PHYSICAL TECHNIQUES IN THE STUDY OF ART, ARCHAEOLOGY AND CULTURAL HERITAGE

Volume 1

Edited by

DAVID BRADLEY

& DUDLEY CREAGH

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Cover photograph: The pots are part of the Egyptian Collection of the Royal Albert Memorial Museum and Art Gallery, Exeter, UK.

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VOLUME 1

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First edition 2006

ISBN-13: 978-0-444-52131-6
ISBN-10: 0-444-52131-3

ISSN: 1871-1731

Printed and bound in The Netherlands

06 07 08 09 10 10 9 8 7 6 5 4 3 2 1

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Preface

This volume is the first of a series on "Physical Techniques in the Study of Art, Archaeology and Cultural Heritage". It follows a successful earlier publication by Elsevier (*Radiation in Art and Archaeometry*), also produced by the editors of this book, Dr David Bradley (Department of Physics, University of Surrey) and Professor Dudley Creagh (Director of the Cultural Heritage Research Centre, University of Canberra).

There has been an upsurge of interest world wide in cultural heritage issues, and in particular, large organizations such as UNESCO and the European Union are active in providing funding for a very diverse range of projects in cultural heritage preservation. It is perceived that it is essential to preserve the cultural heritage of societies, both to benefit the future generations of those societies, and to inform other cultures. Also, institutions and locations of cultural heritage significance provide an impetus for the tourist industry of a country, and for many, cultural tourism contributes substantially to their national economy.

A growing need exists for the education of conservators and restorers because it is these professionals who will make decisions on how best to preserve our cultural heritage. Therefore, the primary aim of this book series is the dissemination of technical information on scientific conservation to scientific conservators, museum curators, conservation science students, and other interested people.

Scientific conservation, as a discipline, is a comparatively modern concept. For many years, interested scientists have addressed scientific problems associated with cultural heritage artefacts. But their involvement has been sporadic and driven by the needs of individual museums, rather than a personal lifetime study of issues of conservation of, for example, buildings, large functional objects, paintings, and so on.

The contributors of this book series are from both "interested scientists" and the "museum-based scientists". The authors have been selected with an eye to involving young as well as established scientists.

The author of chapter 1, Dr Jean Louis Boutaine, was Head of the Research Department of the *Centre de Recherche et de Restauration des Musées de France* at the Louvre, at his retirement. He trained initially as a physicist in the application of non-destructive analytical techniques, and has extensive experience in equipment design, and in the application of radioisotopes to the solution of scientific problems. Dr Boutaine has had the most distinguished career within the conservation science community. Since his retirement, he has been extremely active in driving the expansion of cultural heritage research within the European Community, through involvement in EU Projects and the organization of

conferences; He is the EU-ARTECH Networking Activity Coordinator. This chapter is a veritable "treasure trove" of information. It discusses the use of science and technology to study aspects of the preservation of cultural heritage taken in its broadest sense: works of art, museum collections, books, manuscripts, drawings, archival documents, musical instruments, ethnographic objects, archaeological findings, natural history collections, historical buildings, industrial heritage objects and building. This chapter explains how science and technology are used to provide information which will assist us to understand how the artefacts have been created, how they have been handled (or mis-handled) since their creation, and how we can preserve them for the culture and the pleasure of future generations.

A review of the different techniques (examination, characterization, analysis) which are applied in this discipline of "conservation science" is presented. This is illustrated by many recent examples in various cultural areas. Some major national cultural heritage institutions, as well as European networks active in this area, are indicated. An important bibliography, including websites of interest, is provided.

The author of chapter 2, Professor Franco Casali, is a physicist by training and his interests include the study of scientific conservation. He has been a researcher at the ENEA (the Italian nuclear authority) and was the Director of a Research Centre with two experimental reactors. He was also an Expert of the United Nations (IAEA) for nuclear power stations. His last position at the ENEA was as Director of Physics and Scientific Calculus Division of the ENEA. Since 1985, he has been associated with "Health Physics" at the University of Bologna. Also, he is responsible for the teaching of "Archaeometry". At the University of Bologna, he leads a group of young physicists and computer science experts, who have developed advanced equipment for both micro-Computer Tomography and for large-object Computer Tomography. He has been one of the Italian representatives in the European Neutron Radiography Working Group.

