Technical Art History

A Handbook of Scientific Techniques for the Examination of Works of Art

Ingeborg de Jongh, Milko den Leeuw, Jennifer Mass,
Daniela Pinna, Lawrence Shindell, Oliver Spapens

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Prof Dr Roger Lewis – Senior Professor of Physics at the University of Wollongong

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Prof Dr Maria Perla Colombini – Professor of Analytical Chemistry at the University of Pisa

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FOREWORD

This publication is a compilation of descriptions of the fifty most commonly used scientific techniques for studying works of art and cultural heritage in general. It is the first time this information has been assembled in one publication in order to make the scientific component more understandable and accessible for people in allied fields, who are often the users of such data. Scientific reports that accompany objects of art are used by, for example, vetting committees at art fairs, art lawyers, art dealers, art collectors, art conservators, art historians, artists estates and auction house staff. Such reports are ideally prepared with an executive summary explaining the results in layman's terms. However, without a baseline knowledge of the techniques used, the reader cannot discern if the appropriate techniques were used to address the question at hand, if the supporting results match the conclusions made, nor if any further research is required.

The scientific reports that accompany objects of art vary in their level of detail and in their utility when addressing the salient questions about a work. For example, the low cost and portability of X-ray Fluorescence has made it widely accessible and therefore commonly used for studying works of art. However, used on its own it cannot address key questions about a work that may require molecular, microscopic, or imaging methods in addition to elemental analysis. With the help of this publication, the non-scientists who use scientific reports on cultural materials in their work will have a guide for assessing these reports, for asking useful questions about the data presented and any logical next steps. In addition, they can use this information when hiring a scientific firm to make sure that the examination protocol proposed will address the key questions about the work in question.

There is no overseeing body that provides accreditation to entities offering scientific services for authentication research and condition questions. As a result, not all of the firms, academia, museums or auction house laboratories, who offer such services have the requisite and full background ability or knowledge in all techniques or their intertwined relations. Neither do they always choose the appropriate tools for the research questions at hand. In addition, there are entities that offer certificates of authentication without providing any supporting data or information about their analytical protocols. It is up to the consumer of the data to understand if they have been given a report that will be useful to them, addressing the salient questions about the object. For this reason it is important, prior to commissioning a scientific report, that due diligence about the supplier and the proposed techniques is completed.

This Authentication in Art - Technical Art History - publication, which will grow over time as new techniques are introduced to the field or existing ones improved, will empower all in the field of art to work effectively with cultural heritage scientists and provide greater transparency into the scientific component of the art industry. The publication was compiled by leading cultural heritage scientists and stands to become an essential tool for art market stakeholders.

Authentication in Art - Technical Art History Workgroup

Ingeborg de Jongh, Milko den Leeuw, Jennifer Mass, Daniela Pinna,
Lawrence Shindell, Robyn Sloggett and Oliver Spapens

CONTENT OF TECHNIQUES

AUTHORS' BIOGRAPHY

Dr Matthias Alfeld – studied chemistry at the University of Hamburg (DE) and did a double PhD at the Universities of Antwerp (BE) and Hamburg (DE). In his PhD he developed the first practical XRF scanners for the investigation of entire historical paintings and applied them with his colleagues in the investigation of more than 100 paintings by artists such as Rembrandt, Vincent van Gogh and Caravaggio. After his PhD he worked for two years as a PostDoc at the German Synchrotron DESY in Hamburg (DE), implementing multivariate analysis for spectroscopic imaging data.
Since 2015 he is Junior Chair at the CNRS Laboratory for Molecular and Structural Archaeology (LAMS) at the Sorbonne University (Paris, FR), studying the pigment use in antiquity by spectroscopic imaging

