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1|2019

Poste Italiane spa - Tassa pagata - Piego di libro Aut. n. 072/DCB/FI1/VF del 31.03.2005

FIRENZE UNIVERSITY PRESS

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Anno XXVII numero 1/2019
Registrazione Tribunale di Firenze
n. 5313 del 15.12.2003

ISSN 1724-9686 (print)
ISSN 2465-2377 (online)

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Cover photo
Stucco decoration of Stupa 61 (Period II) (photo by L. M. Olivieri; courtesy ISMEO).

graphic design
didacommunicationlab
DIDA Dipartimento di Architettura
Università degli Studi di Firenze
via della Mattonaia, 8
50121 Firenze, Italy

published by
Firenze University Press
Università degli Studi di Firenze
Firenze University Press
Borgo Albizi, 28, 50122 Firenze, Italy
www.fupress.com

Indice

An introduction: the Swat Valley and Florence

Luca Maria Olivieri

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Simona Pannuzi

MIBAC, Istituto Superiore per la Conservazione ed il Restauro

opposite page

Fig. 1
Amluk-dara (Swat), main Stupa. Photo By Luca M. Olivieri

It was Roberto Sabelli who conceived — exactly three years ago — the idea of publishing in the Florentine journal «Restauro Archeologico» the various contributions produced by the second ISCR project on Gandhara directed by Simona Pannuzi (the report on the first ISCR project was published in Pannuzi (ed.) 2015).

I liked the idea, also to acknowledge the contributions that teams from Florence (see also Di Giulio et al. 2018) and Florence University have been giving to the research of the Italian Archaeological Mission in the Swat valley. On the other side, the Mission, that had just contributed to the first issue of «Restauro Archeologico» (Olivieri 2014), have had already collaborated twenty years earlier with Luigi Marino and *Restauro Architettonico* (Olivieri 1996), and with the Cooperativa Archeologia of Florence.

Roberto Sabelli and his team (with his wife Rita Galanti, Anna Mannari, and other members of the Cooperativa) started working in Swat in 1992. In that year, all together, we carried out the topographical and archaeological survey of the area of the ancient city of Barikot (Olivieri 2003) and the first fieldwork on fortified structures and settlements of late ancient and early-Medieval Swat (c. 7th-10th century CE) (published in Olivieri 1996).

In the following three years, Roberto and his team continued working at a steady pace in Swat in a project directed by Domenico Faccenna (the unforgettable 'Direttore' of the Mission) focusing on the survey and documentation of the major Buddhist monuments (stupas and viharas/shrines) of the valley. These majestic structures, true architectural landmarks of the region, are all dated to the golden age of Gandharan art and architecture, i.e. the first four centuries of the current era (with the exception of Butkara I, whose Main Stupa was founded c. 250 BCE). The work was eventually published by Domenico Faccenna in a posthumous monography (Faccenna and Spagnesi 2014).

In 1993 literally Roberto 'fell in love' with the Main Stupa of one Buddhist sanctuary, 5 Km from Barikot: Amluk-dara. In following years we talked at lenght about that site and its problematics. Therefore, in 2012 — I was busy

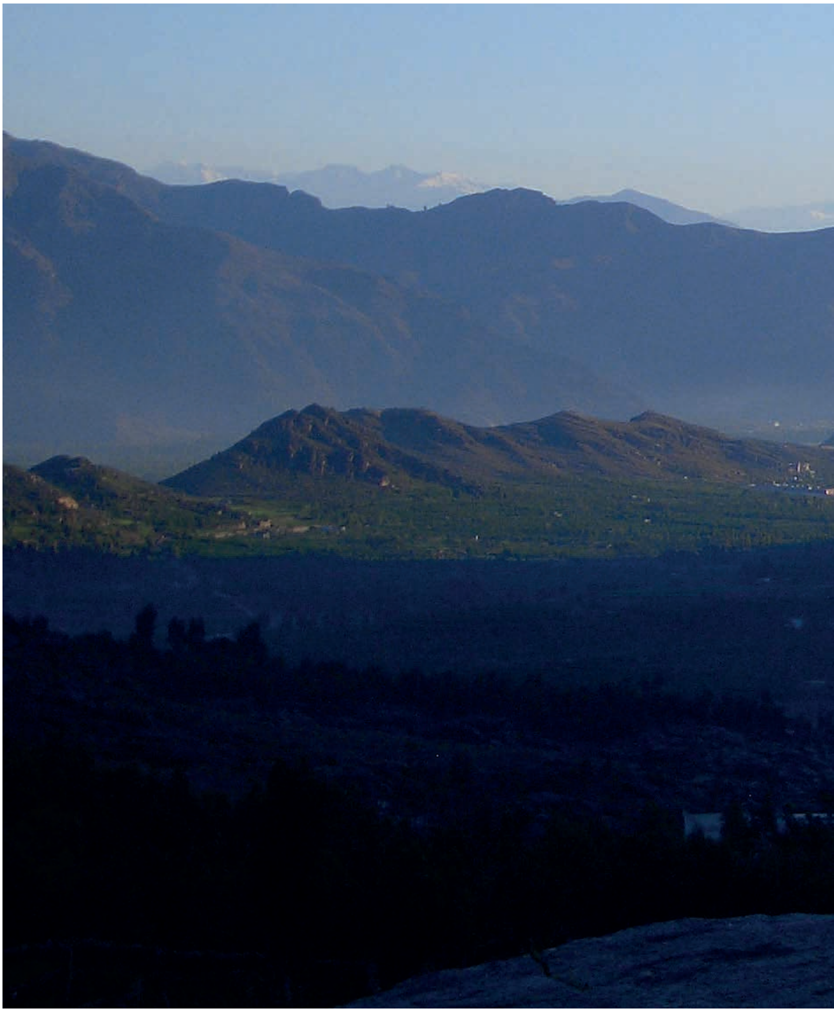

Fig. 2
A view of the Swat valley (view from SW). In the centre the Barikot hill. Photo by Luca M. Olivieri.

in the excavation of Amluk-dara — I asked him to join me in Swat. A specific Memorandum of Understanding was draft and signed by our Mission and Roberto's Department at the University of Florence. On that year we studied together a possible conservation project for the site. Meanwhile he helped us to find the right methodological approach for the conservation of another stupa at Saidu Sharif I, and other sites in Swat, including the restoration of the missing volumes at the colossal rock-carving of the Buddha of Jahanabad (see Olivieri 2014). Eventually, the conservation project at Amluk-dara became the topic of a thesis entrusted by Roberto Sabelli to Gaia Di Pierro (Conservazione e valorizzazione dell'architettura devozionale del Buddismo nella Valle dello Swat (Pakistan): una proposta progettuale).

One issue particularly attracted both of us. The topic was production and processing of the so-called 'stucco' (calcite-based), and its association to

kanjur (an organogenic limestone) which are both extensively utilized in the late (post-3rd century AD) decoration of the Buddhist stupas in Swat, including Amluk-dara. The results of our discussion and studies should have been elaborated — on the basis of the results of the petrographic and chimical analysis — in a joint contribution for this issue of «Restauro Archeologico». Unfortunately our study was not completed in time.

We were both intrigued by the presence of these new materials in a region where schist is widely available, and where the latter was the only material utilized for sculpture and decoration especially in the first two centuries AD (when stucco was randomly used only for the finishing).

Kanjur, or *kankar*, is not local in Swat, and it is quarried and imported from the South-eastern regions of Taxila, Swabi, and Salt Range, closer to the wide alluvial plateau of the Indus basin. This soft stone, that can be easily cut and carved, totally replaced schist, and was largely utilized for archi-

tectural parts (e.g. false brackets, capitals, pillars and semi-columns, modillons, mouldings, friezes, etc.) notwithstanding its texture does not allow the carving to catch the accuracy and finesse standards that Gandharan artists were used to.
Actually, the *kanjur* elements were just the 'skeleton' of the decoration, as they were completed by heavy layers of stucco plasters, which were adding to them volumes, details, and polichromy.
Not only lime based stucco is the natural complement of *kanjur*, but it is also the best one for its cost-effectiveness. J. Marshall, Director General of the Archaeological Survey of India, described carefully the local production system of lime in contemporary British India.

> For making lime, stone or kankar is burned in kilns [and then] slaked (Marshall 1923: 48).

In fact, not only lime-based stucco can be obtained from *kanjur*, but, it might have been even the natural by-product of *kanjur* stone quarrying, cutting and carving. It was evident to Roberto and me — we were together in 2012 at the dig — that what Marshall had pointed out for contemporary lime production might have been tested for ancient times at Amluk-dara. In 2012 I had managed to obtain from the Pakistani archaeological authorities the permit for the export of several samples for destructive analysis. Therefore, Roberto carried out on that year a series of dedicated samplings, especially at Amluk-dara. Othere samples were taken at Barikot and other sites. Once the samples were exported, they were handed-over to various Institutions, including the University of Florence, ISCR, and the University of Pisa. The reports on some of these analysis are presented in the following pages (Rosa, Theye, Pannuzi; Bonaduce, et al.).
(LMO)

While these analysis and studies were in progress, Roberto Sabelli (then the Chief Editor of *RA*) proposed the idea to publish together all the reports in a issue of *Restauro Archeologico*. The idea was immediately accepted with enthusiasm at our Institute (ISCR). ISCR had already started an important research on Gandharan scultures, focusing on polichromy and technology (both on schist sculpture and stucco architectonical decoration) (Pannuzi (ed.) 2015).
Gandharan art has been so far considered, with important exceptions of course, especially from the point of view of fine arts and religious studies. Its intrinsic elements of interest can be instead various and unexpected. They can also capture the appeal of the general public especially for their links and their implications, which are reflected in a crucial historical period (the first half of the 1st millennium) from the Mediterranean to East Asia.
To to all of us the possibility of sharing and exchanging ideas with Roberto's team appeared stimulating since the beginning. While we were carrying out together several meetings aimed at creating a suitable table of

contents for the volume, we were aware that we were potentially laying the path for a future development of the study. The field — up to a certain extent — is new, as demonstrated by the attention dedicated to our preliminary results in International Conferences and Workshops.

Roberto's idea is now real, but we hope that such collaboration will not end up with the publication of this issue. We hope that all the specialists involved in this research will have the possibility to keep on collaborating, and contributing on a new phase of the research: from the study of the materials, possibly to restoration projects.

(SP)

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Geological overwiew of Gandharan sites and petrographical analysis on Gandharan stucco and clay artefacts

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Sigea Lazio, Istituto Italiano di Paleontologia Umana

Thomas Theye
University of Stuttgart

Simona Pannuzi
MIBAC, Istituto Superiore per la Conservazione ed il Restauro

opposite page

Sample BKG 1123 15C: architectonical polycrome decoration from Barikot, Pakistan: the arrow indicates the traces of red colour (photo E. Loliva © ISCR).

Abstract

The Gandharan archaeological sites are mostly located in the Indus Suture Zone and in the lower Swat. In a recent past, scholars observed the use of local different type of schists to build buildings and sacred artworks. In this new research we highlighted the use of limestone for stucco artefacts and architectural decorations. This limestone is not a local rock in Swat but its main, extended and closer outcrops are located in the mountains northwest of Islamabad. Indeed, through specific analyses carried out by our team, the compatibility of these outcrops with the rocks used for stucco artefacts and stucco decorations of buildings was observed. This stucco was made by a mixture of different kinds of local crushed rocks (i.e. schists and granites).

Keywords
Limestone, clay artefacts, stucco decorations, Gandharan artefacts, Swat geology, petrographic analysis.

Geological introduction

The formation of the Himalaya mountain range is due to the collision between Eurasia and the north-western side of the Indian Plate, moving from the south, since the Mesozoic Era and up to the present days[1]. The northern termination of the Indian Plate is defined by the Indus-Tsangpo suture zone[2]. This suture zone continues westwards to the Swat area of Pakistan, where it is called "Main Mantle Thrust" – henceforth MMT [3] –. The MMT separates the metamorphic Kohistan island arc sequence north, from the metamorphic continental basement of the Indian plate in the south. The Suture Zone itself consists of a mélange of klippen of various rock types (Fig.1). The Swat valley is located between the Indian Plate and the Kohistan island arc sequences and the Swat River flows in part inside the tectonic lineament called MMT, a zone intensively fractured and erodible[4].

