Analytical Chemistry in Archaeology

An introductory manual that explains the basic concepts of chemistry behind scientific analytical techniques and that reviews their application to archaeology. It explains key terminology, outlines the procedures to be followed in order to produce good data, and describes the function of the basic instrumentation required to carry out those procedures. The manual contains chapters on the basic chemistry and physics necessary to understand the techniques used in analytical chemistry, with more detailed chapters on atomic absorption, inductively coupled plasma emission spectroscopy, neutron activation analysis, X-ray fluorescence, electron microscopy, infrared and Raman spectroscopy, and mass spectrometry. Each chapter describes the operation of the instruments, some hints on the practicalities, and a review of the application of the technique to archaeology, including some case studies. With guides to further reading on the topic, it is an essential tool for practitioners, researchers, and advanced students alike.

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ANALYTICAL CHEMISTRY IN ARCHAEOLOGY

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Cambridge
University Press

CAMBRIDGE UNIVERSITY PRESS
Cambridge, New York, Melbourne, Madrid, Cape Town, Singapore, São Paulo

Cambridge University Press
The Edinburgh Building, Cambridge CB2 2RU, UK

Published in the United States of America by Cambridge University Press, New York

www.cambridge.org
Information on this title: www.cambridge.org/9780521655729

First published 2006

Printed in the United Kingdom at the University Press, Cambridge

A catalogue record for this publication is available from the British Library

ISBN-13 978-0-521-65209-4 hardback
ISBN-10 0-521-65209-X hardback
ISBN-13 978-0-521-65572-9 paperback
ISBN-10 0-521-65572-2 paperback

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PREFACE

The purpose of this book is to provide an introduction to the applications of analytical chemistry to archaeology. The intended audience is advanced students of archaeology, who may not have all of the required background in chemistry and physics, but who need either to carry out analytical procedures, or to use the results of such analyses in their studies. The book is presented in three parts. The first is intended to contextualize analytical chemistry for students of archaeology – it illustrates some of the archaeological questions which have been addressed, at least in part, by chemical analysis, and also chronicles some of the long history of interaction between chemistry and archaeology. Additionally, it introduces chemistry as a scientific discipline, and gives a brief historical introduction to the art and science of analytical chemistry.

The second part consists of seven chapters, which present a range of analytical techniques that have found archaeological application, grouped by their underlying scientific principles (absorption/emission of visible light, absorption of infrared, etc.). Each chapter describes the principles and instrumentation of the methods in some detail, using mathematics where this amplifies a point. The majority of each chapter, however, is devoted to reviewing the applications of the techniques to archaeology. We do not pretend that these application reviews are comprehensive, although we do hope that there are enough relevant references to allow the interested reader to find her or his way into the subject in some depth. We have also tried to be critical (without engaging in too much controversy), since the role of a good teacher is to instill a sense of enthusiastic but critical enquiry! Nor can we pretend that the topics covered in these chapters are exhaustive in terms of describing all of the analytical methods that have been, or could profitably be, applied to serious questions in archaeology. The critical reader will no doubt point out that her or his favorite application (e.g., NMR, thermal methods, etc.) is missing. All that we can say is that we have attempted to deal with those methods that have contributed the most over the years to archaeological chemistry. Perhaps more attention could usefully have been applied to a detailed analysis of how chemical data has been used in archaeology, especially when hindsight suggests that this has been unhelpful. It is a matter of some debate as to whether it is worse to carry out superb chemistry in support of trivial or meaningless archaeology, or to address substantial issues in archaeology with bad chemistry. That, however, could fill another book!

In order for the intended audience of students to become "informed customers" or, better still, trainee practitioners, we present in the final part some of the basic science necessary to appreciate the principles and practice underlying modern analytical chemistry. We hope that this basic science is presented in such a way that it might be useful for students of other applied chemistry disciplines, such as environmental chemistry or forensic chemistry, and even that students of chemistry might find some interest in the applications of archaeological chemistry.

Chapters 10 and 11 introduce basic concepts in chemistry, including atomic theory and molecular bonding, since these are necessary to understand the principles of spectrometry, and an introduction to organic chemistry. Chapter 12 discusses some basic physics, including wave motion and the interaction of electromagnetic waves with solid matter. Chapter 13 is an introduction to some of the practicalities of analytical chemistry, including how to make up standard solutions, how to calibrate analytical instruments, and how to calculate such important parameters as the minimum detectable level of an analyte, and how to estimate errors. We also outline quality assurance protocols, and good practice in laboratory safety. Much of this material has been used in teaching the underlying maths, physics, and chemistry on the BSc in Archaeological Science at the University of Bradford, in the hope that these students will go on to become more than "intelligent consumers" of analytical chemistry. It is gratifying to see that a number of ex-students have, indeed, contributed significantly to the literature of archaeological chemistry.

In this background material, we have taken a decidedly historical approach to the development of the subject, and have, where possible, made reference to the original publications. It is surprising and slightly distressing to see how much misinformation is propagated through the modern literature because of a lack of acquaintance with the primary sources. We have also made use of the underlying mathematics where it (hopefully) clarifies the narrative. Not only does this give the student the opportunity to develop a quantitative approach to her or his work, but it also gives the reader the opportunity to appreciate the underlying beauty of the structure of science.

This book has been an embarrassing number of years in gestation. We are grateful for the patience of Cambridge University Press during this process. We are also grateful to a large number of individuals, without whom such a work could not have been completed (including, of course, Newton's Giants!). In particular, we are grateful to Dr Janet Montgomery, who helped to collate some of the text and sought out references, and to Judy Watson, who constructed the figures. All errors are, of course, our own.