Susanna Bracci – received a master Degree in Chemistry at the University of Florence. From 1988 to 1993 she was fellowship at IROE-CNR (now IFAC-CNR). From 1994 to1996 she was Researcher (3rd level) at Institute for Applied Physics "Nello Carrara" IFAC-CNR (former Research Institute on Electromagnetic waves-IROE-CNR). From 2002 to 2007 she was Researcher (3rd level) at CSCOA-CNR (from 2002 ICVBC-CNR). From 2007-today she is Senior Researcher (2nd level) at at the Institute for the Conservation and Valorization of Cultural Heritage of national council of Research (ICVBC-CNR)
Her research activity is mainly devoted to the study of the performances and characteristics of the materials for the conservation of stone materials. She is also leading the ICVBC Mobile laboratory for the in-situ diagnostics of works of art including paintings, frescoes and glasses (mosaics and stained glass windows).
She is author of more than 200 publications (including 70 international journals and contributions to books) and more than 100 technical reports

Prof Dr Maria Perla Colombini – She holds the position of Full Professor of Analytical Chemistry at the University of Pisa and in the period 2013-2017 she also was the Director of the Institute for Conservation and Valorization of Cultural Heritageof CNR. She teaches in the courses of Analytical Chemistry and Chemistry of Cultural Heritage. She is the Director of the Pisa University Summer School of Diagnosis in Cultural Heritage. She is coordinating the SCIBEC research group at the Department of Chemistry (www.scich.it). She is the principal investigator of several national and international research projects for the safeguard of Cultural Heritage. Her research has resulted in over 300 publications in refereed journals and books, and in over 400 lectures (60 invited) at national and international congresses. She cooperates with national and international research groups of Universities and several Research Institutions, including Opificio delle Pietre Dure (Florence, Italian Ministry of the Cultural Heritage), Getty Conservation Institute (LA, USA), University of Malta, Duke University (Durham, USA), University of Saragozza (Spain), University of Southern Denmark (Odense,DK), University of London (UK), Tate Gallery (UK), North Carolina Museum of Art (Raleigh, USA)

Prof Dr Augustine Doronila – is currently a Senior Analyst with the Technology Platform - Trace Analysis for Chemical, Earth and Environmental Sciences. He worked in Italy and Switzerland as a contract horticulturist from 1985-89. In 1989, Augustine moved to Curtin University of Technology, Western Australia working as a Senior Tutor and Research Associate for 12 years with the the Department of Environmental Biology, where he was involved in post mining land rehabilitation with different mining and extractive industries.
He then took his Doctoral studies at the School of Botany, University of Melbourne in 2001 on phytoremediation of arseniferous gold mine tailings. He was also a research fellow with the environmental and analytical chemistry research group at the School of Chemistry, University of Melbourne and undertakes research on arsenic and mercury bioavailability and food chain transfer, heavy metal bioavailability, metal hyperaccumulation in plants, soil chemistry and plant nutrition, restoration ecology, post mining reclamation. As well as these he has been collaborating with Conservation scientists in the Grimwade Centre for Cultural Material Conservation, University of Melbourne in the chemical characterisation of cultural materials

Eliza O'Donnell – is currently undertaking her PhD at the Grimwade Centre for Cultural Materials Conservation at the University of Melbourne. Her research is focusing on painting authentication, attribution and art fraud in private collector-established museums based in Indonesia. Since graduating from the Masters of Cultural Materials Conservation with a specialisation in paintings conservation, she has worked with cultural collections across the Asia-Pacific region within Malaysia, Singapore, Taiwan, Indonesian, Sydney and Melbourne. Eliza is an active member of the *Asia Pacific Tropical Climate Conservation Art Research Network* (APTCCARN) and is a recent recipient of the Australian Institute of International Affairs *Euan Crone Asia Awareness Scholarship*, this award received to support archival and collection based research across a number of cultural institutions in Indonesia in 2018. Eliza is a recipient of the 2017 *Universitas 21 Graduate Collaborative Research Award* which aims to develop an international network for graduate researchers in the fields of conservation, material culture and attribution

