Alok Kumar Kanungo · Laure Dussubieux *Editors*

Ancient Glass of South Asia

Archaeology, Ethnography and Global Connection

This book provides a comprehensive research on Ancient Indian glass. The contributors include experienced archaeologists of South Asian glass and archaeological chemists with expertise in the chemical analysis of glass, besides, established ethnohistorians and ethnoarchaeologists. It is comprised of five sections, and each section discusses different aspects of glass study: the origin of glass and its evolution, its scientific study and its care, ancient glass in literature and glass ethnography, glass in South Asia and the diffusion of glass in different parts of the world. The topic covered by the different chapters ranges from the development of faience, to the techniques developed for the manufacture of glass beads, glass bangles or glass mirrors at different times in south Asia, a major glass producing region and the regional distribution of key artefacts both within India and outside the region, in Africa, Europe or Southeast Asia. Some chapters also include extended examples of the archaeometry of ancient glasses. It makes an important contribution to archaeological, anthropological and analytical aspects of glass in South Asia. As such, it represents an invaluable resource for students through academic and industry researchers working in archaeological sciences, ancient knowledge system, pyrotechnology, historical archaeology, social archaeology and student of anthropology and history with an interest in glass and the archaeology of South Asia.

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IITGN

Springer

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Foreword

रमेश पोखरियाल 'निशंक'
Ramesh Pokhriyal 'Nishank'

सत्यमेव जयते

शिक्षा मंत्री
भारत सरकार
MINISTER OF EDUCATION
GOVERNMENT OF INDIA

FOREWORD

In the context of capacity-building in higher education and research for providing high-quality training and exposure to cutting-edge techniques a range of initiatives have been put in place by Government of India. The Ministry of Education has implemented a number of grant-schemes such as SPARC, GYAN, VAJRA, etc. for building international collaborations, providing the resources for hosting leading experts from around the world at Indian institutions for extended periods to foster our own faculty and students. The SPARC scheme also, notably, includes paired provisions for Indian faculty and students to spend time gaining training and research experience at foreign universities.

The core format for intellectual exchange, feedback and the advancement of science remains the focus of International conferences organised around those themes. While conferences undoubtedly advance the development of the focused fields, it is essential that for these events to reap enduring rewards, their products be consolidated in the form of themed publications which can continue to serve as instructive resource materials for Indian and international students and researchers. This volume meets this objective squarely.

Over the last decade, heritage studies and archaeology have emerged fields which require expertise and intervention from a wide range of experts drawn from the humanities, social sciences and scientific and technical fields such as material science, chemical analysis and conservation. Answering this need, several educational institutes of national importance are beginning to create spaces to foster such interdisciplinary expertise. One such example is the establishment of Archaeological Sciences Centre (ASC) by IIT Gandhinagar. Besides a number of interdisciplinary activities, ASC has pursued a program of organising conference cum workshops that focus upon a selected archaeological artifact class or material. The aim of these events has been to expose a selected group of students with an acute sense of the specific problems and opportunities that are involved in the study of that material. The motivation has been to host a conversation between the leading experts in the field, and equally to provide hands on training in the ethno archaeological and experimental prospects of that particular field of archaeological research. Notably, the first of these 'conference cum workshops' was held between the 10th and 14th of August 2015 and focused on stone beads. The proceedings of that conference have subsequently appeared as a volume (Kanungo, A.K. (Ed.) 2017. *Stone Beads of South and Southeast Asia: Archaeology, Ethnography and Global Connections*. Gandhinagar / New Delhi: Indian Institute of Technology Gandhinagar / Aryan Books International) as designedly meant to serve as a resource for both the teaching of stone beads and aid further research into them.

PTO

स्वच्छ भारत

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Continuation Sheet

The book in hand *Ancient Glass of South Asia – Archaeology, Ethnography and Global Connection* edited by SPARC awardee Alok Kumar Kanungo and one of the leading archaeological chemists of the world Dr. Laure Dussubieux of the Field Museum, Chicago interrogates a glass-making technology that is over 3,500 years old. It highlights how innovative ancient Indian artisans were who developed a single-ingredient recipe, unique in premodern glassmaking. Using this glass, craftsmen in preindustrial South Asia mass produced these distinctive beads which were then exported to lands as distant as South-East Asia, Africa and Europe in different periods. The volume considers how the history of South Asian glass is defined by a series of technological innovations and successive adaptations of vitreous materials to social and aesthetic customs of different periods of Indian history. These include the design of innovative tank-furnaces, and the extensive use of expediently constructed furnaces allowing for multiple working ports. Notably, Indian craftsmen developed distinctive blown-drawn glass beads in a period prior to the global invention of blown glass vessels. These glass beads were premier Indian exports in the premodern period, reaching African, European, and South-East Asian consumers.