In northern Pakistan the geological succession from south to the north is formed by the following rock formations (Fig. 3):

1. Indian plate continental crust – lower Swat

The lower Swat sequence occurring in the lowermost tectonic position (Manglaur Formation) consists of a high-grade metamorphic augen

[1] Yin, Harrison 2000; Ding et al. 2005: the scholars dated the start of collision to Cenozoic (65-60 My).

[2] Gansser 1980.

[3] Jan, Tahirkheli 1969; Tahirkheli 1979a and 1979b; Tahirkheli 1980.

[4] Faccenna et al. 1993, pp.257-161.

RA 2 | 2019, pagg. 10 | 35
ISSN 1724-9686 (print) | ISSN 2465-2377 (online)

Fig. 1
Map of Northern Pakistan: shaded area represents pre-Quaternary rock (from Dipietro et al. 1991, fig.1).

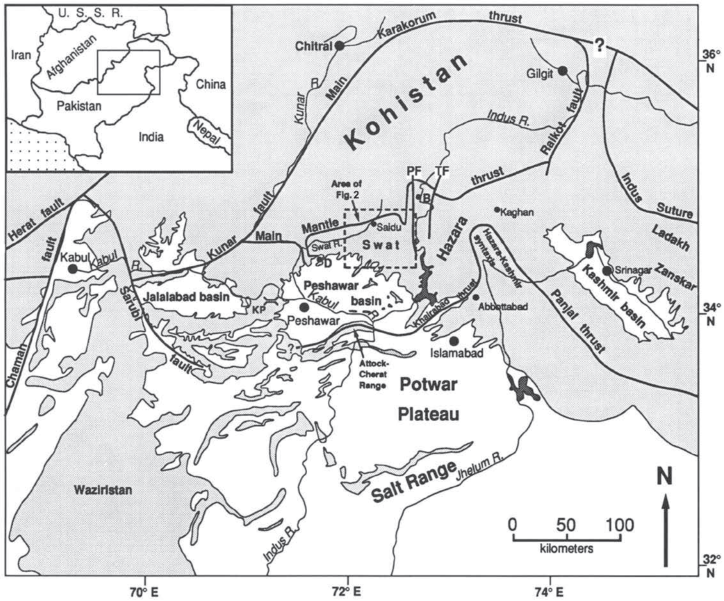
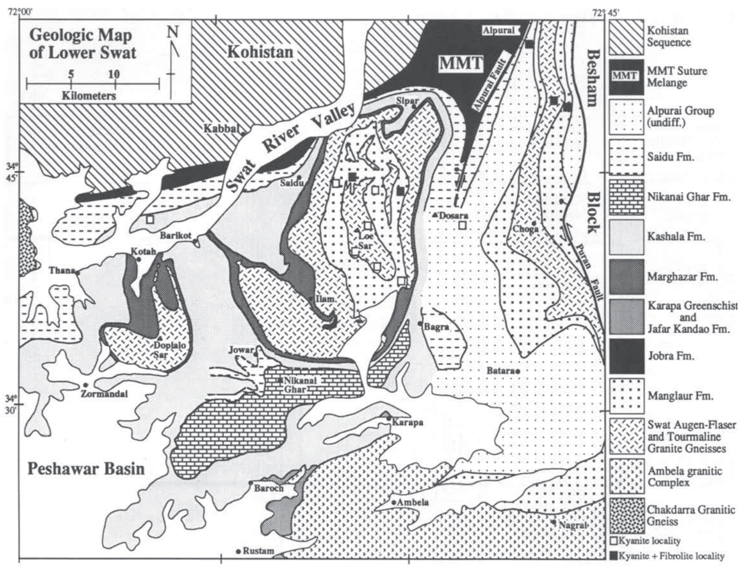


Fig. 2
Geological map of Lower Pakistan (from Dipietro et al. 1991, fig.3).



gneiss, of a tourmaline-bearing granite gneiss and associated metasediments. The metasediments include garnet-bearing micaschists, with parts of kyanite, quartzite, amphibolites, and tremolite marble[5]. This lower Swat sequence is overlaied by subcontinental, low to intermediate grade metamorphic rocks (Alpurai group, Saidu schists). Major rock types in the Alpurai groups are amphibolite schists, mica schists (partly with garnet), calcareous schists, graphitic phyllites, and calc-silicate marbles. Undeformed tourmaline-bearing granite is also attested (Fig. 2).

[5] Dipietro, Lawrence 1991.

2. Indus Suture Zone – separating 1 and 3 zones

The rock types in the suture zone itself includes blocks of low-grade metavolcanics, ultramafic rocks, sheared greenschists, serpentinite, talc-dolomite schists and blueschists[6]. For detailed description of all rock formations and their stratigraphical relationships, the paper of Kazmi et al. in 1984 was a milestone in the geological research of this area[7]. Noteworthy is the occurrence of emerald, close to Mingora[8]. Considered as a whole, the rock assemblage represents a typical, metamorphosed and sheared, ophiolitic mélange association found at convergent plate boundaries (Fig.1).

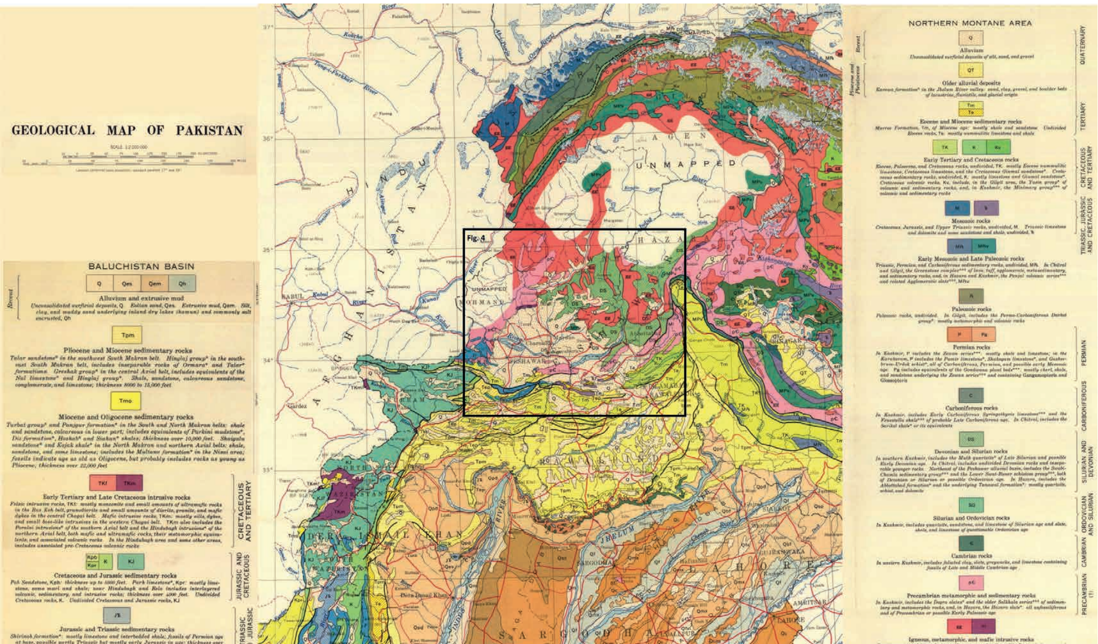
3. Kohistan island arc association in the north

Major rock types in this unit are calc-alkaline volcanics and intrusives rocks of various metamorphic grade (greenschists, amphibolites, granulites, non-metamorphic) and metasediments (Fig. 3).

Alluvial deposits cover the basement in the Swat river valley. Because of the NE-SW trend of the valley, it is expected that the deposits are fed both from the north and the south. It is important to note the complete absence of limestone outcrops in the Swat valley and surrounding areas (Fig. 3), where the main Gandharan sites are located. In these sites the presence of structures built with limestone and stucco is widespread. The nearest limestone outcrops are located in the north-western area of Islamabad (Fig. 4)[9].

Indeed, a geological overview of the Gandharan settlement in Afghanistan, in northern and southern areas of Kabul, shows the presence of different

Fig. 3
Geological map of Pakistan by Geological Survey of Pakistan and U.S. Geological Survey 1964 (detail).



[6] Tahirkheli et al., 1979a; Kazmi et al., 1984.
[7] Kazmi et al., 1984.
[8] Kazmi et al., 1986.
[9] Williams et al., 1988-90.