Daniel Fabian – founded and is currently head conservator of Fabian Restauratoren. As part of his training he studied both at the Hamilton Kerr Institute, as well as The Fog Art Museum, Center for Conservation and Technical Studies. Fabian has published extensively in a large number of scientific papers. His main research focus has been his investigations into lead isotope research culminating in the paper *D. Fabian, V. Köppel, G. Fortunato: Following the trace of lead white pigments in 17th century paintings. EU-ARTECH Workshop on Seventeenth Century Northern European Painting Techniques, to be held at the National Gallery London on December 12th 2005*

Dr Lorenzo Giuntini – is an applied nuclear physicist. He presently serves as one of the responsibles of the tandem accelerator in Florence and is associate professor of experimental physics at the University of Florence, Italy. He has been one of the founders of LABEC, the Florence laboratory of the National Institute of Nuclear Physics (INFN) for the study of Cultural Heritage (CH) and environment by nuclear techniques, and of INFN-CHNet, the INFN network for the development and application of physics instruments, methods and technologies to the study and conservation of CH. He has been the initiator of the Florence external microbeam and of the XRF portable instrumentation. From June 2017, is member of the team of the MACHINA project for the development of a portable accelerator. He has published more than 60 research papers in international refereed journals along with invited chapters in books

Claire Grech – is currently undertaking her PhD in conservation science at the Grimwade Centre for Cultural Materials Conservation. She holds a Bachelor of Science with a major in applied chemistry, and a Masters of Cultural Material Conservation with a specialisation in paintings conservation, both from the University of Melbourne. Her main research interest is the behaviour of modern paints in tropical climates, with a specific focus on artworks in Southeast Asia. In her previous role as Australian Conservation Science Fellow at Harvard Art Museums she collaborated with curators, conservators, and other conservation scientists on a variety of different projects, including a major technical art history analysis of *Grazing Horses IV (The Red Horses)* by Franz Marc

Dr Irka Hajdas – is a researcher and a lecturer at ETH Zurich. She is a specialist in radiocarbon dating with research interest focused on accurate and precise radiocarbon based chronologies. For the past three decades, she has been working on issues related to calibration of radiocarbon ages and a selection and purification of material for 14C analysis. Applications of the methods include archeology, geochronology and cultural heritage including paintings and historic objects such as manuscripts and textiles. The various studies have been published in more than 140 peer-reviewed articles

Drs Ingeborg de Jongh – is a painting conservator and art historian. She founded the Atelier for Restoration & Research of Paintings (ARRS) in 1991. ARRS holds a worldwide reputation for bridging art history, conservation technique and material sciences. After her study Art History she accomplishes a study in conservation techniques at the Studio Dora van Dantzig, followed by internships at several Museums of Fine Arts in Europe. Ingeborg worked for Christie's Amsterdam from 2003-2018 as outdoor painting conservator. She has worked for many museums, art dealers and private collectors all over the world. She compiled several private studies on major masters During her career she published articles and reports about conservation issues with the emphasis on the conservation of 17th century Dutch paintings and Venetian renaissance art

Milko den Leeuw – is a painting conservator specialized in the technical and scientific investigation of paintings. He completed his training in conservation and pictology (an analytical method for attribution and evaluation of paintings) at the studio Dora van Dantzig in Amsterdam in 1989. After an internship on a project of seventeenth century Dutch masters, he founded the Atelier for Restoration & Research of Paintings (ARRS) in 1991. Since then Milko den Leeuw has worked for many museums, art dealers and private collectors all over the world. He has authored numerous publications that have appeared in museum catalogues, international peer-review journals and conference papers. From 1991-2006 ARRS was the outdoor conservation atelier of the Rijksmuseum Catharijneconvent Utrecht. The complete inventor of paintings of the Catharijneconvent was catalogued on condition and authentication questions by ARRS. Milko worked for Christie's Amsterdam from 1993-2003 as outdoor painting conservator.
ARRS holds a worldwide reputation for bridging art history, conservation technique and material sciences. ARRS brings expertise and experience for more than 25 years of cooperative work with auctioneers, private collectors, museum conservators, art advisors, legal advisors, committees of catalogue raisonnées and students. ARRS organized the Authentication in Art Congress of 2012, 2014, 2016 and 2018