In 1986, the 14th International Congress on Glass was held in Delhi. Its proceedings were published in a volume titled "The Archaeometry of Glass", edited by H.C. Bhardwaj. In a much needed update for the field, for the first time since that Delhi glass conference a major gathering of glass specialists was organised to discuss several issues related to Indian glass. This five-day conference-cum-workshop on *History, Science and Technology of Ancient Indian Glass*, was held between January 21st and 25th, 2019, at IIT Gandhinagar. The 22 articles in this volume result from this conference and provide a series of state-of-the-art interventions and synthesis of the current state of research into Indian glass. Using various approaches including archaeology, archaeometry and ethnography, the contributors of this volume placed India in the larger context of ancient glass studies. The individual papers provide insights into different topics such as glass conservation, bead typology, traditional glass bead and bangle making in India, archaeological glass in different regions of India and the diffusion of Indian glass beads around the Indian Ocean and beyond. This volume will constitute a solid foundation for further research in Indian glass and will certainly motivate additional investigations to address unresolved issues about the origin of glass in India, the organisation of its production in ancient times, and the identification, distribution, and chronology of the different Indian glasses.

The chapters of this book, written by some of the most eminent national and international experts in the field, bear testimony to the vast amount of research carried out on these artifacts. Rich contributions in the fields of archaeology, craft traditions, ethnography and literature make this book not only a major reference on South Asian glass, but also a model of cross-disciplinary studies. I hope it will go a long way in fulfilling the textual and research needs of Archaeology.

New Delhi
December, 2020

(Ramesh Pokhriyal 'Nishank')

Preface

The Archaeological Sciences Centre (ASC) at the Indian Institute of Technology Gandhinagar (IITGN) has pursued a programme of organising short-term courses cum workshops/conferences that focus upon a selected archaeological artefact class or material. The aim of these events has been to expose a selected group of students with an acute sense of the specific problems and opportunities that are involved in the study of that material. This has taken shape in hosting a conversation between the leading experts of the field and equally to provide hands-on training in the ethnoarchaeological, experimental and scientific prospects of that particular field of archaeological research.

With these objectives in mind, at these events, the resource persons are invited to speak for 45 min slots and allowing ample time for discussion. In these talks, they are required to address pre-assigned themes and topics that combine their research expertise and knowledge towards the planned content for a volume. These volumes themselves are envisaged not as the collection of papers or conference proceedings; they are intended to be valuable and useful resources on the subject. They are aimed at being useful for both students and researchers and thus to be useful for archaeological syllabi in South Asia and also globally.

The first of these 'conference cum workshops' was held between 10 and 14 August 2015 and focused on stone beads. The proceedings of that conference have subsequently appeared as precisely such a volume meant to serve as a resource for both the teaching of stone beads and to aid further research into them (Kanungo, A.K. 2017. Ed. *Stone Beads of South and Southeast Asia: Archaeology, Ethnography and Global Connections*. Gandhinagar/New Delhi: IIT Gandhinagar/Aryan Books International). The second of such a conference was held from 21 to 25 January 2019 and focused on the History, Science and Technologies of Ancient Indian Glass. The book you are holding is the outcome of this second conference.

The conference brought together a wide range of experts, which included archaeologists who have extensive experience of South Asian proto-glass, glass and archaeological chemists with expertise in the elemental analysis of glass. In addition, it included established ethnohistorians and ethnoarchaeologists of South Asian glass and vitreous materials, alongside craftspeople who brought their lifelong and inherited skill, expertise and knowledge.

These five days of conference cum workshop included four days of academic presentations and two field trips, veritably covering all aspects of the study of glass. These ranged from the origin of glass and faience, to the manufacturing techniques developed at different times in South Asia and the regional distribution of key artefacts both within and as traded far outside the region. Valuably, the talks developed to papers for this book also included detailed introductions and extended examples of the analytical chemistry of ancient glasses. Finally, the field trips gave exposure to the contemporary traditional glass working at Kapadvanj and to the world famous archaeological heritage site of Vadnagar in Gujarat.

The invited craftspeople at this workshop included glass bead-makers from Banaras, stone bead-makers from Khambhat and beading and mirror-stitching craftspeople from the Rabari and Mir communities of north Gujarat. An interesting experimental archaeology workshop on replication of Indus Valley faience technologies was conducted parallelly by Profs. Mark Kenoyer and Massimo Vidale.

These diverse contributions brought together the challenges of studying the history, science and technology of ancient Indian glass in vivid detail. Considered together, they provided the best introduction to the complexities of regional diversity in glass traditions, the archaeometric challenges that stand before the field and the prospects of all we stand to learn from further investigations. The last major collective evaluation of the state of scientific interdisciplinary research on ancient Indian glass had been made in 1987 (*Archaeometry of Glass: Proceedings of the Archaeometry Session of the XIV International Congress on Glass, 1986, New Delhi, India.* Calcutta: Indian Ceramic Society). Similarly, the last monograph that had synthesised the available data on the history of Indian glass was written yet a generation earlier (Dikshit, M.G. 1969. *History of Indian Glass.* [Bombay]: University of Bombay). This book aims at filling precisely this gap. The description above has communicated the efforts made to provide as multifaceted, thorough and valuable an experience to the next generation of researchers, who will hopefully pose research questions and pursue methods of analysis that will build on, extend and exceed those reported here.

