tory of the arts, its extraction and processing and, obviously, its use in modern industry. Thus, the geologist will find out how a super-white calcium carbonate slurry is produced from marble for use in paper making. The paper manufacturer, in turn, will be on home ground when the difference is explained between the calcium carbonate coating pigments produced from chalk or marble.

This book is therefore not targeted at a specific professional group with clearly defined knowledge and closely outlined interests, but rather at a very broad spectrum of specialists – among them geologists, processing technicians, paper manufacturers and agricultural scientists – as well as interested laymen who are interested beyond their own particular fields.

The book will reveal how, over a period of many millions of years, coccoliths (Coccolithophorida) have formed mountains composed of a vital filler that has become irreplaceable in modern industry for many everyday products, be they paints, varnishes, plastics or high-quality art paper. This book sets out to fulfil the formidable task of elucidating all these varied aspects – a truly demanding aim that places the highest expectations on the authors and the editorial work for this publication.

Since technical museums are responsible for presenting the sciences, technology and history in a popular form, and since calcium carbonate is extracted by mining methods, it was only natural that the German Mining Museum in Bochum was approached to take over the responsibility of realising this book project. I found two very competent and committed partners in Dr. Evelyn Kroker and Johannes Rohleder who, after three years of intensive and inspiring work, transformed the initial ideas into this remarkable compendium.

At this point I would also like to thank Professor Jacques Geyssant (Paris), Dr. Peter Hess (Cologne), Dr. Eberhard Huwald (Gummern), Dr. Ralph Kuhlmann (Wuppertal), Dr. Christian Naydowski (Oftringen) and Dieter

Strauch (Oftringen) for their invaluable work. Obviously, I knew beforehand that they were all outstanding experts in their respective fields of "Calcium Carbonate". However, their contributions also proved that, as authors, they had mastered in a very impressive manner the need for scientific exactitude in conjunction with a lucid, generally understandable presentation.

There was also another direct reason for our company to have this book published under the scientific guidance of the German Mining Museum, namely the fact that the company looks upon itself as a modern mining company as it gains calcium carbonate as a raw material from marble, limestone and chalk extracted by quarrying as well as open-cast and partially underground mining of its own extensive deposits in Europe, America and Australia. Moreover, the company refines the raw material by sophisticated technological processes to produce high-quality fillers for industrial production. Some of these processing and refining operations are actually conducted in close co-ordination with the buyers of a products – a partnership that cannot be taken for granted but which is very much to our mutual advantage.

Three years of hard work for a book that is exclusively concerned with calcium carbonate – Is such considerable effort really worth while? The answer is a clear yes! Cal-

cium carbonate has not only had a long history that started long before the Cretaceous Period, but it also has a great future that will extend far beyond the 21st century. And it has been the purpose of this book to unite the two – the past and the future. "Calcium Carbonate – From the Cretaceous Period right into the 21st century" – All the current knowledge has been compiled in this book so that it will be available for tomorrow.

If this is not reason enough, then allow me to draw attention to the French philosopher Denis Diderot who, when asked about the reason for his "Encyclopédie ou Dictionnaire raisonné des sciences, des arts et des métiers", gave a very simple reply: "If the only thing to be saved in the Great Flood had been a copy of the 'Encyclopédie', then not everything would have been lost."

And I hope that Denis Diderot would not mind if I, as a person of the 21st century, were to add: In the event that a CD-ROM version of the "Encyclopédie" were to drift in the Great Flood onto some remote piece of land, there would bound to be someone who would revive the knowledge stored in bits and bytes to produce a beautiful art-print binding in the old bibliophile form to satisfy Man's thirst for knowledge.

F. Wolfgang Tegethoff