This chapter commences with a description of the physical principles underlying the techniques of X-ray and neutron and digital radiography. It then proceeds to discuss the application of these techniques for the study of objects of cultural heritage significance.

Professor Tim Wess is responsible for Chapters 3 and 4 of this volume, which were co-authored by his research associates (Jennifer Hiller, in Chapter 3, and Craig Kennedy, in Chapter 4). Professor Wess holds the Chair of Biomaterials in the Biophysics Division in the School of Optometry and Vision Science at Cardiff University. His research interests include: the characterization of partially ordered biopolymers and mineralizing systems; and structural alterations of biophysical systems due to strain and /or degradation. The systems in which he is interested contain collagen, fibrillin, and cellulose (which relate, in the cultural heritage discipline, to an interest in parchment and papers). A parallel interest is in the structure of bone and artificial composite materials (which relates to his interest in historical studies of bone materials).

Chapter 3 will describe the technique of SAXS (Small-angle X-ray scattering), and show how this has been used to study alteration to structure of minerals in the bone. Preservation of intact bone mineral crystallites has been shown to relate to the endurance of amplifiable ancient DNA from archaeological and fossil bone. Moreover, the variation in bone crystallite size and habit across a two-dimensional area has been studied in modern and archaeological samples. Finally, the alteration to bone mineral during experimental heating has been investigated.

In Chapter 4, there is a description of research being undertaken on historical parchments in collaboration with Dr K. Nielsen and Rene Larsen (School of Conservation, Copenhagen, Denmark). This research involves the analysis of the deterioration of historic parchments and also the simulation of the ageing process by induced oxidative damage. (This work has been supported by the EU 5th Framework on Cultural Heritage Conservation and the National Archive for Scotland).

The author of chapter 5, Andrew Hardy, received his D.Phil. in X-ray Crystallography, from Sussex University (UK) in 1971. He began studying Middle Eastern eye cosmetics ("kohls") in the early 1990s whilst working in Oman. He has continued this work in his present position at the School of Humanities and Social Sciences, Exeter University, Political and Sociological Studies, Exeter University. The chapter summarizes and reviews the published data on the usage and composition of kohls in ancient (Pharaonic) Egypt. It also gives some information, from later time periods, on kohl usage and its "recipes". This is followed by a brief description of the experimental techniques used in his studies of past and present Egyptian kohl samples. The techniques used were: XRPD (X-ray powder diffraction), LV SEM (low vacuum scanning electron microscopy), IR (infrared spectroscopy) and the relatively new technique QEMSCAN (quantitative scanning electron microscopy). Results are given on thirty-three samples of both old and new kohls using these analytical techniques. The old samples were obtained from the Pharaonic kohl pots shown on the front cover of this book; the pots are part of the Egyptian collection of the Royal Albert Memorial Museum and Art Gallery, Exeter, UK. Finally, there is a comparison of past and present kohl compositions, concentrating on the toxicology of lead and how it is related to the particle size of the galena present. Also, there is consideration of the cultural usage of kohl, *via* information on its containers etc., in ancient and modern-day Egypt.

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Chapter 1

The Modern Museum

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Abstract

At present science and technology is being used to study many aspects of the preservation of our cultural heritage taken in its broadest sense: works of art, museum collections, artefacts, books, manuscripts, drawings, archive documents, musical instruments, ethnographic objects, archaeological findings, natural history collections, historical buildings, industrial heritage objects, and buildings. This chapter tries to explain how science and technology is used so that we may better understand how the artefacts have been created, how they have been handled (or mis-handled) since their creation, and how we can better preserve them for the culture and pleasure of future generations.

A review of the different techniques (examination, characterisation, analysis) which are applied in this discipline of "conservation science" is presented. This is illustrated by many recent examples in various cultural areas. Some major national cultural heritage institutions and also European networks which are active in this area are indicated. An important bibliography, together with websites of interest, is given.

Keywords: Conservation science, cultural heritage, artefacts, works of art, museum collections, non-destructive testing, analysis, preventive conservation, photography, radiography, microscopy, X-ray fluorescence, ion beam analysis, spectrometric techniques, dating.

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