The experts and participants at this truly international event were from eleven countries including USA, UK, France, Italy, Denmark, Cyprus, Poland, Malaysia, Thailand, Sri Lanka and India. It was gratifying to see that participants represented 54 universities, research institutes, laboratories, museums and state departments. The sixty student participants had been selected on the basis of prior interest in glass and/or ancient Indian technologies, and the conference-cum-workshop prepared them to embark on diverse research projects of their own.

An ambitious series like this and workshop having a target to publish a time-bound reference manual, covering all related research areas of the topic, are not possible without the vision and support of the head of the Institute, trust of the authorities and tireless team effort of the unit in which we work.

We are indebted to Prof. Sudhir Jain, Director of IITGN, for not only supporting the workshop at every stage but also giving his precious time in meeting the experts, participants and craftsmen who came for the workshop for the welfare of the centre; Prof. Amit Prashant, Dean of Research and Development, Prof. S. P. Mehrotra,

Dean of External Affairs and Co-ordinator of ASC, and Prof. Michel Danino, Co-coordinator of ASC, for all the encouragement; Prof. D. P. Roy for the administrative support without entertaining any excuses yet making no reservations about the required paraphernalia; and Dr. Yadubirsingh Rawat for advocating that we develop a good publication of the outcome. The efforts put by our postdoctoral fellow and nodal officer for the conference, Dr. Oishi Roy, in organizing the event were tremendous. As always, Dr. Trupti More, Librarian of Deccan College Post-Graduate & Research Institute, played her role in promptly providing rare literature and references.

Mr. Yashwant Chouhan and Mr. Shailesh Patani took care of all local logistical support, safety, local transport, campus accommodation and food. Mrs. Sunita Menon left no stone unturned to facilitate the smooth functioning of the workshop. Mr. Hatim A. Sham was the man behind the attractive posters, banners, brochures, invitations, conference tags and visuals. Mr. Devarsh Barbhaya captured the motions of the events. Ms. Shivangi Bhatt made the coordination with media look effortless. A special word of thanks to Dr. Neeldhara Misra for her professional best in managing the visual and media team.

The field visits to Kapadvanj and Vadnagar were made under the guidance of Ahmed Basir Sisgar, proprietor of the Kapadvanj glass mirror workshop, and Dr. Abhijit Ambekar and his team from the Vadodara Excavation Branch of Archaeological Survey of India, respectively.

Our gratitude to all the leading experts who came to IITGN presented their results, trained the students and made sure that the outcome of the workshop in book form was prepared with rigorous scientific and academic standard. Stone bead craftsmen Mr. Anwarhusain Shaikh and Mr. Pratap Bhai of Khambhat; glass bead craftsmen Nandlalji and Krishan-ji from Banaras Beads Limited; and glass beading craftswomen Meghaben Rabari, Ashaben Rabari, Sakinabe Miri, Madinabed Miri and Zanab Miri of Kutch made the workshop an experimental training reality for the participants. Prof. Sonal Mehta of CEPT University and Mrs. Niyati Kukadia of Eklavya Foundation, Ahmedabad, coordinated the beading works.

Dr. Alok Kumar Kanungo would like to add a special thanks to Mrs. Banabasini Kanungo and Dr. Shahida Ansari that have been the two pillars of strength and inspiration for him while organising this conference leading to this book. He is grateful for the regular discussions and the affectionate waiting until he is done with the daily work during the six-month long preparation for the conference.

We would also like to thank Scott Staszak for his help with some English language-related matter.

If we have omitted anyone, we offer our deepest apologies. We once again express our heartfelt thanks to all who have helped in this huge endeavour.

IITGN acknowledges financial support received from the Indian Council for Historical Research (ICHR), the Indian Council of Social Science Research (ICSSR), the National Science and Engineering Research Board (NSERB-DIA), the Gujarat Council on Science and Technology (GUJCOST) and the Directorate of Archaeology—Gujarat State. Gratitude is also expressed to the International Commission on Glass (ICG) and the Elemental Analysis Facility—Field Museum (FM) for timely

support for a few international travels, and to Banaras Beads Ltd. for logistic support for the live glass bead-making display during the conference.

Delegates during the workshop on ‘History, Science and Technology of Ancient Indian Glass’, twenty-first January 2019 at IIT Gandhinagar

Gandhinagar, India — Alok Kumar Kanungo
Chicago, USA — Laure Dussubieux

Introduction

There has been a growing need for books with an international reach focusing on archaeological artefacts from ancient India and South Asia encompassing scientific applications. Glass objects are part of these artefacts that have been neglected by scholars. Glassmaking and glass working are among the early pyrotechnologies and chemistry processes applied by human. Beads and bangles, being small and easy to wear, carry and trade, have been transported thousands of kilometres, across both land and sea. They have a long history of production and use in the Indian subcontinent and are still produced in the present-day traditional craft centres. Their history is preserved in the archaeological record, epigraphy and ancient literature. They are represented in sculpture and paintings, as well. Bead and bangle production techniques encompass a wide range of technologies ranging from simple to highly complex. These technologies developed and evolved through time based on both the creative inspiration of individual craftspeople and the needs to meet the demands of both local and international consumers. Beginning with the earliest glass beads dating to more than 3400 years ago at Bhagwanpura in India, furnace wound glass beads have been mastered in North India for 3000 years and furnace drawn beads have been produced in South India for 2500 years. Quickly, they became most sought-after glass products in the ancient and modern world. These beads and bangles were used by all levels of society as a way to both integrate communities culturally through the use of important symbolic objects and differentiate people by the designs and complexities of production.