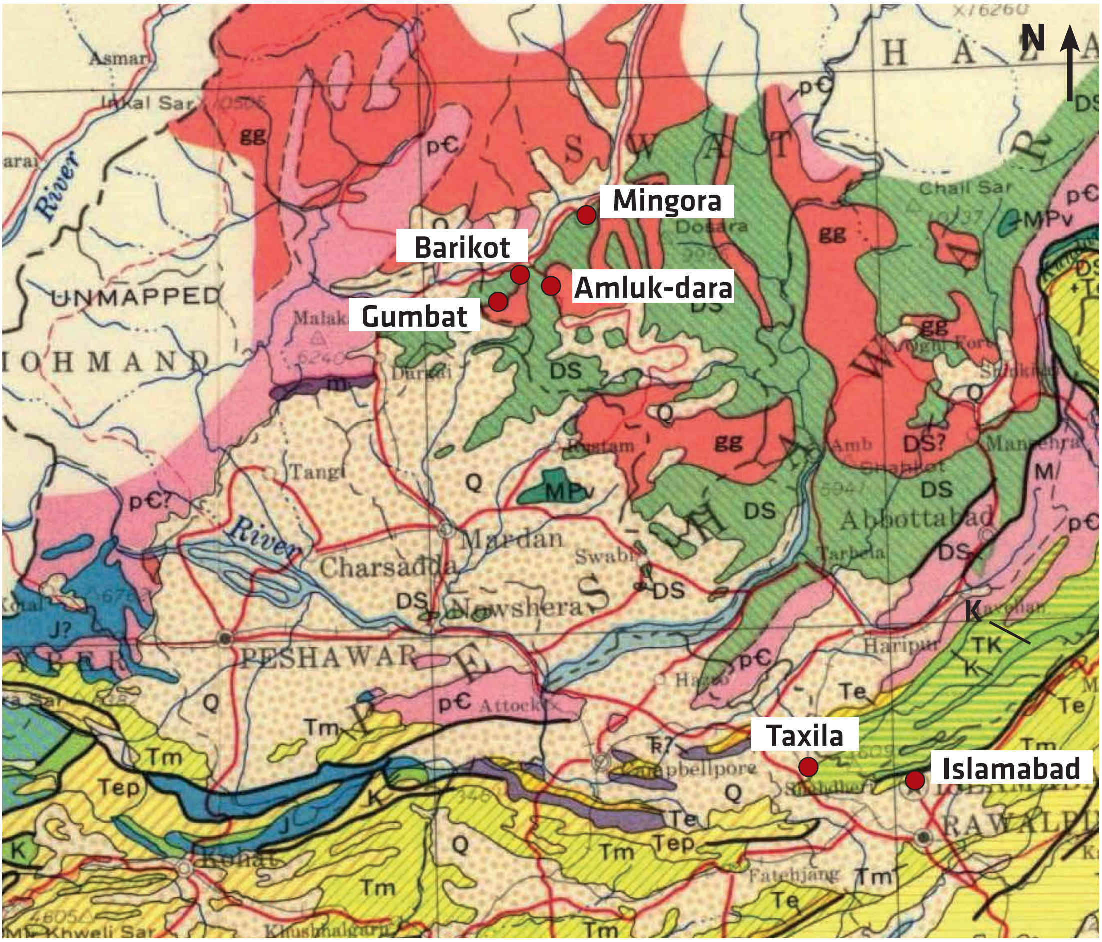


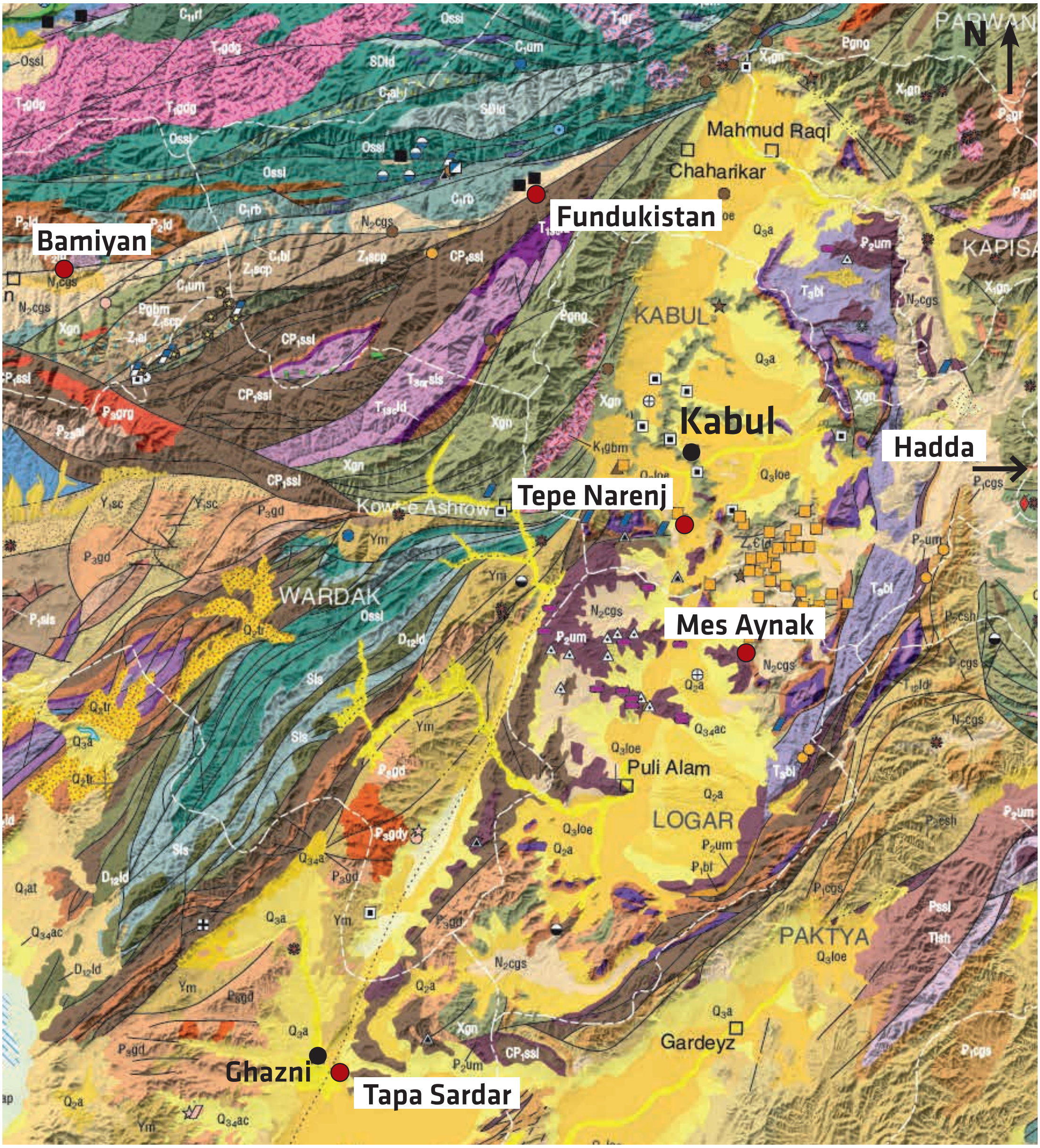
Fig. 4
Islamabad area in Geological Map of Pakistan (Detail of Fig.3) (TK = mostly Eocene nummulitic limestone, Cretaceous limestone and mostly Giumal sandstone; K = mostly limestone and Giumal sandstone).

opposite page
Fig. 5
Geologic and Mineral Resource Map of Afghanistan by U.S. Geological Survey 2006 (detail).

geological formations (Fig. 5). In particular, in the area of Ghazni (where Tapa Sardar is situated), we note the presence of Pleistocenic continental deposits, composed by alluvium and colluvium, loess deposits, conglomerate, and Triassic sandstone and siltstone.

In the Fundukistan area, north of Kabul, we note the presence of: grey schist and phyllite of the Neoproterozoic age; sandstone and siltstone of the Carboniferous-Permian age; limestone and dolomite of Late Triassic and Early Triassic; Miocenic conglomerate and sandstone; gray conglomerate and sandstone more abundant in siltstone, clay and limestone from Pliocene.

The southern area of Kabul (where Mes Aynak, Hadda and Tepe Narenj are located), shows the presence of gneiss (Paleoproterozoic), marble and quartzite Cambrian and Neoproterozoic, limestone and dolomite Middle and Early Triassic, sandstone and siltstone Late and Middle Triassic, ultramafic intrusions (dunite, peridotite and serpentinite of Eocene), Pliocenic conglomerate and sandstone, alluvial conglomerate and sandstone of



$Q_{34}ac$ **Fan alluvium and colluvium (Holocene and late Pleistocene)**—Fan alluvium and colluvium: shingly and detrital sediments, gravel, sand, clay

Q_3a **Conglomerate and sandstone (late Pleistocene)**—Alluvium: shingly and detrital sediments, gravel, sand more abundant than silt and clay

Q_3loe **Loess (late Pleistocene)**—Loess more abundant than sand, clay

Q_2a **Conglomerate and sandstone (middle Pleistocene)**—Alluvium: shingly and detrital sediments, gravel, sand more abundant than silt and clay

N_2cgs **Conglomerate and sandstone (Pliocene)**—Gray conglomerate, grit, sandstone more abundant than siltstone, clay, limestone, marl; gypsum, salt; felsic to mafic volcanic rocks

P_3ssl **Sandstone and siltstone (Oligocene)**—Sandstone, siltstone more abundant than clay, conglomerate, limestone, marl; felsic and mafic volcanic rocks

P_3gdy **Granodiorite and granosyenite (Oligocene)**—Granodiorite, alaskite, granosyenite more abundant than granite (Phase II)

P_1cgs **Conglomerate and sandstone (Paleocene)**—Conglomerate, sandstone more abundant than siltstone, limestone, shale; mafic volcanic rocks

P_1bl **Basalt lava (Paleocene)**—Basalt lava

K_1gbm **Gabbro and monzonite (Early Cretaceous)**—Gabbro, monzonite more abundant than diorite, granodiorite

Tlsh **Limestone and shale (Triassic)**—Limestone, shale more abundant than sandstone

T_3sab **Sedimentary and volcanic rocks (Late Triassic)**—Shale more abundant than phyllite, andesite to basalt (greenstone altered), limestone (Kotagai series)

T_3rl **Rhyolite (Late Triassic)**—Rhyolite lava

T_3bl **Basalt lava (Late Triassic)**—Basalt lava

$T_{13c}ld$ **Limestone and dolomite (Late Triassic (Carnian) and Early Triassic)**—Limestone, dolomite more abundant than conglomerate, chert, marl (Middle Afghanistan); limestone, sandstone, shale, conglomerate, chert, mafic volcanic rocks (Khashrud zone); limestone, dolomite (Kismaran zone)

C_1rb **Volcanic and sedimentary rocks (Early Carboniferous)**—Rhyolitic to basaltic volcanic rocks more abundant than limestone, slate, sandstone, conglomerate

SDld **Limestone and dolomite (Devonian and Silurian)**—Limestone and dolomite more abundant than schist, sandstone

Sls **Limestone (Silurian)**—Limestone, marl more abundant than slate

Ossl **Sandstone and siltstone (Ordovician)**—Sandstone and siltstone more abundant than shale (Logar and Argandab zones); limestone, sandstone, siltstone, shale (Middle Afghanistan); shale, sandstone, chert (North Afghanistan)

X_2vl **Metavolcanic lava (middle Paleoproterozoic)**—Metavolcanic lava

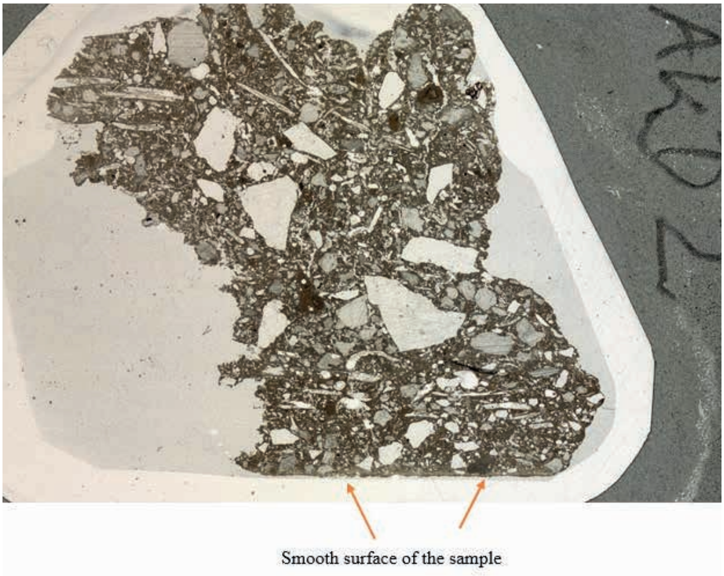
X_1gn **Gneiss (early Paleoproterozoic)**—Two-mica, biotite, biotite-amphibole, garnet-biotite, garnet-sillimanite-biotite, pyroxene-amphibole, plagioclase, and cordierite gneisses; schist, migmatite, quartzite, marble, amphibolite

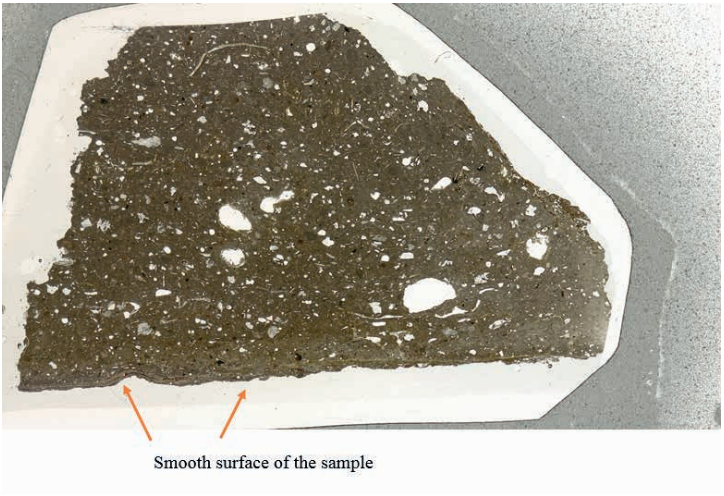
Xgn **Gneiss (Paleoproterozoic)**—Two-mica, biotite, biotite-amphibole, garnet-biotite, and plagioclase gneisses; migmatite, quartzite, marble, amphibolite

Ym **Metamorphic rocks, undifferentiated (Mesoproterozoic)**—Greenschist, gneiss, quartzite, marble, amphibolite (metavolcanic lava and sedimentary rocks)

Fig. 6
Cross section of sample AKD 2 from Amluk-dara, Pakistan (image is 37 mm across).

Fig. 7
Cross section of sample AKD 4 from Amluk-dara, Pakistan (image is 37 mm across).





the Middle and Late Pleistocene, alluvial and colluvial fan (Late Pleistocene and Holocene).
(C.R., S.P.)

Petrographic analysis of Gandharan stucco samples from Pakistan

Sample AKD 2

This sample was taken from a stucco architectonical decoration of a building in Amluk-dara archeological site.

Through a petrographic microscope analysis we noted that the large white grains are angular fragments of quartzite, whereas grey colored grains are mainly fragments of single crystals of calcite, probably originating from coarse marble (Fig. 6). The fine-grained binder matrix consists of calcite

appears brownish (note the smooth surface at the bottom of the image). Fragments of a smooth surface layer are preserved. This is mainly composed by fine-grained sheet silicates and some larger mica flakes. Small quartz grains are also present.
As the microscopic study shows, the surface layer derives from a smoothing, because the original one was rough, owing to the presence of coarse-grained components in the stucco, such as quartzite or calcite grains. It can also be expected that the original surface was somehow shiny, due to the presence of coarser mica flakes.

Sample AKD 4
This sample was taken from a stucco architectonical decoration of a building in Amluk-dara archeological site.
Through a petrographic microscope analysis we noted that intermediate size white grains are angular fragments of quartzite; the grey colored grains are mainly fragments of single crystals of calcite probably originating from coarse marble. The fine-grained binder matrix, mainly consisting of calcite, appears brownish (Fig. 7).
Fragments of a smooth surface layer are also preserved. This is mainly composed by fine-grained sheet silicates ('clay') and of some larger mica flakes. Small quartz and tourmaline grains are also present. Interesting results also came from microprobe analysis, about the presence and the amount of calcite (Fig. 8).
On the surface we observed three layers: a very thin (c. 2 μm) red brownish layer is covered by a fine-grained ochre layer, covered by a dirty layer rich of sheet silicates, mica flakes and quartz grains (and tourmaline) (Fig. 9).