Dr Eberhard H. Lehmann – received his PhD in physics from the Academy of Science Berlin. He started his career in reactor physics of the fast breeder reactor by designing different reactor configurations for reactivity measurements with the aim to improve the nuclear data knowledge. After his move to Switzerland he participated in the operation of the 10 MW research reactor with respect to the core layout and the practical applications of neutron beams from that facility. This know-how was very essential to establish new methods in the field of neutron imaging at the newly build spallation neutron source at the Paul Scherrer Institut, Villigen, Switzerland. He became head of the Neutron Imaging & Activation Group (NIAG) and organized the 10th World Conference on Neutron Radiography in 2014 in Grindelwald, Switzerland.
The new neutron imaging stations allowed also the investigation of objects from cultural heritage. Therefore, he initiated a network among museums experts within Switzerland and on European level for systematic studies of bronzes from Roman, Renaissance and Asian origin. After his retirement, he continues in such studies and transfers his knowledge with research papers, talks and dedicated new studies

Dr Marco Leona – is the David H. Koch Scientist in Charge of the Department of Scientific Research at The Metropolitan Museum of Art. He studied Chemistry (M. Sc., 1991) and Crystallography (PhD, 1995) at the University of Pavia, Italy.
Dr Leona started his career in art conservation research at the Conservation Research Laboratory of the Los Angeles County Museum of Art (LACMA). He has held research scientist positions at the Freer Gallery of Art in Washington DC, and at the Los Angeles County Museum Art LACMA. He is currently the head of the Department of Scientific Research of the Metropolitan Museum of Art, where he supervises a team of eleven scientists conducting research on artists' materials and techniques and on art conservation. Since 2010 Dr. Leona has taught Analytical Chemistry at the Conservation Center of New York University's Institute of Fine Art

Prof Dr Roger Lewis – is a Senior Professor of Physics and Associate Dean Research in the Faculty of Engineering and Information Sciences at the University of Wollongong, Australia. He is an expert and pioneer in the application of terahertz-frequency radiation to physical systems of fundamental and practical interest. The

basis for this is set out in his book *Terahertz Physics* (Cambridge, 2013). The approach has been employed in such diverse areas as the analysis of soil and soil constituents, industrial production lines, and paints and pigments. Lewis serves on the College of Experts of the Australian Research Council and is a member of the board of the International Society for Infrared, Millimeter and Terahertz Waves

Dr Jennifer Mass – has been teaching and conducting research in cultural heritage science for over twenty years. She has a Ph.D. in inorganic chemistry and materials engineering from Cornell University, and did her Andrew W. Mellon postdoctoral fellowship at the Metropolitan Museum of Art's Department of Objects Conservation. She is currently the Senior Scientist and Director of the Winterthur Museum's Scientific Research and Analysis Laboratory and Adjunct Faculty in the Winterthur/University of Delaware M.S. Program in Art Conservation. She also acts as Consulting Senior Scientist for the Rijksmuseum, and as Adjunct Faculty at the University of Delaware Department of Chemistry and Biochemistry. She has been President of Scientific Analysis of Fine Art, LLC, a consulting firm specializing in questions of art attribution and state of preservation for the past eight years. Most recently she has focused her research program on the degradation mechanisms of the pigments of the early modernists, in particular the works of Henri Matisse, Pablo Picasso, and Edvard Munch. She has also worked on the development of new non-destructive depth-profiling techniques for the study of buried paintings, including confocal XRF for which she and her colleagues won awards from the American Materials Research Society and the Italian Society for Nondestructive Testing. She presents plenary and keynote lectures on her research worldwide each year, and her work has been widely published in the physics, chemistry, materials engineering, and art conservation literature as well as in the international press. She has lectured at the Louvre, the Getty, the Metropolitan Museum of Art, the Art Institute of Chicago, the Smithsonian Museum of American Art, the Barnes Foundation, and the Guggenheim Museum in Bilbao. She is currently studying the alteration mechanisms of the yellow paints in Edvard Munch's c. 1910 version of *The Scream*

