Science in the art museum: Federico Carò of The Met on studying Indian artworks

The researcher on how scientific analysis continues to reshape our understanding of art

Updated - November 13, 2026 10:02 pm IST

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Federico Carò, a research scientist at the Metropolitan Museum of Art in New York, studies South Indian Buddhist sculptures and Gupta-period bronze-casting techniques. | Photo Credit: Courtesy The Met

Science reveals aspects of art that are otherwise difficult to uncover. By investigating how artworks are made, for instance, scientific analysis encourages us to understand art not simply as the impulse of a royal or religious patron but also the work of an artisan. It thus probes a range of humanistic concerns in the production, circulation, and preservation of art.

Working at the intersection of material science and art history, Federico Carò, a research scientist at the Metropolitan Museum of Art in New York, brings a distinct perspective to the study of ancient Indian sculpture. From tracing the geological provenance of Buddhist sculptures in South India to investigating Gupta-period bronze-casting technologies, his research demonstrates how scientific methods can deepen our understanding of artistic practices and material histories. In this conversation, he reflects on the vital contribution of scientific research to the study of Indian art and to contemporary museum practice. Edited excerpts:

How did you enter this field of study?

I have been passionate about art and archaeology since childhood and developed an interest in the geosciences in school. While completing my degree at the University of Pavia in my hometown, I

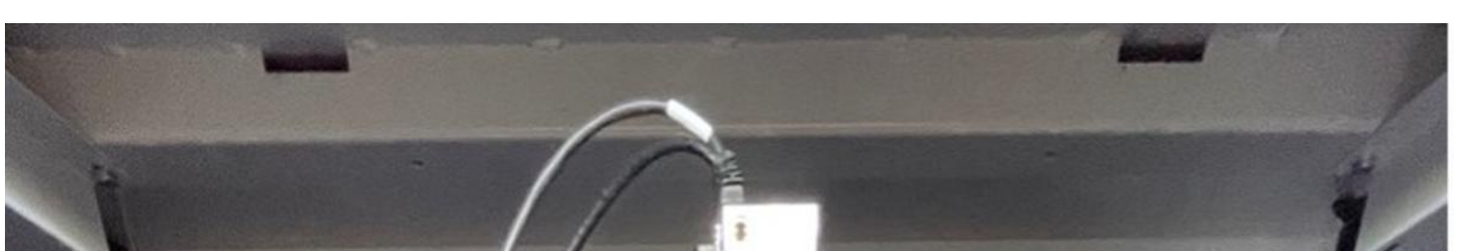
learnt that geological knowledge could be applied to understanding the material choices of artists, as well as to investigate the sources and production processes of these materials. At the time, there were no specialised degrees in museum-related sciences in Italy, but rather, research groups within scientific departments that collaborated with archaeologists, art historians, and museum staff. I made this interdisciplinary approach the focus of my career, which I initially pursued in an academic setting while earning my Ph.D in Italy. I later joined The Metropolitan Museum of Art and gained my first experience in multidisciplinary research, collaborating with scientists, conservators, and curators. I remained at the Met for three additional years, followed by a year at the Smithsonian Institution in Washington D.C., and in 2012, obtained a permanent position in the Met's Department of Scientific Research.