This book on ancient glass is the second in a series of books dealing with various artefacts that started with a book on stone beads and demonstrates important continuities from past to present. Ancient artefacts help us to better understand the importance of the past for developing new technologies in future.

The book is divided into five parts. The first of these parts is 'Glass Origin and Evolution' that included four chapters. Thilo Rehren in his chapter on 'The Origin of Glass and the First Glass Industries' introduces the chemistry of glass as a matter of three different components: the sand/quartz base to which a flux is added alongside the third component—a variety of 'spices' to colour, opacify and lend it special qualities. Professor Rehren's paper provides an overview of the complexity involved in the study of trace element contributions from both the flux and colourants. His

paper also stresses the need to locate all archaeometric analysis within a sense of the contemporary glass cultures and elite networks of political economy that sustained them. The chapter on 'Glass in the Middle East and Western Europe at the End of the First Millennium CE, Transition from Natron to Plant Ash Soda or Forest Glasses' by Bernard Gratuze, Nadine Schibille and Inès Pacta addresses the issue of the specificities of the transition from natron glasses to plant ash glasses and 'forest' glasses in the connected spheres of the Middle East and Western Europe at the end of the first millennium. Dr. Gratuze's paper shows what chemical analysis can reveal when are combined an innovative sample selection from well dated assemblages with the precision of Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS). Chapter 'Glazed Steatite and Faience Technology at Harappa, Pakistan (> 3700–1900 BCE): Technological and Experimental Studies of Production and Variation' by Jonathan Mark Kenoyer summarizes the results of more than twenty years of the study of Harappan glazed steatite and faience technologies. The paper provides a sense of the pyrotechnical virtuosity and playfulness with which Harappan craftsmen excelled at the manipulation of this material. Prof. Kenoyer summarizes results not only from the use of a range of instrumental techniques [ICP-MS, scanning electron microscope (SEM) and others] but also from his extensive replication studies. The chapter on 'Traditional Bead and Bangle Crafts in India' by Alok Kumar Kanungo summarises key insights from his ethnoarchaeological work at sites like Papanaidupet, Purdilnagar, Jalesar, Akrabad and Hasayan, to ask Indian archaeologists to be more attentive to the skill, expertise and innovations with which South Asian glass crafts developed and diversified. In doing so, the paper highlights the need to be attentive to the 'when and why' of changes in Indian glass craft traditions, especially in the pre-colonial era, a task in which archaeology can contribute but hitherto has not. Turning to the evidence for production, he argued that the problem in Indian archaeology persisted on account of our expectations as far as the forms of evidence and a misunderstanding of the taphonomic processes that are involved. As a result, the distinctive debris of both glass production and glass working is likely often misrecognized.

There are four chapters under the second part, i.e. 'Scientific Study and Care of Glass'. The chapter on 'Elemental Compositions and Glass Recipes' by Laure Dussubieux provides a synoptic overview of the kinds of questions which can be chemically asked of glass artefacts. Dr. Dussubieux very usefully organises these into three kinds of questions. First are questions that can be asked of glass making: (who made glass, where, with what technology, which ingredients, and what was the organisation of primary production). Second are questions that we can ask of trade in glass: (who traded what, what trade in raw glass existed, how networks sustained varied trade) and finally questions of the use of glass. The chapter on 'Isotope Analysis and Its Applications to the Study of Ancient Indian Glass' by Laure Dussubieux, Christophe Cloquet and Thomas Oliver Pryce introduces new scientific approaches to understand glass production and trade. By looking at strontium, neodymium and lead isotope signatures of ancient glass, it is possible to determine the origin of the raw materials and understand the circulation of raw materials as well as finished products. The chapter on 'The Conservation of Glass' by Stephen P. Koob is an introduction

to the kinds of care which are demanded in the handling of glass. It provides a very useful and detailed discussion of the preferred binders (Paraloid B-72) that should be used in the conservation of glass. The chapter on 'Typology of Glass Beads: Techniques, Shapes, Colours and Dimensions' by Joanna Then-Obłuska provides a tour-de-force survey of the issues, challenges and attention to detail which the typological study of ancient glass beads demands. The paper admirably summarises the different methods by which ancient glass beads were made and provides excellent illustrations of their visible traces on artefacts.