Dr Serge Mathot is physicist at CERN since 1995. He finished its PhD at the University Notre Dame de la Paix (NAMUR-Belgium) in 1992 in a laboratory for the analysis of materials by nuclear reactions. Its works were related to the analysis of gold artefacts and the development of a new soldering procedure. Before joining CERN, he made a post doctorate in a European Joint Research Center (JRC-Geel) on Hydrogen profiling by resonant nuclear reaction. At CERN, he was in charge of the development of the vacuum brazing facilities and was leading for several years the assembly section in the Mechanical and Materials Engineering group. He has been involved in several project related to the construction of RFQ (Radio Frequency Quadrupole) accelerators. He is now the project leader for the PIXE-RFQ project developing the first transportable proton accelerator. This project is developed in collaboration with INFN. He is also the technical coordinator for the CLOUD experiment at CERN and is involved in the development and improvement of Cherenkov detectors for the Experimental Area group in the Engineering department

Dr Lachlan McInnes – has recently completed a PhD in chemistry from the University of Melbourne. His PhD focused on the synthesis and characterization of radioactive diagnostic agents for neurodegenerative disease. Lachlan also holds a BSc and MSc in chemistry from the University of Melbourne. He is currently a Post-Doctoral researcher at the University of Melbourne

Dr Daniela Pinna – graduated in Biology at Padua University in 1976. Since 1987 she has been working as a biologist at Italian Cultural Heritage Ministry and she was coordinator of the scientific laboratory of Opificio delle Pietre Dure, Firenze, Italy in the period 2003-2012. Since 2011 she has been lecturing '*Biodeterioration and degradation of bioarcheological materials*' at the same University (International Degree Course Science for the Conservation-Restoration of Cultural Heritage). She has been involved in the European Projects EU-ARTECH (Access Research and Technology for the Conservation of the European Cultural Heritage – 2004 to 2009) from, and CHARISMA (Cultural Heritage Advanced Research Infrastructures: Synergy for a Multidisciplinary Approach to Conservation/Restoration – 2009-present). She was awarded the following grants:

1996-1998 Grant from Italian National Research Center for the research '*Endolithic lichens on limestone:*

ecological and physiological study. Evaluation of suitable control methods'. 2008 Grant by Florence municipality to carry out the scientific study of Neptune stone statue and bronze statues located in Piazza della Signoria, Florence. 1988 Grant from Italian National Research Center for the organization of the course '*Lichens and deterioration of stones*', Villa Adriana, Tivoli (Roma), 17-22 September 1990. January – March 2010 Grant as Conservation Guest Scholar at the Getty Conservation Institute, Los Angeles, US. Project title: *Assessment of methods and products applied for the control of biodeteriogens growing on artificial and natural stone objects. State of the art and perspectives*. October 2012 – January 2013 Grant as Guest Scholar at the Metropolitan Museum, New York, US. Project title: *Darkening alterations occurring on marble statues located at Orsanmichele Church (Florence, Italy). What is their origin?* Daniela is involved in the activity of CEN/TC 346 (CEN – European Committee for Standardization and TC346 is in charge for standards related to conservation of cultural heritage). Her main research fields are biodeteriotation of heritage objects, prevention and control methods against biodeteriogens, water repellent and consolidant products for stone objects, assessment of past conservation interventions. She is author of 'Scientific Examination for the Investigation of Paintings: A Handbook for Conservator-Restorers', two other books and almost one hundred articles. Daniela is Adjunct Professor of Biology Applied to Cultural Heritage, School of Sciences University of Bologna