Sample AKD 5
This sample was taken from a stucco architectonical decoration of a building in Amluk-dara archeological site.
Through petrographic microscope analysis we noted that the sample contains centimetric angular fragments of quartzite, granite, gneiss, garnet, and marble. In addition, mica flakes are present. The fine-grained binder matrix, mainly consisting of calcite, appears brownish (Fig. 10).
The surface layer is composed of fine-grained sheet silicates ('clay') and some larger mica flakes. Small quartz grains are also present.
This layer is separated from the stucco by a 20 μm thick sheet of fibrous calcite with fiber axis perpendicular to the surface. This layer could represent the product of a water-lime suspension painted into the stucco surface.

Sample AKD 14C
This sample was taken from a stucco architectonical polychrome decoration of a building in Amluk-dara archeological site.
Through a petrographic microscope analysis we noted that the stucco in this sample has been made using a lime mortar. The added rock fragments

Fig. 8 a, b, c
Sample AKD 4 from Amluk-dara, Pakistan (back-scattered electron image). The surface layer consists of mica flakes that are aligned parallel to the surface. Quartz and titanite grains are present as well. Spots 2 to 5 are mainly composed of calcite with smaller amount of Al and Si (see spectra 2 to 5) probably resulting from a small portion of clay minerals.

mainly consist of angular rock compounds, up to 2 mm in size. The grain size spectrum is continuous (Fig.11).

The stucco contains mm-sized angular fragments of quartzite, granite, gneiss, garnet, and marble. In addition, mica flakes are present in the fine-grained matrix. The fine-grained binder matrix, mainly consisting of calcite, appears brownish (Fig. 12).

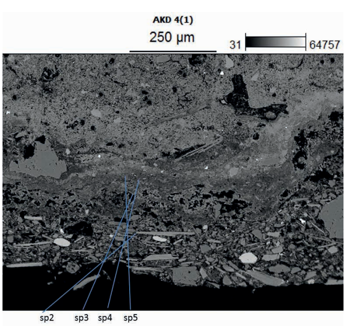
Fragments of a smooth surface layer are preserved. The layer rested on a smooth surface of the stucco material. The layer itself is composed by two sublayers: an inner one is a thin reddish layer (0.01 mm thick). This inner layer is covered by an outer layer that contains a large amount of fine-grained material (binder ?) and some larger mica flakes. The red colour results hematite (c. 2 µm) by Raman analysis (Figg. 13, 14). Partly, the surface of the sample is covered by a layer of dirt rich in fine grained sheet silicates and calcite.

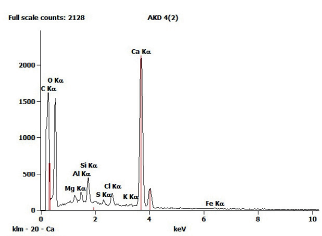
Sample AKD 13C

This sample was taken from a stucco architectonical polychrome decoration of a building in Amluk-dara archeological site.

This sample is a fragment of an architectural decoration in stucco, made using lime mortar (fig. 15). Petrographic microscope analysis and Electron Microprobe analyses highlighted that the matrix contains a great amount of calcite (Figg. 16, 17, 18).

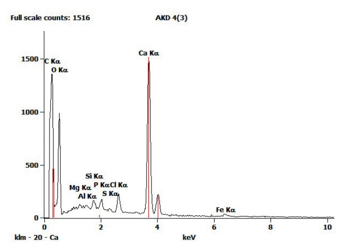
The added rock fragments mainly consist of angular rock compounds up to 7 mm in size. The grain size spectrum is continuous. Rock fragments comprise high-grade metamorphic rocks, plutonic rocks and marble. The region of provenance is probably an heterogeneous basement area. Some rock fragments of garnet micaschist are composed of a large, mm sized garnet, with attached mica rich country rock. Such aggregates are unstable in the sedimentary process. It is therefore evident that the rocks were artificially crushed to produce the lime mortar.





Acc.Voltage: 15.0 kV Take Off Angle: 40.0 deg.
Quantitative Results for: AKD 4(2)

Element	Weight %	Weight % Error	Atom %	Compnd %
O	30.965	---	51.92	---
Mg	1.02	+/- 0.08	1.13	1.69
Al	1.23	+/- 0.08	1.22	2.32
Si	3.55	+/- 0.14	3.39	7.60
S	0.80	+/- 0.08	0.67	2.00
Cl	2.40	+/- 0.17	1.81	2.40
K	0.33	+/- 0.09	0.23	0.40
Ca	57.96	+/- 0.55	38.79	81.10
Fe	1.74	+/- 0.30	0.84	2.49
Total	100.00		100.00	100.00



Acc.Voltage: 15.0 kV Take Off Angle: 40.0 deg.
Quantitative Results for: AKD 4(3)

Element	Weight %	Weight % Error	Atom %	Compnd %
O	29.805	---	51.01	---
Mg	0.67	+/- 0.10	0.75	1.11
Al	0.47	+/- 0.09	0.48	0.89
Si	1.38	+/- 0.10	1.34	2.94
P	1.75	+/- 0.11	1.55	4.01
S	0.38	+/- 0.09	0.32	0.94
Cl	4.32	+/- 0.23	3.34	4.32
Ca	57.93	+/- 0.65	39.59	81.06
Fe	3.31	+/- 0.43	1.62	4.73
Total	100.00		100.00	100.00

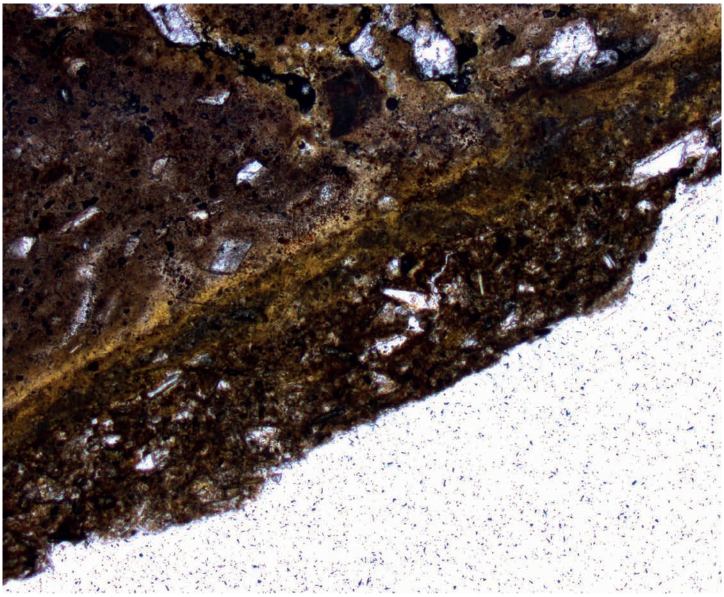


Fig. 9
Sample AKD 4 from Amluk-dara, Pakistan (image is 1.8 mm across).

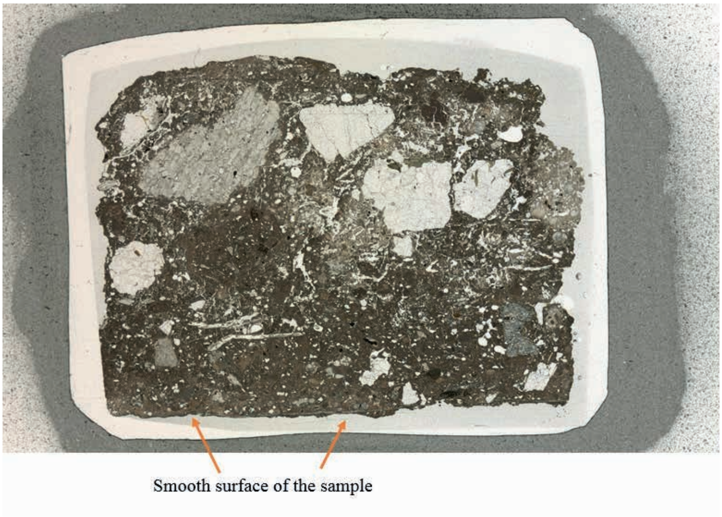


Fig. 10
Cross section of sample AKD 5 from Amluk-dara, Pakistan (image is 37 mm across). Note the smooth surface at the bottom of the image.

XRD analyses on sample AKD 14C and AKD 13C show a similar chemical composition of the stucco material, with a high presence of calcite (Fig. 19).

Sample BKG 1123 16C

This sample was taken from a stucco architectonical polychrome decoration of a building in Barikot archeological site.

The sample BKG 1123 16C consists in stucco produced from a lime mortar. The added rock fragments mainly consist of angular rock compounds up to 1 mm in size. The grain size spectrum is continuous (Fig. 20).

opposite page

Fig. 11
Sample AKD 14C of architectonical polycrome decoration from Amluk-dara, Pakistan (photo E. Loliva ©ISCR).

Fig. 12
Cross section of sample AKD 14C from Amluk-dara, Pakistan (image is 37 mm across). Note the original smooth surface on the right side of the image. Remnants of reddish color are visible there.

Fig. 13
Sample AKD 14C from Amluk-dara, Pakistan (petrograpich microscope image is 1.8 mm across-1 polar). Detail of the partly preserved smooth surface layer.

The added rock and mineral fragments mainly indicate a sedimentary origin (limestones). Only a few fragments come from some relatively high metamorphic or igneous rocks. Angular fragments mainly consist of quartz and limestone. The grain size distribution is serial with a few fragments of more than 1 mm in size. Fragments are embedded in a brownish, fine-grained matrix representing the former lime mortar. The grain size distribution of added fragments is mainly in sand fraction or finer (Fig. 21). Enlarged view of the mortar matrix mainly composed of tiny calcite crystals (Fig. 22).
The EDS analyses reveal that the mortar attached to the rock fragments mainly contains Ca, as due to the calcite content. Additional elements found in the rock fragments contain Na, K, Ca, Mg, Fe, Al, and Si. These elements can be related to various minerals such as plagioclase, K-feldspar, muscovite, biotite, and garnet (Figg. 23, 24). On the surface of the sample we recognise a few traces of very pale, faint and dilute red colour that it was not possible to analyze in this research.

Sample BKG 1123 15C

This sample was taken from a stucco architectonical polychrome decoration of a building in Barikot archeological site.
Sample BKG 1123 15C is a stucco, made using a lime mortar. The added rock fragments mainly consist of angular rock compounds up to 6 mm in size. The grain size spectrum is serial continuous. Added rock and mineral fragments mainly indicate a relatively high metamorphic origin (Fig. 25). By means of a petrographic microscope we note some irregular pore spaces (shrinking cracks ?) in the fine grained brownish matrix (Fig. 26). The sample contains rock fragments of a relatively high-grade metamorphic rock, containing minerals such as feldspar, muscovite, biotite, margarite, tourmaline, and garnet. These minerals are embedded in a fine-grained binder mainly composed of calcite.
EDS analyses of the binder indicate that, in addition to calcite, elements such as Si, Al, K and S are present. This could point to a certain fraction of clay added to the binder of the stucco mixture.

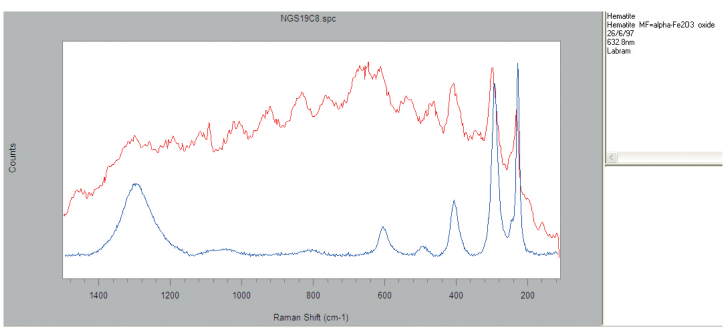


Fig. 14
Sample AKD 14C from Amluk-dara, Pakistan. Raman spectrum of the thin red layer (red) compared with a pure hematite spectrum (blue).