The third part, 'Ethnography and Literature', covers four chapters. The chapter on 'Glass in Indian Archaeology, Ancient Literature, Historical Records and Colonial Accounts' by Alok Kumar Kanungo dismantles the unhelpful debates over the origins of glass, glassmaking and widespread use in South Asia. The paper examines a series of otherwise difficult to understand textual references (in the Satapatha Brahmana, the Arthashastra and other texts) and points to how the metaphorical and allusive use of glass and glassmaking must presume at least a few centuries of familiarity with the material. The latter texts and social customs which define the customs related to use of glass bangles are discussed. The colonial accounts that documented the native glass production and glass bangle making in different regions of India are dealt upon. The chapter on 'Situating Harinagar Hoard Finds in Pre-Iron Age Glass Crafts' by Bhuvan Vikrama argues, contrary to the present knowledge, that there existed a possible knowledge of glass crafts in India from at least 2nd millennium BCE on the basis of the evidence revealed by recent finds from that site. The chapter on 'History of Glass Ornaments in Tamil Nadu, South India: Cultural Perspectives' by Veerasamy Selvakumar is a thorough and thought-provoking review of the evidence for the production, use and status of glass in Tamil Nadu. His paper also provides a very rich account of the historical evidence on glassmakers and especially the caste of bangle traders and makers known from Tamil inscriptions. The chapter on 'Traditional Glass Mirror Making in Kapadvanj, Gujarat, India and an Outline of the Use' by Jan Kock and Torben Sode presents a precis of their work over the last several decades on Indian glass crafts—of primary oval shaped hot lead-coated glass mirror-making, mirror work and mirror use.

The fourth part, i.e. 'Glass Products in South Asia', deals with five chapters. The chapter on 'Glass Beads of Eastern India (Early Historic Period)' by Sharmi Chakraborty addresses the important issue of how we assess the scenario of glass beads and their use in a regional perspective using new methods such as cluster analysis in the case of early historic Bengal. The chapter on 'A Review of Selected Glass Bead Types from the 2007–2009 Seasons of Excavation at Pattanam, India' by Shinu Anna Abraham concentrates on the non-Indo-Pacific beads of Pattanam in an attempt to understand the complexity of the trade network the site was part of. The chapter on 'Glass Bangles in South Asia: Production, Variability and Historicity' by Mudit Trivedi revisits the questions of chronological change, typological diversity and cultural significance of the glass bangle as an artefact type of a much-neglected point of entry into the study of South Asian glass. The chapter on 'West Asian Glass in Early Medieval India as Seen from the Excavations of Sanjan' by Kurush F. Dalal and Rhea Mitra-Dalal details the range and density of tenth- to twelfth-century

glass tableware that they recovered during excavations including bottles, vials, footed plates, distillation apparatus, goblets and other items such as buttons. The chapter on 'Interrelations in Glass and Glazing Technologies in Mughal Tilework' by Maninder Singh Gill presents the results of his study investigating early Mughal architectural tilework. This paper is a case study of the interaction of indigenous Indian glass tradition in the context of a cosmopolitan court culture, which drew equally in its political and material cultures on Central and South Asian traditions.

The fifth and final part, 'The Diffusion of South Asian Glass', covers five chapters. The chapter on 'Indian Glass Beads in Western and North Europe in Early Middle Age' by Bernard Gratuze, Constantin Pion and Torben Sode summarizes recent discovery and identification of a range of Indian glass beads in early medieval Europe in two distinct clusters. The first group of finds were from Western Europe and France in the period between 500 and 800 CE and as recovered from Merovingian era elite burials. The second and more puzzling group was that as recovered from Northern Germany, Denmark and Sweden in the seventh and eighth centuries. The chapter on 'Early Glass Trade Along the Maritime Silk Route (500 BCE–500 CE): An Archaeological Review' by Sunil Gupta reviews the discovery of glass across most of the Old-World civilizations from mid-second millennium BCE till the BCE–CE transition when the maritime trade in raw and crafted glass becomes widespread, with long-distance networks active from the Red Sea to the South China Sea. This paper also provides the first review of the archaeological evidence of glass trade across the Silk Route in the broad period 500 BCE–500 CE. The chapter on 'Indian Glass in Southeast Asia' by Laure Dussubieux draws on her decade long study of the compositional groups of glass in Southeast Asia (especially sites in Thailand, Vietnam and Myanmar). The paper demonstrates how influential models such as the Arikamedu centric story advanced by Peter Francis Jr. of technology transfer and/or the movement of craftspeople are in need of re-evaluation in the light of the elemental analysis of glass from these sites. The chapter on 'Indian Glass: Chronology and Distribution in Eastern Africa' by Laure Dussubieux and Marilee Wood reports on recent research on Indian glass beads found on the western rim of the Indian Ocean, highlighting the chronological shifts of Indian production centres that fed the African bead market throughout the 2nd millennium CE. The final chapter on 'Indian Glass Beads in Northeast Africa Between the First and Sixth Centuries CE' by Joanna Then-Obłuska presents new evidence to the South Asian audience of Indian beads as traded to Northeast Africa in the period between the first and sixth century CE.

The above-mentioned chapters, written by some of the best known authorities, make the book one of its kinds with holistic approach making it a reference work on the subject.