Raymonda Rajkowski – is a PhD candidate at the Grimwade Centre for Cultural Materials Conservation, University of Melbourne, Australia. The focus of her research is the use of synthetic paints by artists who participated in *The Field* exhibition, the first comprehensive survey of Australian colourfield and hardedge painting and sculpture presented by the National Gallery of Victoria in 1968. In addition to establishing the introduction of international acrylic brands to Australia, the study also documents for the first time the historical developments in local manufacture of acrylic paints by Australian companies. Combining documentary evidence and archival material, video-recorded artist interviews, technical examination and scientific analysis of works of art, this project pieces together the history of acrylic paints in Australia from a conservation perspective. Raymonda holds a Masters in Cultural Material Conservation, University of Melbourne (2013), completing a minor thesis titled 'Liquitex acrylic emulsion paints: developing baseline data for the material investigation of works of art by contemporary artists'. She also holds an Honours degree (Fine Art), Queensland University of Technology (2004) and an Honours degree (double major in Art History), University of Queensland (2007). She has over ten years' experience working within the arts sector in various project management, administration and research support roles at National Gallery of Victoria and Queensland Art Gallery | Gallery of Modern Art. She has also completed internships with The Grimwade Centre for Cultural Materials Conservation—Conservation Consultancy Service and International Conservation Services, Sydney

Lawrence M. Shindell – co-founded, led the regulatory organization and several rounds of financing of, and for eleven years headed the first title insurance company serving the international art industry, U.S.-New York-headquartered ARIS Title Insurance Corporation (NAIC #12600), which today is a wholly-owned subsidiary of Argo Group International Holdings, Ltd. (NASDAQ: AGII). During his tenure as its chairman and chief executive officer, ARIS became the art industry's leading art asset risk management institution focusing on the industry's range of legal title-ownership risks. Because the art industry's legal title risks intersect with the art industry's authenticity risks, ARIS also became a global leader in innovations to help address the art industry's authenticity risks on a prospective basis. A lawyer by profession, Mr. Shindell holds licenses in a number of U.S. jurisdictions including admission to the Bar of the United States Supreme Court. Before forming ARIS, Mr. Shindell was a public prosecutor and then in private practice, representing or litigating against Fortune 500 companies in complex commercial and insurance trial and appellate litigation including in international forums, in many instances in significant profile cases resulting in reported U.S. state or federal trial or appellate court decisions. Mr. Shindell has given expert testimony before the U.S. Tax Court on behalf of ARIS clients and before the U.S. Congress, House Financial Services Committee, on art and financial industry and regulatory sector risk related to art objects and the art industry. Mr. Shindell holds the highest rating "AV Preeminent" by the legal profession's leading Peer Review Rating organization, Martindale-Hubbell

Prof Dr Robyn Sloggett – is Director of the Centre for Cultural Materials Conservation (CCMC). She has qualifications in Art History, Philosophy and Cultural Materials Conservation. As Director of the CCMC she manages the diverse conservation, teaching and research programs of the Centre. These programs include responsibility for the conservation of the cultural collections of the University of Melbourne (with over 32 separate collections owned or managed by the University) and the provision of a large program for external clients with specialist expertise in painting, frame, paper, objects and textiles conservation. The CCMC also delivers the only comprehensive post-graduate conservation professional programme in the Australasia-Pacific region, as well as courses in Art Authentication and Photographic Preservation. Her contribution to research and teaching has developed in both an academic and professional framework. In her previous role as Deputy Director and Grimwade Chief Conservator in the Ian Potter Museum of Art she managed both Conservation and Collections Management, developing research programs which linked the scientific analysis of art and archival material (in partnership with researchers in the Faculty of Science) with art historical analysis (in partnership with researchers in the Faculty of Arts) and collection management (in partnership with staff in the Ian Potter Museum of Art and Information Services). These collaborations resulted in over 23 competitive research grants and 17 successful ARC projects. Robyn is currently a member of the University's Cultural Collections Committee; founded and is Production Manager for the Melbourne Journal of Technical Studies in Art; is a member of the Collections Committee of the Library Board, State Library of Victoria; and is currently Chair of the Indemnification Committee Arts Victoria. In the past she has been a member of a number of editorial boards (including Museums National Museum Australia Magazine and Open Museum Journal) and a number of organising committees (including the IIC's 50th Congress Tradition and Innovation). She was a Board Member of the Ian Potter Museum of Art from 2000 to 2005, a Foundation Director of AusHeritage, a member of the Federal Government's Conservation and Collection Management Working Party of the Heritage Collections Council, and both a State and National President of the Australian Institute for the Conservation of Cultural Material (AICCM Inc). She has been a member of course advisory committees for both the University of Canberra and Deakin University. She is an associate of the School of Enterprise and the Centre for Free Radical Chemistry and Biochemistry at the University of Melbourne. Her research interests include programs in cultural materials conservation that focus on the materials and techniques of artists (particularly in Australia and South East Asia), ethical and philosophical issues in cultural materials conservation, and the development of scientific techniques for conservation. In 2004 she was awarded the Australian Institute for Cultural Materials Conservation's Conservator of the Year Award for service to the profession

