Investigating gilding techniques on Gandharan stone sculptures and architectural components: a preliminary note

Marco Zaminga,
Ivana Angelini,
Massimo Vidale

Department of Cultural Heritage: Archaeology, History of Art, of Music and Cinema, University of Padova, Italy

Luca Maria Olivieri

ISMEO, Associazione Internazionale di Studi sul Mediterraneo e l'Oriente, Director Italian Archaeological Mission in Pakistan

Giuseppe Guida

MiBAC, Istituto Superiore per la Conservazione e il Restauro

Abstract

A series of samples taken from gilded Gandharan sculpted objects in schist (both portable artifacts and architectural decorative components), coming from different sacred sites of ancient Gandhara and the Swat valley, are in the course of analytical inspection. They are studied by the means of different archaeometric techniques. Although, given the precarious conservation and rarity of the objects available for analysis, our preliminar results cannot be generalized, the emerging evidence is discussed in the light of the gilding technologies so far described in other cultural areas and periods. It is also argued that, in the Gandharan cultual complexes, the surface of sacred images might be covered with diverging procedures, dictated by various technical and/or religious concerns.

opposite page

Fig. 4
View of Barikot from NW.
Photo by Luca M. Olivieri

Introduction: Gandharan art towards materiality

The technology of gilding in ancient Swat had intrigued for years our mission Director and old friend Domenico Faccenna, who in many occasions asked two of the authors, LMO and MV, to start investigating the matter. What follows is based on an original MA thesis of Marco Zaminga (2015/206) at the University of Padova, tutored by the other authors, and is respectfully dedicated to the memory of Domenico and his unforgettable role in the extraordinary scientific adventure of the Italian Archaeological Mission in the Swat valley. We thus contribute to a long-established but discontinuous wave of technical studies on the base materials and technologies of Gandharan sculptural production, that was recently resurrected and intensified. On the background of the crucial repertory of architectural terms, ancient imagery, and technical components of the immense sacred Gandharan production reviewed in Faccenna and Filigenzi, 2007, important were the early petrographic studies on schist sculptures kept at the Musée Guimet, Paris (Curtois, 1962, pp. 107-113; Cambon and Leclaire, 1999, pp. 135-147) as well as those carried out on the sculptures on exhibit in 1992 at the Fitzwilliam Museum, Cambridge (Reedy 1992, pp. 264-277). Lithological analyses and study of the stone quarries of Swat ware are

RA 2 | 2019, pagg. 88 | 97
ISSN 1724-9686 (print) | ISSN 2465-2377 (online)

due to the fieldwork by Di Florio et al., 1993, pp. 357-372; Olivieri, 2006, pp. 137-156; see also Pannuzi, 2015 with updated bibliography, further specialistic studies including the recording of tools traces and preliminary information on gilding. The interest on Gandharan polychromy and chrysochromy goes back to original observations by Foucher, 1905, pp. 1918-1922, 1951, and was kept alive by the keen observations by Domenico Faccenna (1980-1981, *passim*) on the remnants of colours and gilding traces on the stone sculptures and architectural parts of the sacred complex of Butkara I in Swat. S. Pannuzi, 2015, gathers a series of palaeotechnological data on residues of pigments, ground preparations and gilded surfaces collected from sculptures of Butkara I and Panr, at the former MNAO "Giuseppe Tucci" (now Museo delle Civiltà) of Rome and from other Gandharan artworks at the Musée Guimet at Paris, Civic Archaeological Museum of Milan and Museum of Oriental Art of Turin.

Gilded statuary: a state of art

While gilding on metals has been the subject of important studies (e.g. Oddy, 1981, 1983, 2000; Oddy *et al.*, 1988; Giumlia-Mair *et al.*, 2002; Brambilla 2012), gilding on stone, also because of the prolongued exposure to open-air weathering or prevalently moist burial conditions of many artworks and monuments, still remains poorly explored.

In Kushan times, gilding was outstandigly important in Gandharan architecture and sculpture. Gold, in Mahayanic views, may simply (and absolutely) represent light; and light has obvious cognitive and symbolic links with the *bodhi*, the experience of enlightment by Buddha and other perfected beings, thus signalling the way to the general spiritual evolution of mankind. The chinese pilgrim Song Yun, in the 6th century CE, saw at the temple of To-lo, perhaps the religious complex of Butkara I, many buildings decorated by not less than 6000 golden images, and other constructions where the shining surfaces of stone statues dazzled the eyes of the faithful onlookers (Beal [1906] 1981, p. CII).