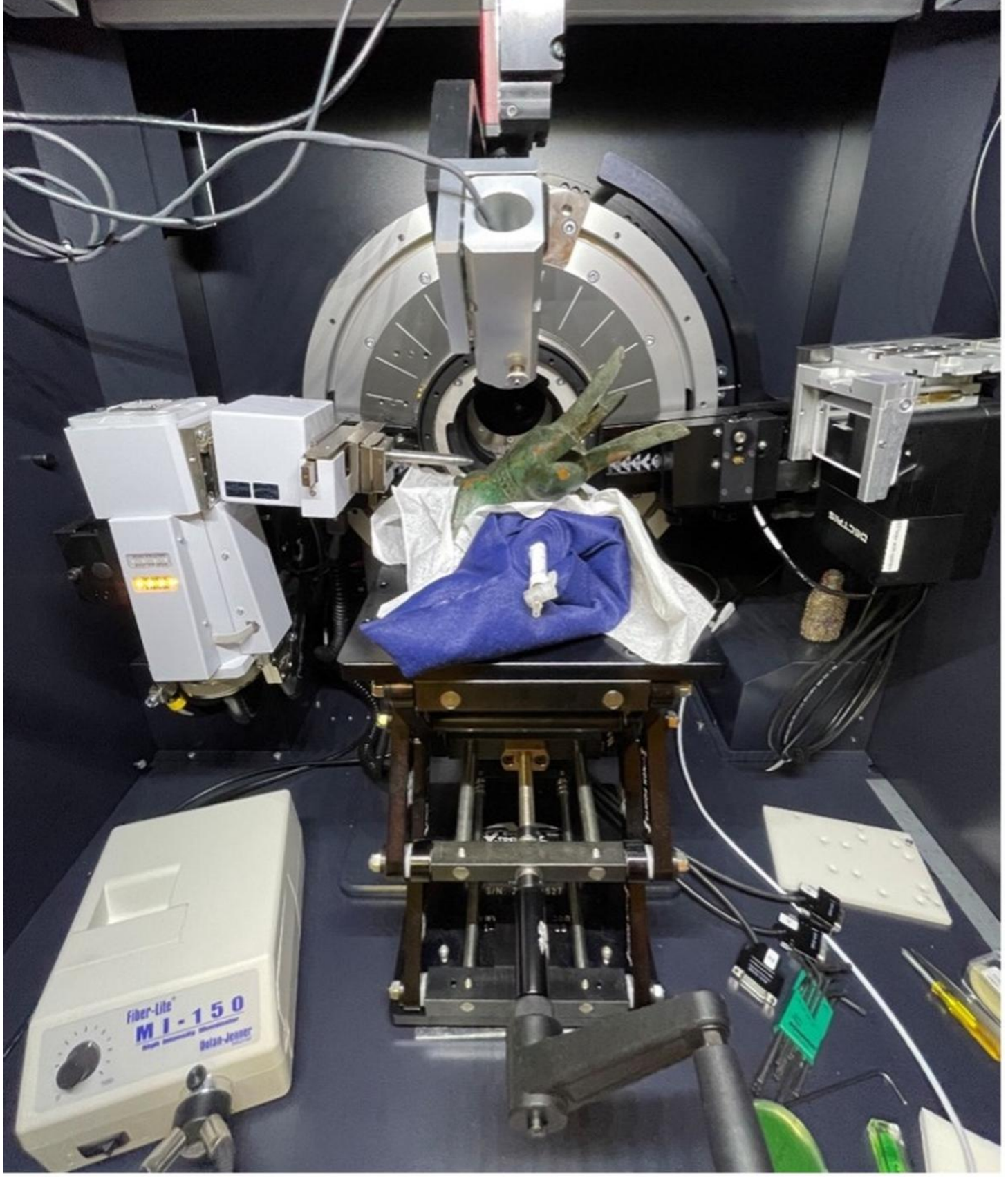


Federico Carò performing x-ray fluorescence spectroscopy on Khmer sculptures in the galleries of the Metropolitan Museum of Art. | Photo Credit: Special Arrangement

Could you elaborate on your scientific study of South and Southeast Asian sculpture?

I was involved for several years in a project on the stone sculptural production of pre-Angkorian and Angkorian Cambodia. In collaboration with the Ministry of Culture of Cambodia, the APSARA National Authority, and museums in Cambodia and abroad, the project aimed to understand the sourcing, use, and movement of stone materials in the construction of temples and freestanding sculptures. We applied petrographic and geochemical techniques to track changes in preferred stone types over time and to determine how specific sedimentary rocks were selected according to their intended use. I continue to collaborate with archaeologists on excavations in Angkor, focusing on stone and ceramic studies. I have also worked with curators John Guy and Kurt Behrendt and conservators Debbie Schorsch and Lawrence Becker on the examination of casting technologies of Gupta-period bronze sculptures.