Oliver Spapens – has a degree in Civil Law, as well as Early Modern Art from Leiden University. Oliver has worked as paralegal at several law firms both Dutch and International. He has done several internships focused on History of Law, including an internship at the Peace Palace Library. He was assistant at the 66th conference of the Société Internationale 'Fernand de Visscher' pour l'Histoire des Droits de l'Antiquité (SIHDA). He gained art historical experience at the Dutch National Museum for Antiquities and Galleri Tom Christoffersen. He has been working for Authentication in Art since 2012. He is involved with the Authentication in Art ADR Board and co-organized the 2014 and 2016 Authentication in Art Congress. During the 2016 Conference he was part of the Workgroup on Education

Francesco Taccetti – is a physicist, presently employed as "technologist" by INFN, and works at LABEC, Florence, a laboratory devoted to applications of nuclear techniques to Cultural Heritage and environmental problems. Since about 2000, he has become one of the technological leaders at LABEC, where he followed the commissioning of the new tandem accelerator, and is now R&D coordinator for the Cultural Heritage branch, dealing with Ion Beam Analyisis (IBA) and Accelerator Mass Spectrometry (AMS) measurements. Thanks to his experience in mechanical apparatuses, detectors, electronics and data acquisition systems, since 2006 he has been the principal investigator, for ten years, in experiments funded by the INFN Fifth National Committee (CSN5, Technological and Interdisciplinary Research) aimed at improving cutting-edge technologies in the field of Cultural Heritage for both applications of IBA and AMS (radiocarbon dating), besides the development of portable instrumentation like spectrometers for X Ray Fluorescence (XRF)

David Thurrowgood – is Director of Applied Conservation Science Pty Ltd, which provides high level analytical services to the cultural heritage industry, including synchrotron radiation based commercial experiments. David has university degree education in Arts, Analytical Chemistry and the Conservation of Cultural materials. He has twenty years' experience in the cultural heritage profession, including in the roles of Senior Conservator National Museum of Australia, Head of Conservation at the National Gallery of Victoria and Manager Collection Care State Library of New South Wales. David's career highlights include directly conserving (restoring) the first cast of Auguste Rodin's "Thinker" sculpture, the resurrection of viable yeast from a 220 year-old submerged shipwreck beer bottle and commercial release of a beer, and the publication in a Nature masthead journal of a widely read article on the recovery of a "lost" painting by Degas but synchrotron x-ray fluorescence that was among the top 100 read articles of all 22,000 published by Nature in 2017. David has completed over 25 successful synchrotron experiments with private and government partners in the cultural heritage sector, including Australian and international collaborations with grant funding. David works closely with staff at the Australian Synchrotron in technique development and producing research outcomes. He actively seeks to promote the technological capabilities in Australia for cultural heritage research, including accessible nuclear reactor and synchrotron based instrumental technologies

Frederik Vanmeert – holds a Master's degree in Chemistry and is currently undertaking his PhD research at the Antwerp X-ray analysis, Electrochemistry and Speciation (AXES) research group at the University of Antwerp. In his research, he applies various X-ray imaging techniques available at synchrotron radiation facilities for the study of pigment alteration processes that take place inside paint layers. Furthermore, he has developed mobile X-ray diffraction scanners capable of visualizing the distribution of pigments in painted works of art. Throughout his research he has collaborated closely with several museums, such as the Royal Museum of Fine Arts Antwerp, the musea Bruges, the Van Gogh museum, the Rijksmuseum and the Kröller-Müller museum