From the mountain tops, the look of the manifold domes that crowded the Swat and its lateral valleys, suddenly shining with gold when sunrays rose from the crest of the local mountains, must have been bewildering. We still now very little about the technical know-how and skills required by gilding. This technology must have been shared by large group of specialized craftpersons involved for a long time (1st-3rd centuries CE, and probably longer) in the construction and maintenance of the numberless Buddhist sacred areas of the region. Also, it is not clear how fare Gandharan gilding technology was endebted to the previous experience and specilized skill of the craftsmen of the Achemenian courts: at Persepolis, for example, gold foils were commonly applied onto architectural components and bodily part of the human figures, like hair, beards and personal ornaments (Nagel, 2013).

In a holistic view, stone gilding in ancient Gandhara turned into a part of a more general and globalized interest of late Hellenistic visual imagery for

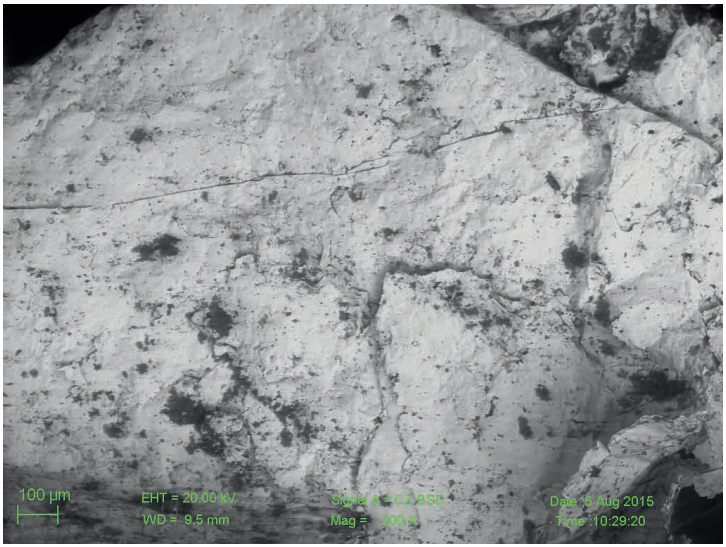

Fig. 1.
ESEM view of Sample BKG-107, a cluster of gold sheet microfragments probably detached from the surface of an object made of a decayed organic material (G. Guida, ISCR, Roma). Note the double layer of gold foil (200 X).

sensational effects, through a intensified use of polychromy and light. Buddhist iconographic programs may have shared this interest, transforming it in specific religious and devotional programmes. Buddhist sculptures and architectural components, in fact, may have had parts that were individually gilded, sometimes enhanced aside other applied and contrasting colours. In other cases, entire images, including their backgrounds, basements and frames, were entirely covered with gold foils without gaps; this type of treatment may also be due to common devotional practices. The faithful, by repeatedly applying gold foils to her/his divinity, might have thus obtained favour and particular merits.

The Chinese pilgrim Xuan Zang, for example, saw at Pi-mo, in the kingdom of Kothan, a statue of the Buddha, made by Udayana, a celebrated Indian king. Here people suffering in some body parts seeked for supernatural healing by applying gold leaf on the anatomical part of the statue that corresponded to their affected body part (Beal 1906 : 322-323). Similar rituals are still currently performed at Sarnath (Uttar Pradesh, India) (unpublished photographs given by Costanza Pera to the authors). In this and similar cases, gold leaf seem to be applied directly on the weathered stone surface of the ancient monuments, without ground layers or visible adhesive preparation (however, the absence of a adhesive would be not easily understandable; at least a physical anchorage must be assumed - G. Sidoti, personal communication). This suggests that with the development of archaeometric studies, the presence or absence of bole-like ochre as adhesive preparation under the gold leaf might reveal different technical planning, practices of maintenance of the surface of the sculptures, and/or devotional practices in various parts and components of the Buddhist sacred complexes.

Stone gilding in Mediterranean contexts

Without claiming to offer an exhaustive review of the overall available taskscape, the following Table 1 compares the basic technological approaches in five different Hellenistic contexts of ancient Mediterranean regions. From left to right, Table 1 reports the reconstructed micro-stratigraphy on as many material case-studies, from the stone surface (left) to the outer surface of the applied gold foil to the right).