Micro-X-ray diffraction used to analyse a Chinese bronze at the Metropolitan Museum of Art. | Photo Credit: Special Arrangement

What is your assessment of ongoing scientific research on art in India?

Scientific research on art is emerging fast in India, and many programmes are being developed at museums and cultural institutions, including at the Chhatrapati Shivaji Maharaj Vastu Sangrahalaya in Mumbai, the Indira Gandhi National Centre for the Arts and the National Museum Institute of the History of Art in New Delhi. The Met and the Ministry of Culture of the Government of India established The Indian Conservation Fellowship Programme (ICFP) in 2011, a long-term cooperative relationship to share expertise between the museums and cultural institutions in India. This agreement was renewed with an MOU in 2016, and again in 2024.

Under the aegis of the ICFP, the Met collaborated with the National Research Laboratory for Conservation in 2019 to hold a workshop with conservation scientists working on cultural heritage in India. More recently, my colleagues Maria Mieites Alonso and paper conservator Marina Ruiz

Molina joined specialists at the City Palace Museum in Udaipur to study the pigments of an 18th century Mewar court painting. Scientific analysis uncovered the cause of an unusual degradation in a green pigment mixture of indigo and Indian yellow, traced to exposure to a highly alkaline environment. The study yielded a rare discovery — bromine-based compounds in Indian yellow — and shed new light on historic pigments tied to cows being fed mango leaves. The research was presented at the International Council of Museums-Committee for Conservation 20th Triennial Conference in September 2026, and highlighted how scientific analysis continues to reshape our understanding of art.



Details of the 18th century Mewar court painting that was analysed by MET's research scientists. | Photo Credit: Special Arrangement





What analytical techniques do you use?

I work with techniques used to study geological materials. In a museum setting, protocols prioritise non-invasive techniques that gather chemical and physical information from artworks without sampling. These include X-ray fluorescence spectroscopy, Raman and Fourier transform infrared spectroscopy, and micro-X-ray diffraction. This non-invasive approach has been fundamental to understanding ancient polychromy in Cycladic and Greek sculptures. When sampling is necessary, the material collected is microscopic and allows analysis by multiple complementary techniques. I examine micro-samples using optical and petrographic microscopy, as well as scanning electron microscopy equipped with specific analytical detectors. These methods enable the characterisation of the sample's constituents and the description of their textures and structures. Sometimes the application of scientific analysis provides clues for identifying geographic origin, patterns of use, and trade of materials, such as in the scientific study of limestone in ancient Buddhist sculptures from South India displayed in the 'Tree and Serpent: Early Buddhist Art in India' exhibition at the Met in 2023.

Do you have advice for emerging scientists in India interested in your area of expertise?

My field is multidisciplinary and thrives on contributions from different disciplines. I have been able to combine my passion for art and history with my scientific and technical mindset. Whether you are studying mathematics, biology, or earth science, you can provide a fundamental contribution to the understanding and preservation of art, since artworks are complex systems composed of both inorganic and organic materials in continuous interaction with each other and with their environment. I recommend experiencing first-hand a scientific laboratory devoted to museum or archaeological studies, and encourage those interested in the intersection of art and science to apply for fellowships that put them in contact with different research groups and analytical techniques. The field of museum science is relatively small but constantly needs innovation and new minds. The cultural heritage of India is immense and precious, and provides countless opportunities for research, discoveries, and innovation. The scientists of today can play crucial roles in understanding and preserving this heritage for future generations.

The writer is a postdoctoral fellow at NYU Shanghai and former research fellow at the Metropolitan Museum of Art.