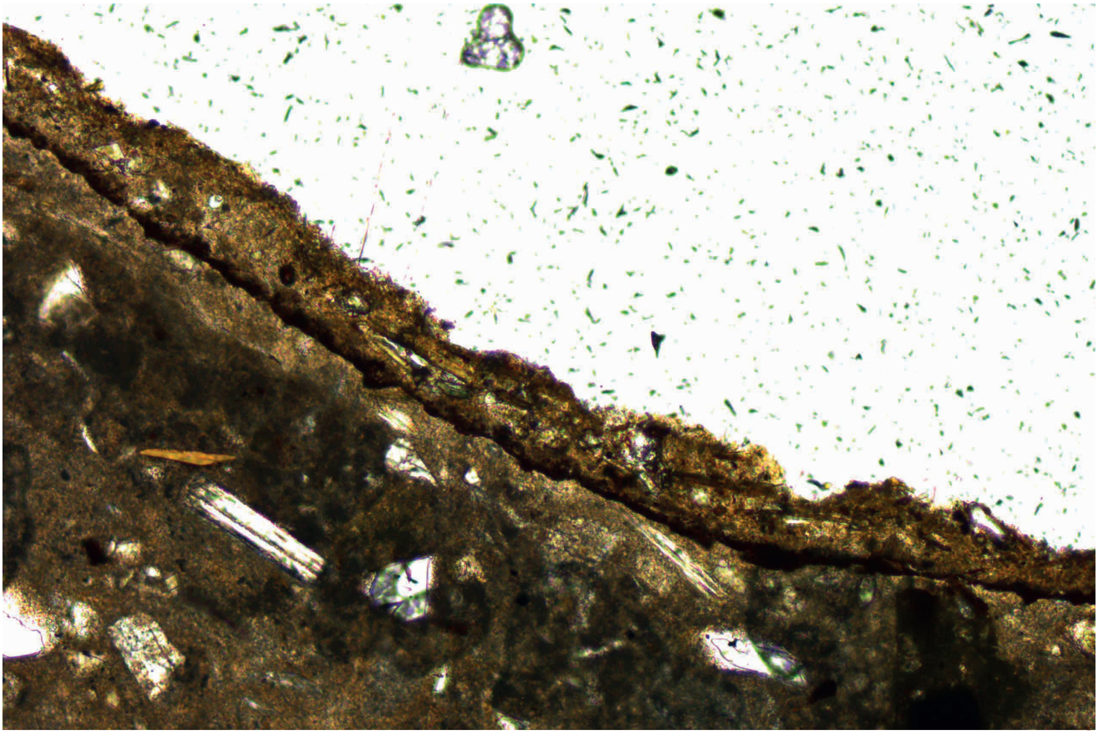
On the surface of the sample a few traces of very pale, faint and diluted red color were observed, though it was not possible to analyze them, we hope to do it in next future.

Sample GBK 17A

This sample was taken from a stucco architectonical polychrome decoration of a building in Gumbat archeological site.

By petrography analysis we highlighted that the sample GBK 17A is a stucco made using lime mortar. The added rock fragments mainly consist of limestones up to 1 mm in size and, to a lesser extent, of quartz grains. The grain size spectrum is serial continuous. The added rock and mineral fragments mainly indicate a sedimentary origin (limestones). Only a few fragments come from relatively high metamorphic or igneous rocks. A surface layer has a different composition if compared to the bulk sample. The surface layer contains a higher fraction of mica flakes (Fig. 27).

In addition, irregular pores are visible (possibly partly artificially created during preparation). The origin of a thin, curved pore is not clear (Fig. 28), fibre-like pore structures have an unknown origin (Fig. 29). The surface layer of the sample is composed by much finer grained material. The surface layer is about 0.6 mm thick (Fig. 30). By Electron microprobe analyses the bulk sample is mainly composed by fragments of limestone with a few fragments of relatively high-grade metamorphic rock (Fig. 31).



These minerals are embedded in a fine-grained binder, mainly composed of calcite. EDS analyses of the binder indicate that, in addition to the calcite, elements such as Si, Al, K and S are present. This element could point to a certain fraction of clay added to the binder. A surface layer has a different composition: it contains a high fraction of metamorphic minerals such as feldspar, muscovite, garnet, and chloritoid. Furthermore, XRD analysis pointed out that the surface layer contains much more feldspar, mica, and calcite than the bulk sample.

Sample of 'Kanjur'

This fragment of 'kanjur' rock is a sample of building material taken in an archaeological excavation in Amluk-dara site (Swat) (Fig. 32). Petrographical analysis higlighted that this sample is an organogenic limestone, mainly composed of calcite. A prominent feature of this rock is a porous microstructure (Fig. 33). Furthermore, spherical structures and pagoda-like structures characterized by a central void (marked by arrows) are visible. The rock was probably originate by a colony of calcareous porifera or calcareous algae in a marine environment (ancient Tethis sea). Such a rock may be classified as a biocalcarenite. The rock can easily be cut and shaped. In addition, the rough surface of the porous rock is decorative and may be used for ornamental purposes.

By an analysis of the microstructure of the rock we noted a cone-like structure of calcite sheets with a central channel (Fig. 34). Moreover, relatively closely packed structure of spheroidal shape are present (Fig. 35).

Fig.15
Sample AKD 13C of architectonical decoration from Amluk-dara, Pakistan (photo E. Loliva ©ISCR).

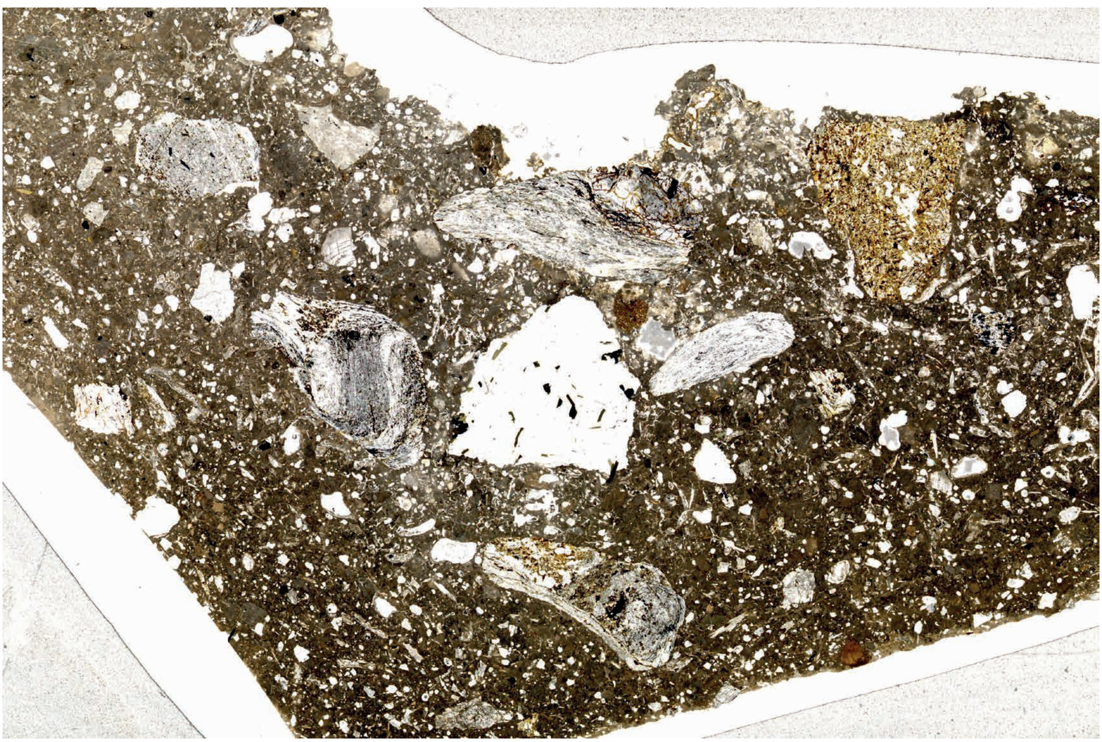


Fig.16
Thin section of sample AKD 13C from Amluk-dara, Pakistan (image is 37 mm across). Large rock fragments partly consist of micaschists that contain mm-sized garnet crystals.

Then, back scattered electron images are used to document the microstructure of the samples. Compared to transmitted light images, the resolution is higher because only the polished surface of the samples is displayed (Figg. 36, 37).
For the phase analysis, X-ray diffraction techniques were also applied. It can be confirmed that calcite is the main phase of this sample of stone. No other mineral can be detected (Fig. 38).
(T. T)

Petrographic analysis on the Gandharan clay samples from Afghanistan

Sample 1 from Tapa Sardar, Afghanistan
Sample 1 is a fragment of a relatively hard and solid fired clay artefact (Fig. 39). By a petrographic microscope analysis we noted that the color is red, with 0.5 to 1 mm sized, bright sand components, visible to the naked eye (Fig. 40). It contains sand fragments that are angular shaped minerals (feldspar, quartz) and rock fragments (phyllite, limestone, quartzite) (Fig. 41). A natural clay served as a binder. Chemical analyses of sheet silicates show that particularly biotite was oxidized during the burning process. Remnants of clay minerals are characterized by low totals and also oxidized during the burning process. The rock and mineral fragments can derive from sedimentary rocks (limestone) or from crystalline rocks (hornblende, K-feldspar, garnet). The compositions of the latter ones conform to a medium to high grade metamorphic basement.
In addition to the petrographic microscope, the microstructure of this sample was analyzed with an electron microprobe. The chemical composition of the minerals is measured with the same machine, employing wavelength dispersive techniques.

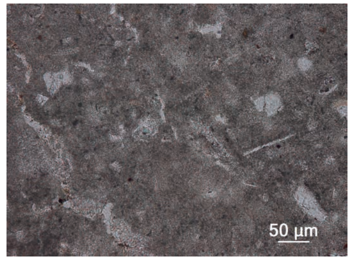


Fig.17
Sample AKD 13C from Amluk-dara, Pakistan (petrographic microscope image: 1 polar). The fine-grained brownish matrix is composed of µm-sized calcite crystals.

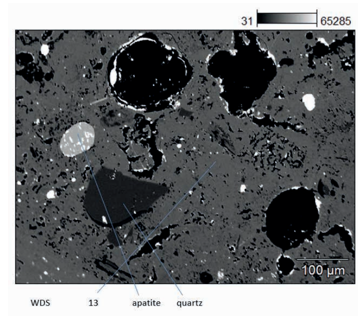


Fig. 18
Sample AKD 13C from Amluk-dara, Pakistan. Back-scattered electron image, 13 calcite: fine-grained matrix with mica flake and pore space (black).