This limited review suggests that, in a rather variable technical inventory, two features are more regularly present: a light-coloured background, laid directly over the stone surface, which was often abraded for granting a better grip; and organic adhesives for fixing the gold leaf (possibly, animal glues, egg yolk, gums soluble in water and resins in solvent. Resins like colophony, also mixed with siccative oils, could also have been used as adhesive, honey, or starch) which, however, as a rule, were not better identified. Different materials were used for the light-coloured backgrounds: at Delos and Antiochia sculptors used lead-based compounds (like lead white, massicot or litharge) while at Aphrodisia were apparently preferred calcium carbonate-based mixtures. Thin red or yellowish-red layers of bole-like ochre were applied above such preparations (in a few cases, this red "pigment" was also used to mark or partition on the ground the parts of the statues that had to be gilded). In general, the presence of coherent reddish-yellowish layers below the gold foils had the function of strengthening the reflectance of the light and enhancing the yellow-glowing effect of the coated surfaces.

Some technical issues in Gandharan stone gilding

Current research by S. Pannuzi and the authors is investigating a series of samples of gilded stone objects, sculpted images and architectural components recovered at the early historic site of Barikot and recently excavated sacred areas of the Swat valley (Olivieri, this issue.) and in Italian and French museum collections (Pannuzi, 2015; Pannuzi, Talarico, in stampa; passim, this issue). Other samples were obtained from collections of artifacts found at the previously excavated sacred complex of Saidu Sharif I (Callieri, 1989). To obtain relevant samples of good quality is not easy, due to the bad conservation of the surfaces and the need of sacrifying part of the objects to observe them in cross-section. Because technical studies are still in progress, the following information is still partial and preliminary.

Archaeometric studies collected in Pannuzi, 2015, indicate that Gandharan sculptures, like hellenistic ones in the mediterranean region, may have been covered by light-coloured backgrounds. Some schist sculptures of the Rome collections still bear on surface residues of a very subtle whitish-yellowish background, mainly including calcium carbonate and quartz, clays being secondary components, and traces of magnesium and iron. Applied on a ground layer of such description, a least a sample shows a thin layer that, containing silicon, iron and aluminum, may be considered a red ochre (Pannuzi, 2015, p. 56). The hypothesis is that similar layers

Delos, 1st century BC	Stone surface (probably abraded)	White ground: cerussite, $PbCO_3$ + calcium-based compounds	Bole clay, yellowish	Organic adhesive (?)	Gold foil	-
Delos, 1st century BC (variant)	Stone surface (probably abraded)	White background: cerussite, $PbCO_3$ + calcium-based compounds (?)	-	Organic adhesive (?)	Gold foil	-
Delos, 1st century BC	Stone surface (probably abraded)	-	-	?	Gold foil	-
Antiochia, 2nd century AD	Stone surface	White-yellowish background: lead oxide, PbO + bioapatite (ground bones) + organic binder	Bole clay (?)	Organic adhesive (?)	Gold foil	-
Aphrodisia, 2nd century AD	Stone surface (abraded)	White background: Carbonate ($CaCO_3$)	Bole clay	Organic adhesive (?)	Gold foil	-
Musei Vaticani, sarcophagus, ca. 300 AD	Stone surface	White background: caolin + organic binder	-	-	Gold foil	Vegetal resin (a vernice?)

Table 1
Comparing five "recipes" for stone gilding in the Hellenistic mediterranean region, ca. 1st century BC-3rd century AD. Sources are, for Delos, Burgeois and Jockey 2002; 2004-2005, pp. 343-345, 348-349, 497-505; Burgeois and Jockey 2009; 2010, p. 230; Burgeois et al. 2011, p. 648; Ostergaard 2010, p. 94; see also for the bole Paolucci 2014, p. 56. For Antiochia, Artal-Isbrand et al. 2002. For Aphrodisia, Abbe, 2010, pp. 278-282.

(lime-based, sometimes covered with films of ochre) might have been originally applied as ground for pigmented layers, sometimes for gilding, but also for regularizing or restoring the sculpted surfaces. This technical feature - whatever its contextual meanings - seems also reflected in a wider sculptures tradition of the Subcontinent. In fact, samples taken from scuptures at Mathura, Sarnath and Varanasi show a lime-based surface ground apparently obtained by grinding sea shells, or from egg shells (Giuliano 2015, pp. 20-21, with extensive references to ancient treatises on painting; see also the entry "Eggshell" in Eastaugh et al. 2008, p. 153). The possible presence of organic binders in these calcareous-clays layers was tested by gas chromatography (GC-MS); while various samples showed a undefined proteic component, only one sample revealed the presence of egg (Talarico et al., 2015, p. 58).