Dr Maurizio Vretenar – is an applied physicist specialised in particle accelerators. Since 1988 he is working at CERN, the European Organization for Nuclear Research, where he has exercised several responsibilities including being the project leader for the design and construction of Linac4, the new injector of protons for the Large Hadron Collider (LHC) that was inaugurated in May 2017. He is presently the Coordinator of ARIES (Accelerator Research and Innovation for European Science and Society), a large collaborative project of 41 European universities, laboratories and industries aiming at the development of novel particle accelerator technologies within the Horizon 2020 Programme of the European Commission. He is in parallel Advisor for International Relations for the Accelerators and Technology sector of CERN and he is in charge of the CERN medical accelerator programme. His present scientific interests cover the applications of particle accelerators outside of the scientific field, in particular to medicine, industry, and cultural heritage. The author of more than 100 scientific publications on different aspects of particle accelerators, he is an elected member of the Accelerator Group of the European Physical Society, and is a member of several scientific committees and groups

Dr Zachary Voras – is an analytical chemist with a focus in soft materials interface analysis. Zachary received his PhD in 2017 under the tutelage of Dr. Thomas P. Beebe, Jr. at the University of Delaware with a dissertation entitled "Binding Medium Alteration and its Effect on Fine Art Painting as Observed by Surface Analysis". During his time as a graduate researcher he was able to work and publish on various projects related to soft materials in cultural heritage science. These works included novel identification of an unpigmented *imprimatura* layers in Raphael's *Madonna of the Candelabra*, selective fatty-acid degradation of egg tempera layers in various Renaissance paintings, as well as fatty acid degradation associated with cadmium yellow paints in Matisse's *Le Bonheur de Vivre*. He received his B.S in Forensic and Toxicological Chemistry from West Chester University of Pennsylvania in 2011 where he conducted archaeometry research into chemical signatures of residues

found in ancient steatite vessels. He is currently employed at the University of Delaware in the Interdisciplinary Sciences Learning Laboratories (ISLL) program teaching an integrated chemistry/biology curriculum to first-year STEM majors as well as conducting research into visualization methods for STEM education

Dr Inez Dorothé van der Werf – has been working as conservation scientist for over twenty years. In 1991 she has obtained a post-graduate Diploma in conservation of paintings from the Istituto Superiore per la Conservazione ed il Restauro in Rome and in 1996 she has been awarded with a master's degree in Chemistry at the University of Bari (Italy), performing the research for her thesis within the framework of the MOLART project at AMOLF (Amsterdam). In 2011 she got a PhD in Chemistry of Innovative Materials from the University of Bari, where she is currently employed as post-doc researcher in Analytical Chemistry.
During the past years she has worked on the development and application of mass spectrometric techniques – Py- and SPME-GC/MS, MALDI-MS - for the characterisation of binders, resins, dyes and pigments. Her recent research activities are focused on the analysis of modern paint and ink, the development of nanomaterials for the treatment of stone and wall paintings and analysis of amber.
Since many years she is involved in research requests from museums, cultural heritage organizations and private conservators. This research addresses the study of organic and inorganic materials as well as the evaluation of restoration treatments and includes different artworks: easel paintings, polychrome sculptures, stucco, wall paintings, mosaics, stone monuments, etc. For this research she uses a combination of techniques: microscopy, micro-Raman and FTIR spectroscopy, (Py)-GCMS, MALDI-MS and VIS-reflectance spectroscopy.
She has a broad experience in teaching as well as in assisting BSc, MSc and PhD students. Her work has been widely published in the chemistry and art conservation literature

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All authors and contributors shared disinterestedly their knowledge and experience.
The book is compiled to build bridges between different specializations and for the benefit of who study and work in the field of art.

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