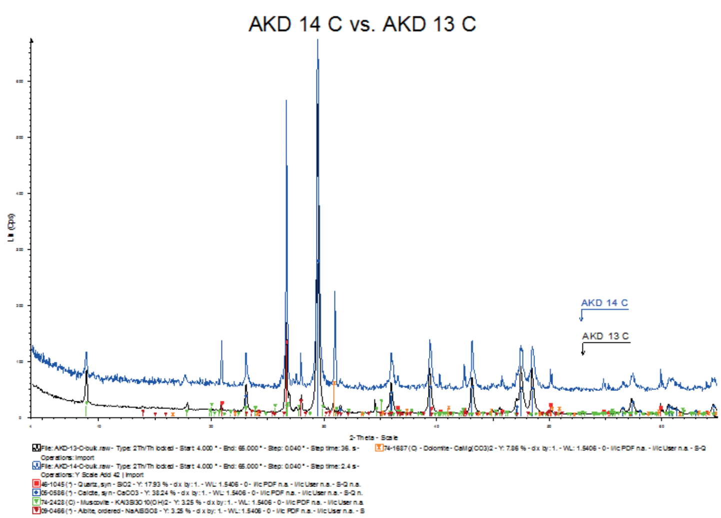
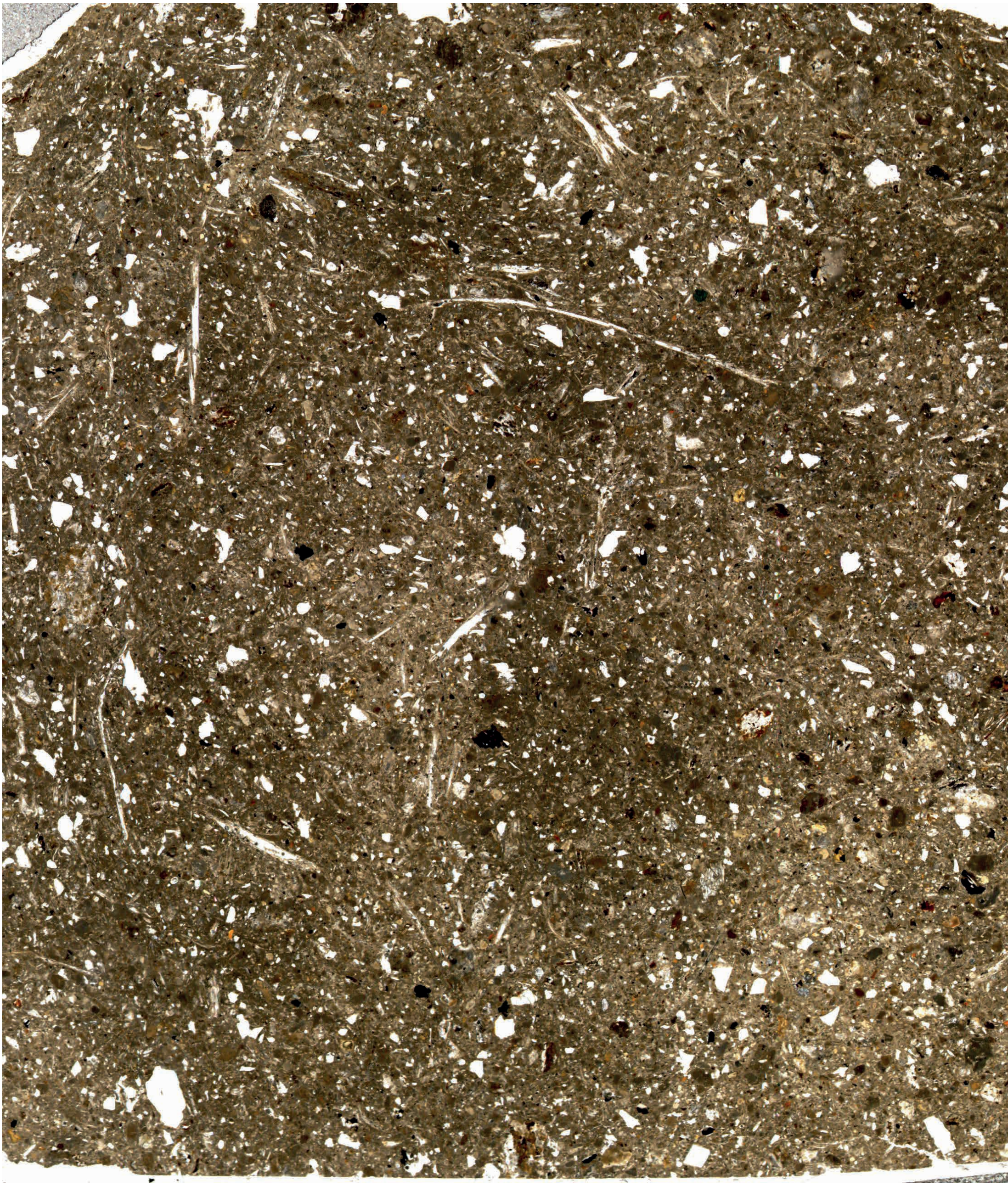


Fig. 19
X-ray diffraction (XRD) analyses on samples AKD 14C and AKD 13C from Amluk-dara, Pakistan.



The black colour on the surface of this sample was so far not found to have a chemical characterisation (Fig. 42).

Moreover, by an X-ray diffractogram analysis of this sample the following phases were recognized: quartz, plagioclase (albite), K-feldspar, hornblende, and muscovite (Fig. 43).

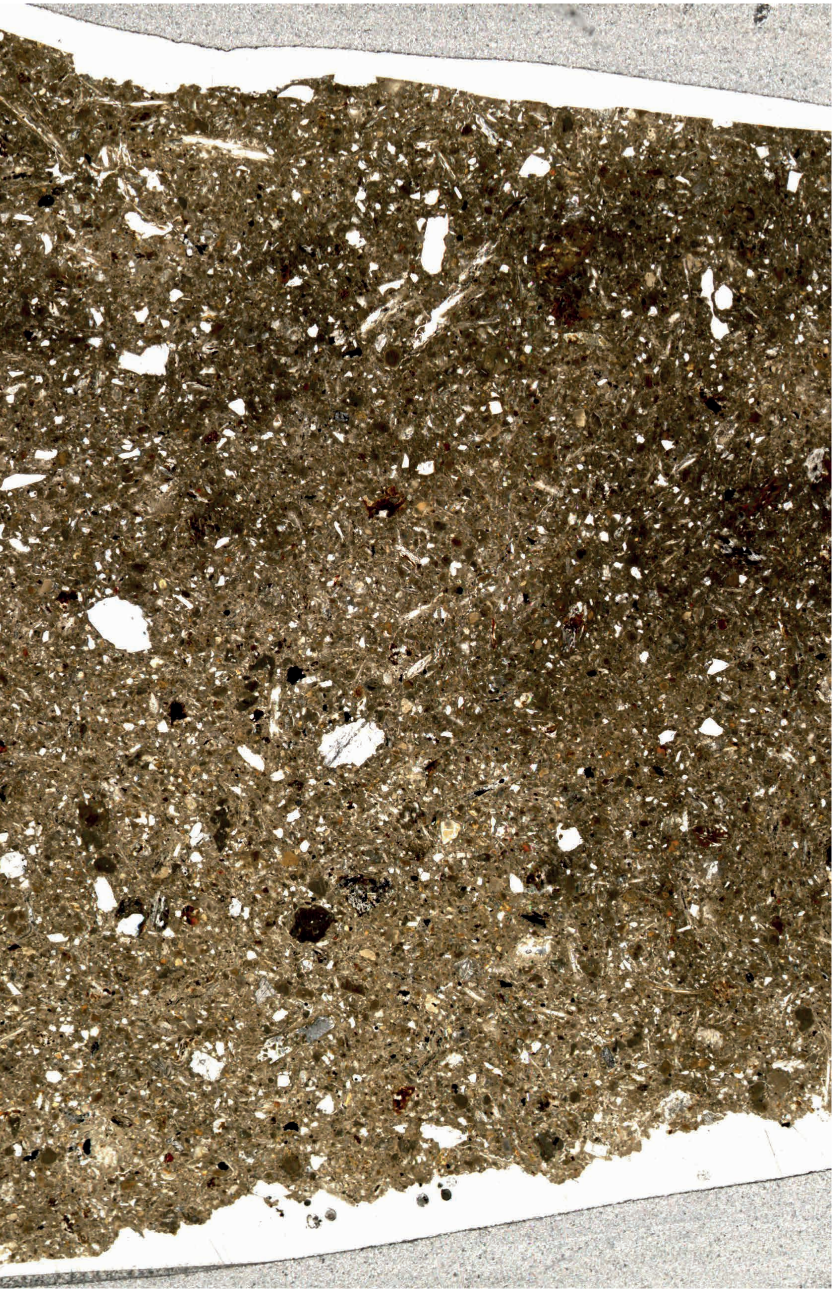
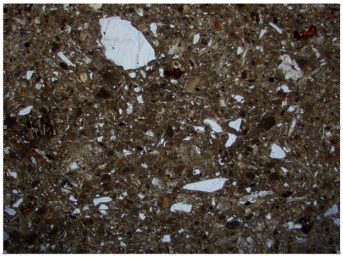
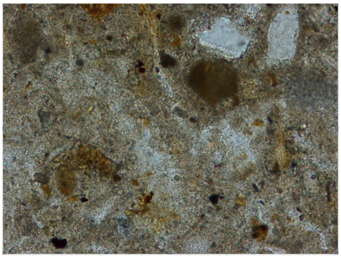


Fig. 20
Thin section of sample BKG 1123 16C from Barikot, Pakistan (image is 37 mm across).

Fig. 21
Sample BKG 1123 16C from Barikot, Pakistan (petrographic microscope image: image is 7 mm across - 1 polar).

Fig.22
Sample BKG 1123 16C from Barikot, Pakistan (petrographic microscope image: image is 0.45mm across - 1 polar).





Sample 2 from Tepe Narenj, Afghanistan

Sample 2 is a fragment of a relatively soft fired clay artefact (Fig. 44), which tends to disintegrate during the handling. The color is red with 0.5 to 1 mm size, bright sand components are visible to the naked eye. By petrographic microscope analysis we highlighted that it contains sand fragments consisting in angular shaped minerals (feldspar, quartz) and rock fragments

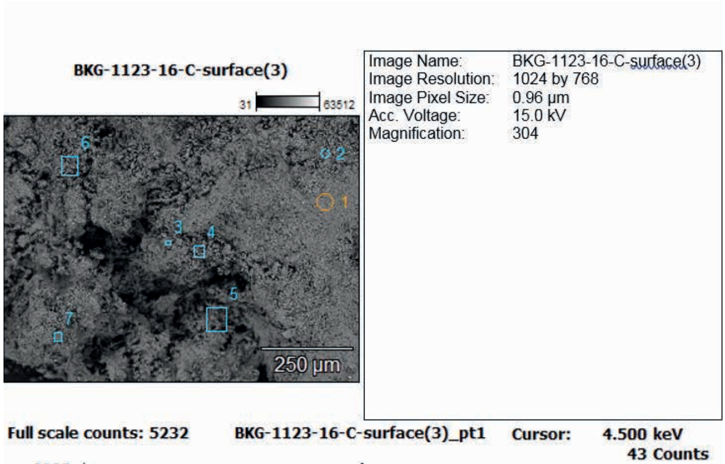


Fig. 23
Sample BKG 1123 16C from Barikot, Pakistan. Electron Microprobe analyses (WDS): surface of the sample.

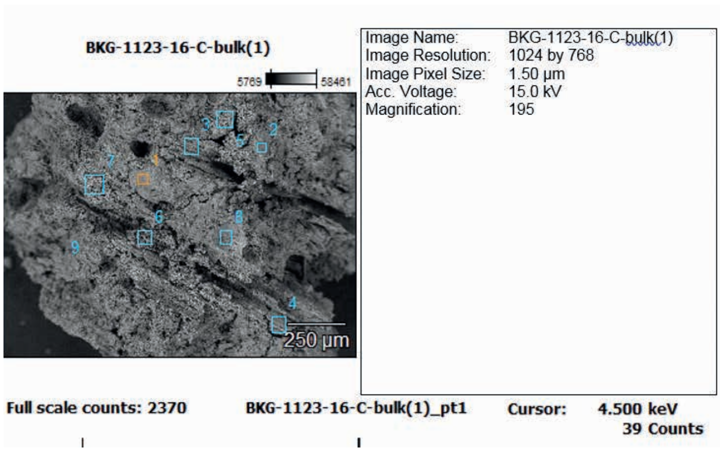


Fig. 24
Sample BKG 1123 16C from Barikot, Pakistan. Electron Microprobe analyses (WDS): bulk of the sample.

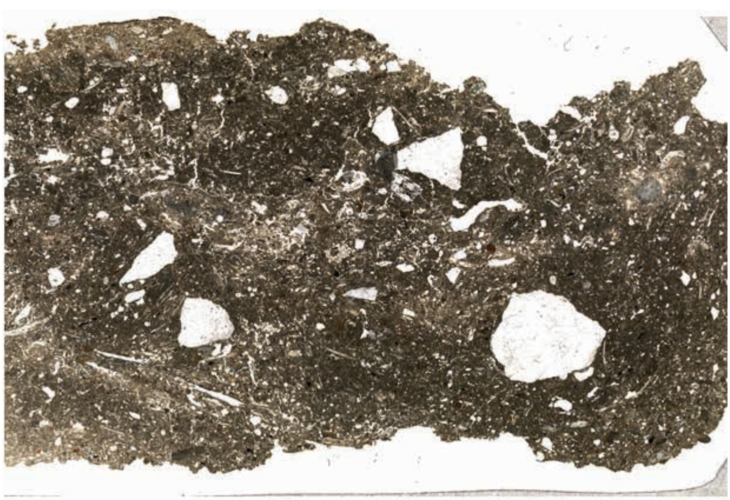


Fig. 25
Thin section of sample BKG 1123 15C from Barikot, Pakistan. Petrographic microscope image: image is 37 mm across.