While the described light-coloured covering may, or may not, have been applied as grounds for coating the stone surfaces with gold leaf, their nature and relationships with additional layers of ochre, may be relevant for better understanding the specific techniques used in ancient Swat for stone gilding.

So far, two samples of gilded objects from Saidu Sharif I, and two from Barikot, were observed at the optical microscope, then studied at the ESEM, with EDS system (ZEISS IVO 60, EDS Oxford Instruments, software INCA 4.15) of the Laboratory of Chemistry and Non Destructive Testing of the Istituto Superiore per la Conservazione e il Restauro, Rome. One of the samples (BKG 107, from Barikot) was formed by a cluster of micro-fragments of gold foil, possibly detached, in this particular case, from the surface of a wooden object that did not survive deterioration (Figs. 1 and 2). Figs. 1 and 2 show that the gold foil was applied in form of superimposed sheets, and that the foil was probably applied with a repeated pressure, leaving series of parallel streaks on part of the gold surface.

One of the other samples, from Saidu Sharif I, was then sectioned at the Department of Geoscience of the University of Padova. Here the sections were embedded in transoptic resin, polished with diamond pastes, and observed again with optical microscopes at reflected light, both in parallel and crossed nichols, with a range of magnification from 50 to 1000 X.
Also, Raman analysis (with a DXR Thermo Scientific Raman, with a laser operating at 532 nm) are currently performed on the sections thus prepared. The aim, in every case, is to investigate the micro-stratigraphy of the samples - from the stone surface to the background layers, to end with the chemical composition of the gold foils. Finally, fractions of a sample from Saidu Sharif I were also analyzed by the means of GC-MS at the Laboratory of Analytical Chemistry for the Conservation of Cultural Heritage of Pisa University (I. Bonaduce, A. Lluveras-Tenorio).
So far, the stratigraphy of the sections, joined with chemical testing, failed in revealing any "white" calcareous ground below the gold foil layer or layers. There is no evidence of any organic material, let alone of a continuous layer of an organic glue; a circumstance also confirmed by the GC-MS tests so far performed on our samples. However, at present it cannot be escluded that an organic binder originally mixed in low amounts to the hematitic pigment had completely decayed, becoming not detectable.
Our best specimen, the cross-section of SS1 (from Saidu Sharif I, perhaps part of a stupa model, or of a minor architectural component; see Oliv-