Alok Kumar Kanungo
Laure Dussubieux

About This Book

This book *Ancient Glass of South Asia—Archaeology, Ethnography and Global Connections* provides a comprehensive research on ancient Indian glass. The contributors include experienced archaeologists of South Asian glass, and archaeological chemists with expertise in the chemical analysis of glass, besides, established ethnohistorians and ethnoarchaeologists. It is comprised of five parts, and each part discusses different aspects of glass study: the origin of glass and its evolution, its scientific study and its care, ancient glass in literature and glass ethnography, glass in South Asia and the diffusion of glass in different parts of the world. The topic covered by different chapters ranges from the development of faience to the techniques developed for the manufacture of glass beads, glass bangles or glass mirrors at different times in South Asia, a major glass-producing region and the regional distribution of key artefacts both within India and outside the region, in Africa, Europe or Southeast Asia. Some chapters also include extended examples of the archaeometry of ancient glasses. It makes an important contribution to archaeological, anthropological and analytical aspects of glass in South Asia. As such, it represents an invaluable resource for students through academic and industry researchers working in archaeological sciences, ancient knowledge system, pyrotechnology, historical archaeology, social archaeology and student of anthropology and history with an interest in glass and the archaeology of South Asia.

Contents

Editors and Contributors

About the Editors

Alok Kumar Kanungo is a faculty at IIT Gandhinagar and an adjunct faculty at Flinders University. He was born in Odisha and grew up in close contact with many indigenous communities of eastern and north-eastern India. His early childhood experiences led him to eventually focus on archaeological and ethnographic studies of indigenous and ancient technology. For the last two decades, Dr. Kanungo has travelled and documented the rich heritage of the Nagas of northeast India, and the Bondos and Juangs of Odisha both in the field and in museums across Europe and the UK. He has worked in many areas where it is difficult to say where anthropology or history stops and archaeology begins. He has studied and published extensively on the subject of glass and glass-bead production and written or edited fifteen books and seventy research articles and book chapters. He has been the recipient of many prestigious awards including SPARC, Humboldt, Fulbright, Rakow and Homi Bhabha Fellowships. He has lectured at many universities and research institutes in Taiwan, England, USA, New Zealand, Bangladesh, Italy, France, Turkey, Malaysia, Germany and Thailand, besides India.

Laure Dussubieux is a chemist specialized in the determination of the compositions of ancient artefacts made from synthesized or natural glass, metals and stones. She obtained her Ph.D. in Chemistry from the University of Orléans (France) in 2001 with a dissertation focused on the use of laser ablation—inductively coupled plasma—mass spectrometry (LA-ICP-MS) to study the provenance and the circulation of ancient glass beads around the Indian Ocean. Prior to her appointment at the Field Museum, she was a post-doctoral fellow at the Smithsonian Institution (Museum Support Center, Maryland, USA) where she developed the application of LA-ICP-MS to the study of ancient gold and the use of portable X-Ray Fluorescence to survey cultural artefacts. Since 2004, she has managed the Elemental Analysis Facility (EAF) at the Field Museum and her current title is a research scientist. At the EAF, in a little more than a decade, in addition to her own research on ancient glass from South and Southeast Asia, she has facilitated more than 150 projects addressing questions related to the archaeology of cultural production, interaction and exchange.

Contributors

Dr. Shinu Anna Abraham is Associate Professor at St. Lawrence University and Archaeologist. She has done fieldwork in Egypt, Israel, India and the USA. She has two ongoing research projects: the systematic survey of iron and glass production in southern Andhra Pradesh, India, and the investigation of South India glass beads to reconstruct both Indian Ocean exchange patterns and ancient South Indian craft production processes. She is interested in the archaeology of craft/technology, state formation and archaeological theory. As Senior Editor, she published Connections and Complexity: New Approaches to the Archaeology of South and Central Asia, by Left Coast Press in 2013.

Dr. Sharmi Chakraborty works as Fellow, Centre for Archaeological Studies and Training, Eastern India. Her main interest is the archaeology of the early historic period of India in West Bengal. Her doctoral dissertation has been on the early historic site of Chandraketugarh (2000). She directed exploration in the Bakreswar River Valley and conducted excavation in Paharpur (historic to early medieval) and Kusumjatra (chalcolithic). Her ethnographic work was published as a monograph (*Ceramic Variability: An Ethnographic Perspective*, 2018). She is Editor of *Pratna Samiksha* (New Series), a peer-reviewed journal of archaeology.

Dr. Christophe Cloquet works as Research Engineer in geochemistry at CRPG and Head Manager of a CNRS National Facility for rocks and mineral analysis (SARM). He did Ph.D. in geosciences at CRPG, University de Lorraine, France, and postdoctoral in Montréal, Canada, at the Geotop (UQAM) and Ghent University, Belgium. He specializes in isotopic geochemistry, developing and using clean room conditions and MC-IC-PMS instrument. He has a strong track record in using isotope ratios to understand sources and processes in the critical zone. He is focused on tracing anthropogenic or natural sources by using metal isotope ratios.