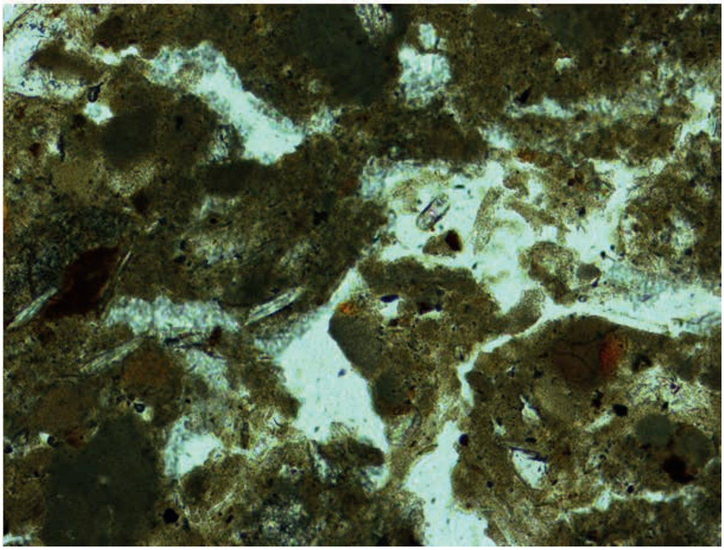
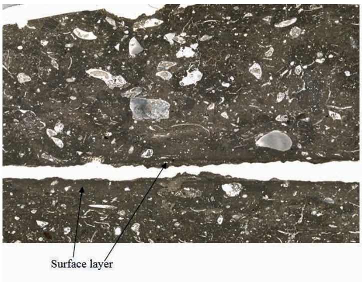


Fig. 26
Sample BKG 1123 15C from Barikot, Pakistan (image is 0.9 mm across - 1 polar). Petrographic microscope image: view of irregular pore space (shrinking cracks ?) in the fine grained brownish matrix.



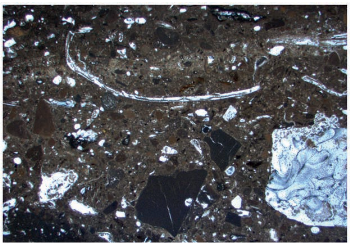
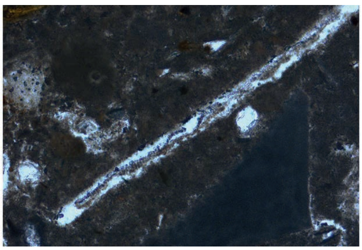


Fig. 27
Thin section of sample GBK 17A from Gumbat, Pakistan (image is 37 mm across).

Fig. 28
Sample GBK 17A from Gumbat, Pakistan (image is 7 mm across - 1 polar). Petrographic microscope image: an overview of the sample shows angular rock fragments in a fine grained matrix.



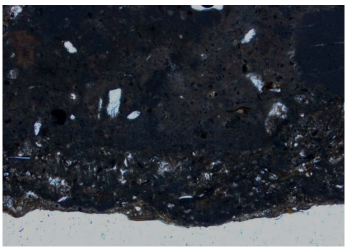
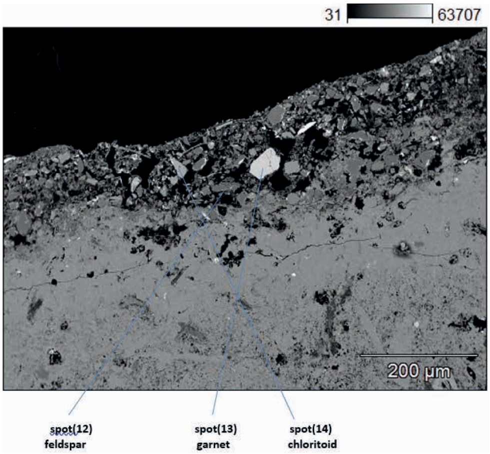


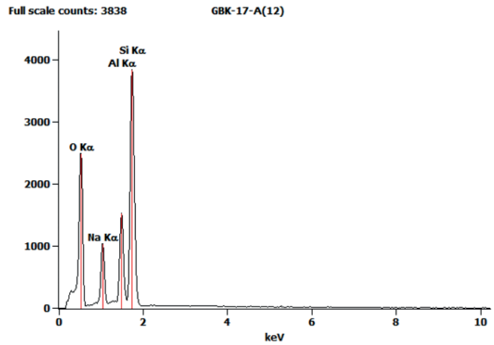
Fig. 29
Sample GBK 17A from Gumbat, Pakistan (image is 0.9 mm across -1 polar). Petrographic microscope image: a fibre-like pore structure of unknown origin and, at the bottom of the image, a fragment of limestone embedded in a matrix of fine grained calcite is visible.

Fig. 30
Sample GBK 17A from Gumbat, Pakistan (image is 1.8 mm across -1 polar). Petrographic microscope image: the surface layer (facing down) is composed by much finer grained material compared to the bulk sample.

(phyllite, limestone, quartzite). A natural clay and fine-grained calcite served as binders (Fig. 45).

The peculiarity of the sample is that relatively large single crystals of gypsum are in the sand fraction. Because gypsum is thermally not stable during a normal, high temperature burning process, it can be concluded that this mineral is either the result of a secondary process or the temperature of the burning process was very low (Fig. 46).

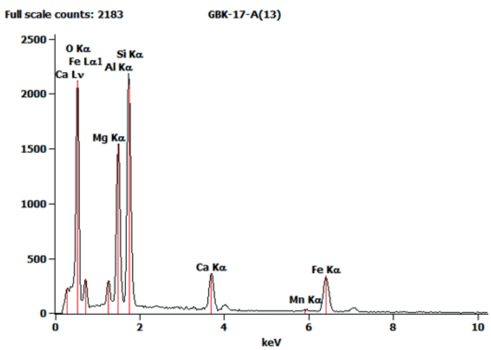




Live Time: 5.1 sec.

Acc.Voltage: 15.0 kV Take Off Angle: 40.0 deg.
Quantitative Results for: GBK-17-A(12)

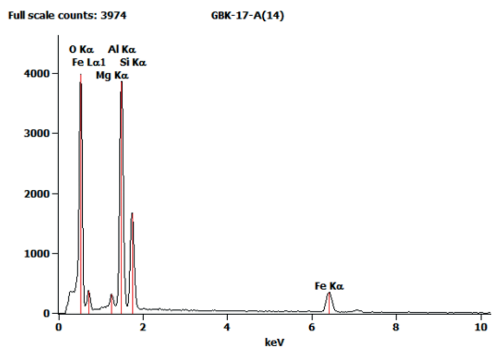
Element	Weight %	Atom %	Compnd %
O	49.00S	61.76	---
Na	8.31	7.29	11.21
Al	10.11	7.56	19.11
Si	32.57	23.39	69.68
Total	100.00	100.00	100.00



Live Time: 5.1 sec.

Acc.Voltage: 15.0 kV Take Off Angle: 40.0 deg.
Quantitative Results for: GBK-17-A(13)

Element	Weight %	Atom %	Compnd %
O	42.33S	61.81	---
Mg	1.71	1.65	2.84
Al	11.06	9.58	20.90
Si	17.44	14.51	37.32
Ca	5.93	3.46	8.30
Mn	0.86	0.37	1.11
Fe	20.65	8.64	29.52
Total	100.00	100.00	100.00



Live Time: 6.5 sec.

Acc.Voltage: 15.0 kV Take Off Angle: 40.0 deg.
Quantitative Results for: GBK-17-A(14)

Element	Weight %	Atom %	Compnd %
O	43.62S	61.74	---
Mg	1.28	1.20	2.13
Al	22.61	18.97	42.71
Si	12.28	9.90	26.27
Fe	20.21	8.19	28.89
Total	100.00	100.00	100.00

Fig. 31 a, b, c, d

Sample GBK 17A from Gumbat, Pakistan. Electron Microprobe analyses (WDS): detail of fine-grained minerals in the surface layer. Note the presence of mica, feldspar, and garnet. Spot 12, 13 and 14: EDS analysis of the fine-grained matrix.

Chemical analyses of sheet silicates show that most of them were altered during the burning process. The analyzed compositions are particularly rich in Ca, in contrast with the naturally occurring ones. The rock and mineral fragments could derive from sedimentary rocks (limestone) or from crystalline rocks (hornblende, K-feldspar, garnet). The composition of the latter ones, conform to a medium to high grade metamorphic basement (Fig. 47). The composition of hornblende in this sample is different from the one in the sample from Tapa Sardar, indicating a different region of provenance of the sand.

Fig. 32
Sample of 'kanjur' rock (photo T. Theye).

By an X-ray diffractogram analysis the following phases can be recognized: quartz, plagioclase (albite), K-feldspar, hornblende, muscovite, calcite, and gypsum (Fig. 48)
(T.T., C.R.)

Conclusions

The Gandharan archaeological sites are mostly located in the Indus Suture Zone (see above, n.2) and in the lower Swat (see above n.1). In a recent past, scholars observed the use of local different type of schists to build buildings and sacred artworks[10]. In this new research we highlighted the use of limestone for stucco artefacts and architectural decorations. This limestone is not a local rock in Swat (see above) but its main, extended and closer outcrops are located in the mountains northwest of Islamabad. Indeed, through specific analyses carried out by our team, the compatibility of these outcrops with the rocks used for stucco artefacts and stucco decorations of buildings was observed[11]. This stucco was made by a mixture of different kinds of local crushed rocks (i.e. schists and granites).

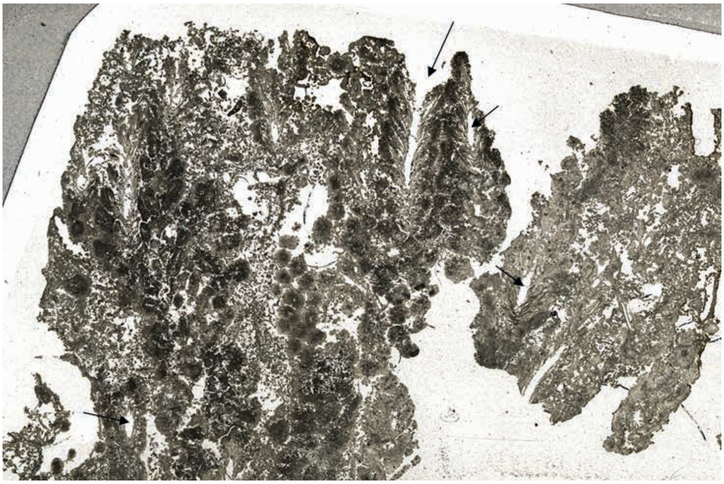


Fig. 33
Polished thin section of 'kanjur' rock, overview: a prominent feature of this rock is a porous microstructure (white areas in the image) (image is 3.5 cm across).

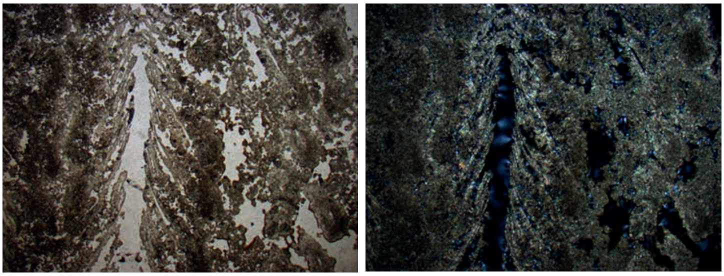


Fig. 34
Sample of 'kanjur' rock, analysis of the microstructure: cone-like structure of calcite sheets with a central channel. Petrographic microscope image: left image: 1 polar; right image + polars (images are 6.8 mm across).