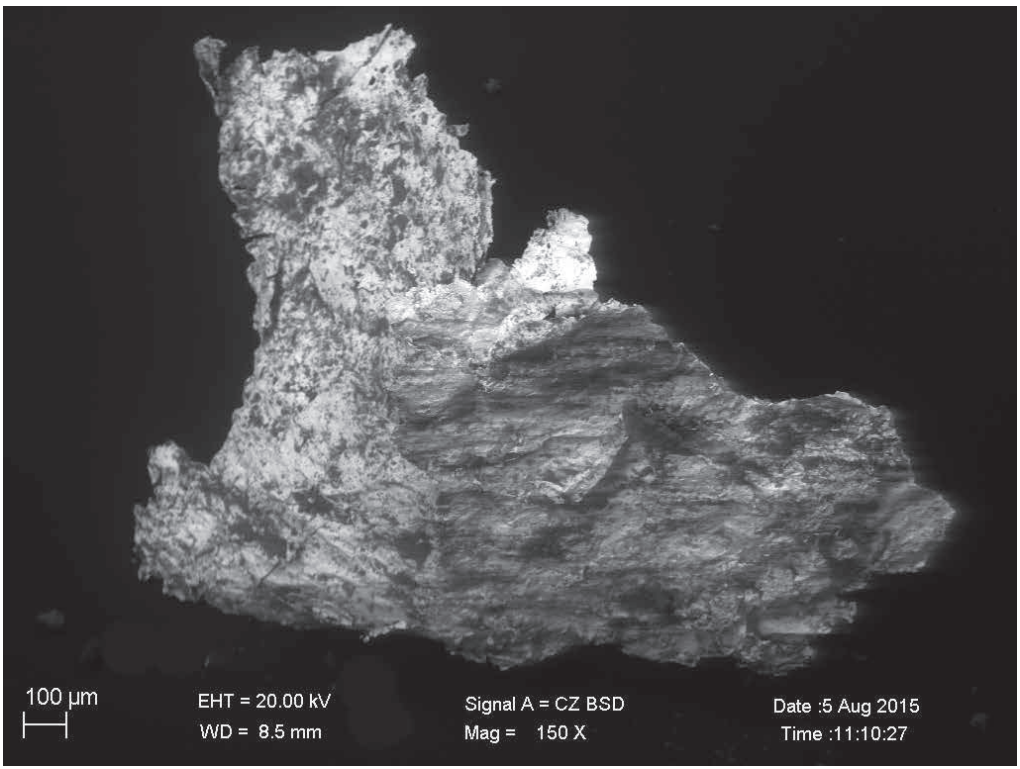

Fig. 2
ESEM view of Sample BKG-107, a cluster of gold leaf micro-fragments probably detached from the surface of an organic object (G. Guida, ISCR, Roma). The left side of the sheet fragment shows parallel striations due to the application of pressing/burnishing movements (150 X).

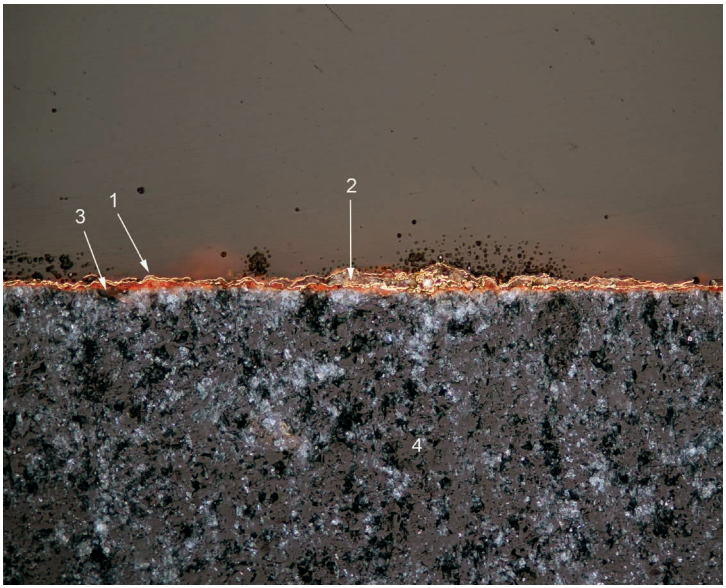

Fig. 3
Polished section of Sample SS1, observed at the optical microscope in reflected light, with crossed nichols. 1, gold sheet in two parallel layers. 2, discontinuous whitish layers containing alumino-silicates, quartz and calcite. 3,a thin layer of red bole-clay, mainly preserved in pockets on the surface of 4, the chloritoschist object (I. Angelini, Dept. of Geosciences, University of Padova).

ieri, this issue) (Fig. 3) shows the application of two, and locally more superimposed gold sheets (Fig. 3, layer 1: possibly, an effect of burnishing). The thickness of the gold leaf was not measured. Between the two gold sheets there is no red bole, but thin and locally very finely textured layers of a whitish material (Fig. 3, 2). These micro-layers, inter-fingered with gold foils, have a quite variable composition: they include fillosilicates, quartz and calcite.

Do these layers represent subsequent coats of fine calcareous films similar to the whitish backgrounds discussed above, and required by the need of renovating the gold surfaces? Or, rather, are they due to subsequent environmental deposition on the sculpture? Only future analytical work and more samples might solve the question. The same section shows that above the medium-textured chlorite-schist, was directly laid a layer of a red bole-like ochre (Fig. 3, 3). The Raman spectra clearly indicate that this thin red layer, most probably applied to the stone in semi-fluid conditions with a soft brush, was mainly composed of hematite (or red ochre). Fig. 3, 4 is the chlorite-schist of which the object was made.

21 EDS spectra obtained by the means of semi-quantitative EDS measurements of standardized spot areas on the uncleaned gold foils (for all the four analyzed samples) are statistically coherent. The samples from Saidu Sharif indicate the use of a rather pure metal, averaging 93.7% in gold, 5.5% in silver, and 0.9% copper. For Barikot, the percentages are relatively similar: 95.3% gold, 3.2% silver and 1.6% copper. Given the low number of samples, all the preliminary and partial results so far reviewed do not allow any generalizing statement. In fact, even while dealing with the few available samples we had to face unexpected and intriguing questions.