Dr. Kurush F. Dalal received his Ph.D. in the Early Iron Age in Rajasthan from the Department of Archaeology, Deccan College, Pune. Later, his research interest shifted to the Early Medieval Period of the West Coast of India, and since then, he has excavated the sites of Sanjan and Chandore. As Assistant Professor (archaeology) in Centre for Extra Mural Studies, University of Mumbai, he co-directed the Salcette Explorations Project, an Urban Archaeology Project, documenting the Archaeology of Mumbai. His interests in archaeology include memorial stones and ass-curse stones in India, numismatics, defence archaeology and architecture, ethnoarchaeology, culinary anthropology, food archaeology and other related subjects.

Dr. Maninder Singh Gill is Art Conservator and Archaeological Scientist based in Noida, India. He trained for a MA in conservation at the National Museum Institute (NMI) and was later conferred with a Ph.D. in archaeological science by the University College London (UCL). He has been working in the field of conservation in India

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Dr. Bernard Gratuze is Director of research at the French National Center for Scientific Research (CNRS), Institut de Recherche sur les Archéomatériaux, Centre Ernest-Babelon (IRAMAT-CEB), CNRS/Université d'Orléans, France. He received his Ph.D. and the Habilitation for the direction of Ph.D. from the Analytical Sciences Department of Orléans University. His current research interest includes the development of analytical protocols using laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) for glass (as well as for lithic materials) to study their production and trade from Protohistory to the Modern Period.

Dr. Sunil Gupta is Director i/c at the Allahabad Museum. He completed his Ph.D. in archaeology from the Deccan College, Pune, in 1998. He has been Nehru Fellow at the Victoria and Albert Museum, UK (1997), and JSPS Postdoctoral Fellow at the International Research Center for Japanese Studies, Kyoto (1998–99). He has done archaeological fieldwork in Japan, China, East Africa and India at Kamrej (Gujarat) in 2003 and Bankat (Allahabad district) in 2008. He is Editor of the *Journal of Indian Ocean Archaeology*. His current focus is the archaeology of 'trade and civilization' in the context of the early Indian Ocean world.

Dr. Jonathan Mark Kenoyer the George F. Dales Jr. and Barbara A. Dales Professor of Anthropology, has been teaching at the University of Wisconsin–Madison since 1985. He has worked on excavations and ethnoarchaeological studies in both Pakistan and India since 1975. He has served as Field Director and Co-Director of the Harappa Archaeological Research Project since 1986. He has a special interest in ancient technologies and crafts, socio-economic and political organization as well as religion. These interests have led him to study a broad range of cultural periods in South Asia as well as other regions of the world, including China, Japan, Korea, Oman and West Asia in general.

Dr. Jan Kock teaches in the Department of Medieval and Renaissance Archaeology, Aarhus University, Denmark, since 1994. He served as Curator in the famous Aalborg Historical Museum in Denmark (1974–1994). His research involves medieval archaeology, ethnoarchaeology, study of glass and history of technology, and also warfare. He is today one of the foremost European authorities in the field of beads and glass studies in general and that of India in particular. Along with Torben Sode, he has been authoring a series of research publications on various crafts of India. He has travelled and documented in almost all corners of India where there is evidence of traditional glass technology.

Dr. Stephen P. Koob Chief Conservator in Corning Museum of Glass since 1998, was responsible for the care and preservation of all of the museum's collections until his retirement in 2020. He also oversaw the maintenance and repair of objects in the museum's conservation laboratory and provides documentation of such objects throughout their repair. He is an expert in dealing with 'crizzling', a condition that affects unstable glass. He has recently taken over the chairmanship of Technical Committee 17, which studies the Archaeometry and Conservation of Glass, as part of the International Congress on Glass. He is Author of the book, *Conservation and Care of Glass Objects* (2006).

Mrs. Rhea Mitra-Dalal graduated from Deccan College, Pune, with a master's in archaeology and has a special interest in food. She also has a great love for the English language. She is Blogger and Freelance Writer as well as Food Entrepreneur and Hand-crafter.

Dr. Inès Pactat completed her Ph.D. in the 'Production, distribution and consumption of glass in France between the eighth and the eleventh century' from the University of Burgundy Franche-Comté. She is involved in French and Croatian archaeological fieldworks and, as Member of the Executive Board of the French Association of Glass Archaeology (AFAV), has co-organized the 8th International Congress on Medieval Glass in Western Europe at Besançon in 2016. She now holds a postdoctoral position at the IRAMAT-CEB in the framework of the ERC project GlassRoutes directed by Dr Nadine Schibille.

Dr. Constantin Pion is Scientific Collaborator of the Belgian Royal Institute for Cultural Heritage (Brussels) and Professor at Free University of Brussels and Royal Institute for Art History and Archaeology where he teaches medieval art history and archaeology. He received his Ph.D. in art history and archaeology from the Free University of Brussels in 2014 with a dissertation focused on Merovingian glass beads in Western Europe. His research focuses on typology, chronology, glassmaking processes and uses. In collaboration with Bernard Gratuze and Orléans University, he studies glass recipes, identifying small Indian glass beads import in Western Europe during fifth and sixth century CE.