References

Abbe M.B. 2010, *Recent research on the painting and gilding of roman marble statuary at Aphrodiasias*, in *Circumlitio: the polychromy of antique and medieval sculpture*, ed. Brinkmann, V., Primavesi, O., Hollein, M. München, pp. 277-290.

Artal-Isbrand P., Lawrence P., Wypyski, M. T. 2002, *Remains of the gilding and ground layers on a Roman marble statue of the goddess Hygeia*, London.

Beal S. 1906, Si-Yu Ki. *Buddhist records of the Western World*, I-II, London.

Bourgeois B., Jockey P. 2003, *La geste et la couleur. Stratégies de mise en couleurs de la sculpture hellénistique de Délos*, «Bulletin Archéologique du Comité des Travaux historiques», vol. 30, pp. 65-77.

Bourgeois B., Jockey P. 2009, *Polychrome Hellenistic sculpture in Delos. Research on surface treatments of Ancient marble sculpture, part II*, in *Asmosia VII. Proceedings of the Seventh International Conference on Interdisciplinary Studies on Ancient Stone*, ed. In Maniatis Y., Tassos, Greece, 15-20 September 2003, pp.799-809.

Bourgeois B., Jockey P. 2010, *The polychromy of Hellenistic marble sculptures in Delos*, in *Circumlitio: the polychromy of antique and medieval sculpture*, ed. Brinkmann, V., Primavesi, O., Hollein, M., München, pp. 225-239.

Bourgeois B., Jockey P., Karydas A. 2011, *New researches on polychrome Hellenistic sculptures in Delos, III: the gilding processes. Observations and meaning*, in *Leukos Lithos. Interdisciplinary studies on Mediterranean ancient marble and stones*, ed. Jockey P., Proceedings of the VIII International Conference of the Association for the Study of Marble and Other Stones used in Antiquity (ASMOSIA), Aix-en-Provence, 12-18 June 2006, pp. 645-661.

Brambilla L. 2012, *Multianalytical approach for the study of bronze and gilded bronze artefacts*. Università degli Studi di Milano, PhD thesis, no printed.

Callieri P. 1989, *Saidu Sharif I (Swat, Pakistan). 1. The buddhist sacred area. The monastery*. IsMEO Reports and Memoirs XXIII.1, Roma.

Cambon P., Leclaire A. 1999, *Étude pétrographique des collections gréco-bouddhiques du musée Guimet*, «Arts Asiatiques», vol. 54, pp. 135-147.

Courtois L. 1962, *Examen mineralogique de quelques roches de monuments greco-bouddhiques*, «Arts Asiatiques», vol. 9, nos. 1-2, pp. 107-113.

Di Florio M.R., Faccenna C., Lorenzoni S., Lorenzoni Zanettin E. 1993, *Lithological analisys of materials used in the buildings of the sacred area of Panr I (Swat Valley, Northern Pakistan) and their origins*, in Faccenna D. et al. *Panr I (Swat, Pakistan)*. IsMEO Reports and Memoirs, vol. XXVI, no. 1, Roma, pp. 357-372.

Eastaugh N., Walsh V., Chaplin V.T., Siddal R.L. 2008, *Pigment compendium. A dictionary and optical microscopy of historical pigments*, Routledge, London-New York.

Faccenna D. 1980-8, *Butkara I (Swat, Pakistan) 1956-1962*. IsMEO Reports and Memoirs, vol. III, nos. 1-5.2, Roma.

Faccenna D., Filigenzi A. 2007, *Repertorio terminologico per la schedatura delle sculture dell'arte gandharica sulla base dei materiali provenienti dagli scavi della Missione Archeologica Italiana dell'IsIAO nello Swat, Pakistan*. ISIAO Reports and Memoirs, New Series, vol. V, Istituto Italiano per l'Africa e l'Oriente, Roma.

Foucher A. 1905, *L'art gréco-bouddhique du Gandhâra: étude sur les origines de l'influence classique dans l'art bouddhique de l'Inde et de l'Extrême-Orient*, Tome I, EFEO, vol. V, Paris.

Giuliano L. 2015, *Investigando le materie del Gandhara. Alcune riflessioni preliminari sulle indagini diagnostiche condotte presso il MNAO*, in *Gandhara. Tecnologia, produzione e conservazione. Indagini preliminari su sculture in pietra e in stucco del Museo Nazionale di Arte Orientale "Giuseppe Tucci"* ed. S. Pannuzi, Gangemi Editore, Roma, pp. 16-27.

Giumlia-Mair A., Meriani S., Lucchini E. 2002, *Indagini archeometallurgiche su dorature antiche: analisi; tecniche e varianti*, in *I bronzi antichi: produzione e tecnologia*, ed. A. Giumlia-Mair, Atti del 15 Congresso Internazionale sui Bronzi Antichi, Università di Udine, sede di Gorizia, Grado-Aquilieia, 22-26 maggio 2001, Editions Mergoil, Montagnac, pp. 338-343.

Nagel A. 2013, *Color and gilding in Achaemenid Architecture and Sculpture*, in *The Oxford Handbook of Ancient* Iran, ed. D. Potts, Oxford University Press, Oxford, pp. 596-621.

Oddy W.A. 1981, *Gilding through the Ages*, «Gold Bullettin», vol. 14, no. 2, pp. 75-79.

Oddy W.A. 1993, *Gilding of metals in the Old World*, in *Metal plating and patination: cultural, technical and historical development*, ed. La Niece, S., Craddock, P., Butterworth-Heinemann, Oxford, pp. 171-181.

Oddy W.D. 2000, *A history of gilding with particular reference to statuary*, in *Gilded metals. History, Technology anche Conservation*, ed. Drayman-Weisser, Archetype Publications in association with the American Institute for Conservation of Historic and Artistic Works, London, pp. 1-19.

Oddy W.A., Pearce P., Green L. 1988, *An unusual gilding technique on some Egyptian bronzes*, in *Conservation of Ancient Egyptian Materials*, ed. Watkins, S.C., Brown C.E., UKIC Archaeology Section, London, pp. 35-39.

Olivieri L. M. 2006, Per Saxa. *Il contributo della Missione Italiana allo studio geoarcheologico e dei manufatti rupestri dello Swat*, in *Architetti, capomastri, artigiani. L'organizzazione dei cantieri e della produzione artistica nell'Asia ellenistica. Studi offerti a Domenico Faccenna nel suo ottantesimo compleanno*, ed. P. Callieri, Serie Orientale Roma, vol. C, Roma, pp. 137-156.

Ostergaard, J.S. 2010, *The polychromy of antique sculptures: a challenge to Western Ideals*, in *Circumlitio: the polychromy of antique and medieval sculpture*, ed. Brinkmann, V., Primavesi, O., Hollein, M., München, pp. 78-105.

Paolucci F. 2014, *Marmi dorati. Esempi di rivestimento a foglia d'oro su alcuni marmi antichi della Galleria degli Uffizi*, in *Oro sacro. Aspetti religiosi ed economici da Atene a Bisanzio*, ed. I. Baldini, A.L. Morelli, Ante Quem, Bologna, pp. 53-73.

Pannuzi S. (ed.) 2015, *Gandhara. Tecnologia, produzione e conservazione. Indagini preliminari su sculture in pietra e in stucco del Museo Nazionale di Arte Orientale "Giuseppe Tucci"*, Roma.

Pannuzi, S. Talarico, F. (in press), *Pigments and gold in Gandharan stone and stucco sculptures*, in *7th Round Table on Polychromy in Ancient Sculpture and Architecture (Florence, 4th – 5th – 6 th November 2015*).

Reedy C.L. 1992, *Petrographic analysis of Gandhara stone sculptures*, in *The Crossroads of Asia*, ed. E. Errington, J. Cribb, Cambridge, pp. 264-277.

Talarico F., Biocca P., Sidoti G., Torre M. 2015, *Caratterizzazione dei materiali pittorici provenienti dal Gandhara*, in *Gandhara. Tecnologia, produzione e conservazione. Indagini preliminari su sculture in pietra e in stucco del Museo Nazionale di Arte Orientale "Giuseppe Tucci"*, ed. S. Pannuzi, Roma, pp. 52-60.

Zaminga M. 2015-16, *La doratura nella scultura gandharica (I-VI secolo d.C.): iconografia e tecniche*, Università di Padova, MA thesis, no printed.