Dr. T. O. Pryce is Senior Researcher at the French National Centre for Scientific Research since 2013. He received his Ph.D. in archaeometallurgy from the UCL Institute of Archaeology (2009). A three-year Leverhulme Trust Early Career Fellowship at Oxford University led to a one-year Senior Postdoctoral Fellowship with the French Institute of Research for Development, based in Laos in 2012. He is Director of the French Archaeological Mission in Myanmar since 2012 and obtained an ANR grant for the 'BROGLASEA' project in 2016. His research focuses on the hunter-gatherer to state transition in Mainland Southeast Asia, with a metallurgical specialization there and in surrounding regions.

Dr. Thilo Rehren is A. G. Leventis Professor for archaeological sciences at the Cyprus Institute in Nicosia, Cyprus, where he leads the research centre for Science and Technology in Archaeology and Culture (STARC). He worked for nearly ten years as Research Scientist at the German Mining Museum in Bochum. In 1999, he joined the University College London (UCL) Institute of Archaeology as Professor for archaeological materials and technologies. From 2011 to 2016, he led the development of UCL Qatar as a centre of excellence for archaeology, museology and conservation based in Doha, Qatar. His research covers topics dealing with ancient glass and metal technology.

Dr. Nadine Schibille obtained her Ph.D. in the history of art from the University of Sussex in 2004. During her doctoral research, she developed an interdisciplinary strategy to investigate the material and aesthetic aspects of light in the art and architecture of the Byzantine Empire. Following a M.Sc. from the Institute of Archaeology at UCL (London) in 2005, she has held postdoctoral positions at Stanford University, the Getty Institute (Research Fellowship), and the University of Oxford (Marie Skłodowska-Curie Intra-European Fellowship). She joined the CNRS in 2015 to lead an ERC project entitled *GlassRoutes* that traces Mediterranean-wide developments in the production, trade and consumption of glass.

Dr. Veerasamy Selvakumar is Faculty Member in the Department of Maritime History and Marine Archaeology, Tamil University, Thanjavur. He completed his doctoral and postdoctoral researches from Deccan College, Pune. He was Nehru Trust for the Indian Collections at the Victoria and Albert Museum (NTICVAM) Visiting Researcher at the Centre for Maritime Archaeology, Southampton University, in 2004. With a NTICVAM UK Visiting Fellowship in 2018, he was trained in ceramic studies at UCL and the British Museum. His research interests include archaeology of India, prehistory, maritime history and archaeology, archaeological theory, heritage management, history of science and technology, ceramic studies, Indian Ocean cultural interactions and ecocriticism.

Mr. Torben Sode is Proprietor of Glass Bead Trading, Denmark, and Independent Glass Researcher. He has travelled all around the world in search of questions related to glass in general and glassmakers in particular. His search for continuity in tradition has resulted in some of the well-referred works on glass bead and bangle productions at Purdalpur, glass production at Jalesar and glasswork at Kapadvanj. He is an expert in glass conservation and has worked on many traditional glass-working centres in Europe as well. Invariably, his publications include references to the people who work on glass.

Dr. Joanna Then-Obłuska is Assistant Professor in the Polish Centre of Mediterranean Archaeology at the University of Warsaw and Research Associate in the Oriental Institute at the University of Chicago, specialising in the archaeology of Northeast Africa. After taking part in various excavations and surveys in Israel and Egypt (2003–2007), she wrote her Ph.D. on burial customs of nomadic people in

ancient Egyptian deserts. Since then, her projects focus primarily on issues of society and economy, looking at ancient Sudanese and Egyptian beads and jewellery, in terms of both their materials and techniques.

Dr. Mudit Trivedi is Assistant Professor of anthropology at Stanford University. His research focuses upon the intertwined archaeology of religion, conversion and urbanism at the medieval fortified city of Indor in district Alwar, Rajasthan, where he conducted survey and excavations in collaboration with the Department of Archaeology and Museums, Government of Rajasthan. Previously, he worked on projects related to the South Indian Megalithic–Iron Age and Early Historic periods, the settlement history of the middle Ganga Plains (with special reference to Kausambi) and the North Indian Palaeolithic.

Dr. Bhuvan Vikrama works as Superintending Archaeologist at the Archaeological Survey of India. He obtained his master's and Ph.D. (Decline of the Indus Valley Civilization: Socio-Economic Factors) degrees in ancient Indian history, archaeology and culture from Ram Manohar Lohia Avadh University, Faizabad. His noteworthy contributions are in excavations at Lalkot, Humayun's Tomb and Shalimar Bagh, Delhi; Siswania, Ayodhya, Ahichhatra, Harinagar and Sakatpur, Uttar Pradesh; and Dholavira, Gujarat. He has, so far, published more than two dozens of research papers on a variety of topics.

Dr. Marilee Wood is Honorary Research Associate at the University of the Witwatersrand specialized in the archaeology of glass beads. She began bead studies while living in South Africa in the 1990s. She received an MA in archaeology from the University of the Witwatersrand in 2005 and then a Ph.D. from Uppsala University in 2012. She specialises in researching and writing about glass beads, mainly from pre-European contact sub-Saharan Africa.