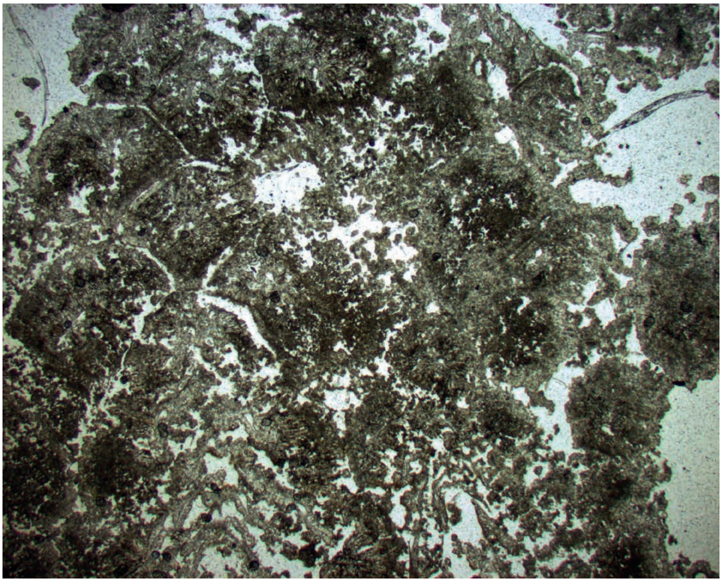
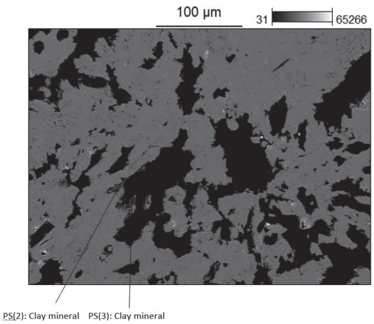
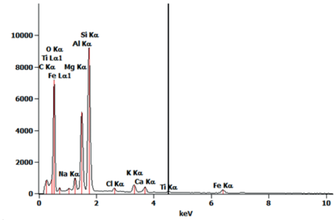


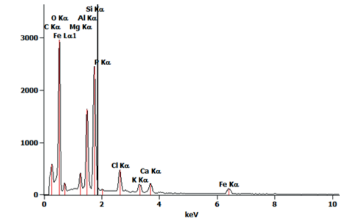
Fig. 35
Sample of 'kanjur' rock, analysis of the microstructure: relatively closely packed structure of spheroidal shapes (petrographic microscope image is 6.8 mm across – 1 polar).





Acc.Voltage: 15.0 kV, Take Off Angle: 40.0 deg.
Quantitative Results for: Sample1-C1(2)

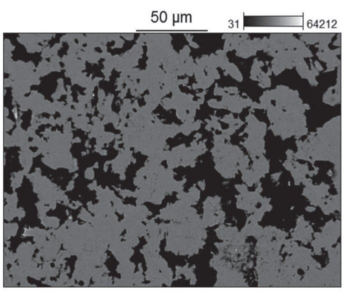
Element	Weight %	Atom %	Atom % Error	Comond %
O	46.805	62.42	+/- 0.70	---
Na	0.45	0.41	+/- 0.04	0.60
Mg	1.97	1.73	+/- 0.06	3.26
Al	12.16	9.62	+/- 0.09	22.99
Si	26.55	20.17	+/- 0.11	56.81
Cl	0.97	0.58	+/- 0.04	0.97
K	2.76	1.51	+/- 0.03	3.32
Ca	2.16	1.15	+/- 0.03	3.02
Ti	0.83	0.37	+/- 0.02	1.38
Fe	5.35	2.05	+/- 0.10	7.65
Total	100.00	100.00		100.00

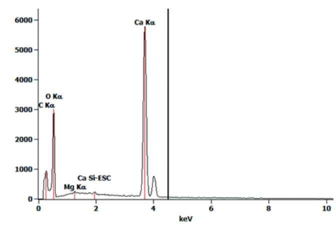


Acc.Voltage: 15.0 kV, Take Off Angle: 40.0 deg.
Quantitative Results for: Sample1-C1(3)

Element	Weight %	Atom %	Atom % Error	Comond %
O	43.285	60.07	+/- 0.67	---
Mg	2.24	2.05	+/- 0.11	3.72
Al	11.70	9.63	+/- 0.15	22.11
Si	22.33	17.66	+/- 0.18	47.78
P	0.32	0.23	+/- 0.04	0.72
Cl	5.39	3.38	+/- 0.10	5.39
K	2.98	1.69	+/- 0.05	3.59
Ca	3.96	2.20	+/- 0.06	5.55
Fe	7.80	3.10	+/- 0.22	11.15
Total	100.00	100.00		100.00

Fig. 36 a, b, c
Sample of 'kanjur' rock. Back-scattered electron image. Impurities in the calcite structure consisting of tiny particles of clay mineralswhich appears darker than calcite. EDS spectrum and elemental composition of clay fragments. Chlorine may be contributed by the resin (araldite).





Acc.Voltage: 15.0 kV, Take Off Angle: 40.0 deg.
Quantitative Results for: Sample1-D1(3)

Element	Weight %	Atom %	Atom % Error	Comond %
O	28.585	50.00	+/- 0.49	---
Mg	0.26	0.30	+/- 0.05	0.43
Ca	71.16	49.70	+/- 0.30	99.57
Total	100.00	100.00		100.00

Fig. 37 a, b
Sample of 'kanjur' rock. Back-scattered electron image. Detail of the core of the spheroidal particle: most of the calcite shows euhedral crystal faces. EDS spectrum and elemental composition of calcite: note the presence of small amount of Mg in calcite.

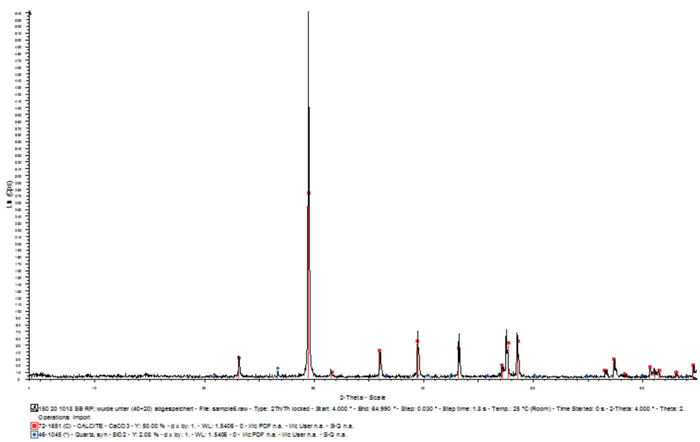


Fig. 38
Sample of 'kanjur' rock. X-ray diffraction (XRD) analysis.

We therefore suppose that the limestone was transported from these sites to Swat mainly by road paths and perhaps through water ways.

The study of the geological outcrops shows a great difference between the area of Gandharan sites in Pakistan and the Afghanistan ones. In Pakistan we mainly note the presence of metamorphic rocks, whereas in Afghanistan, of limestone, sandstone and siltstone, attributed to different ages, are the most abundant geological formation. In the latter Gandharan sites in Afghanistan stucco and clay artworks are frequently found, as these materials are easily available on site.

(C.R., S.P.)

[10] Di Florio et al. 1993, pp. 357-372; Faccenna et al. 1993, pp. 257-270; Olivieri 2006, pp. 137-156.

[11] See Olivieri, in this issue.

Fig. 39
Sample 1 of clay artefact from Tapa Sardar, Afghanistan. Close-up of sample. Bright, mm sized sand fragments embedded in a reddish matrix are visible (photo T. Theye).

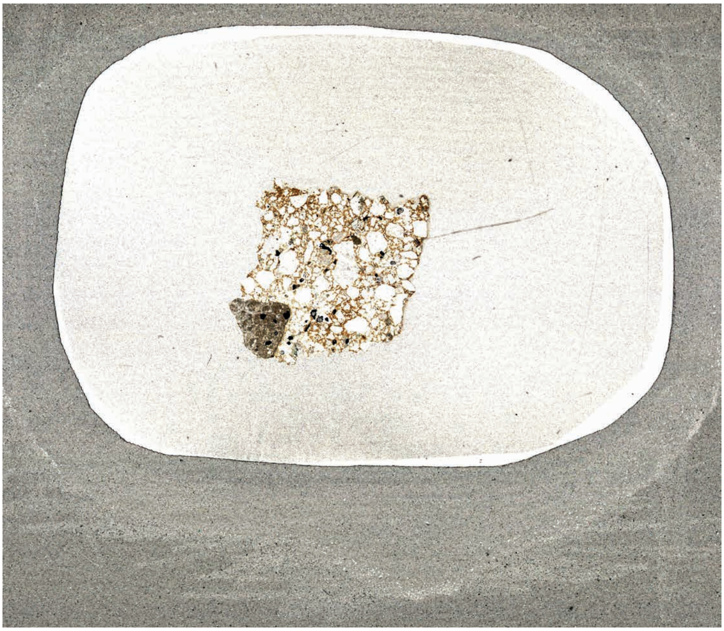


Fig. 40
Sample 1 of clay artefact from Tapa Sardar, Afghanistan. Thin section of sample: the glass slide is 48 mm across, and the fragment is 10 mm across.

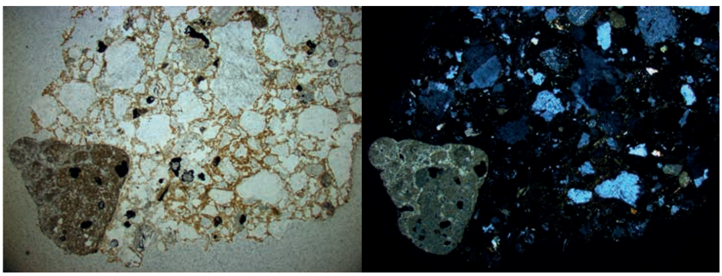


Fig. 41
Sample 1 of clay artefact from Tapa Sardar, Afghanistan. Microscopic overview of the sample. The colorless grains are quartz and feldspar. The large fragment in the lower left is a biogenic limestone. Note the reddish/brownish pigments on the grain boundaries of the sand components. These pigments, responsible for the macroscopic red color, consist of oxidized iron bearing clay particles (petrographic microscope image: left image: 1 polar; right images + polars; image is 6.8 mm across).

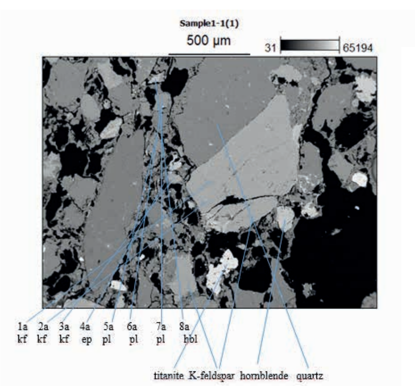


Fig. 42
Sample 1 of clay artefact from Tapa Sardar, Afghanistan. Electron Microprobe analyses.

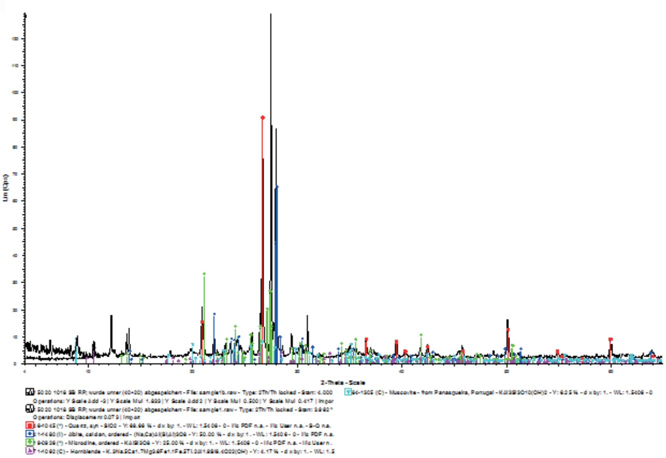
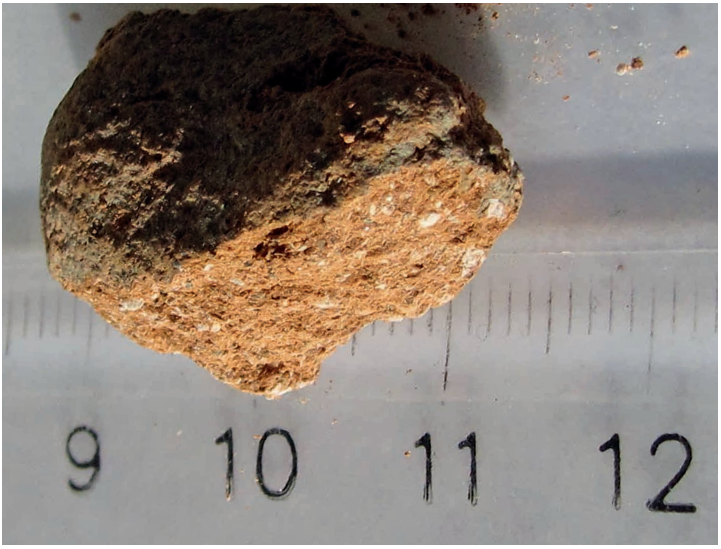
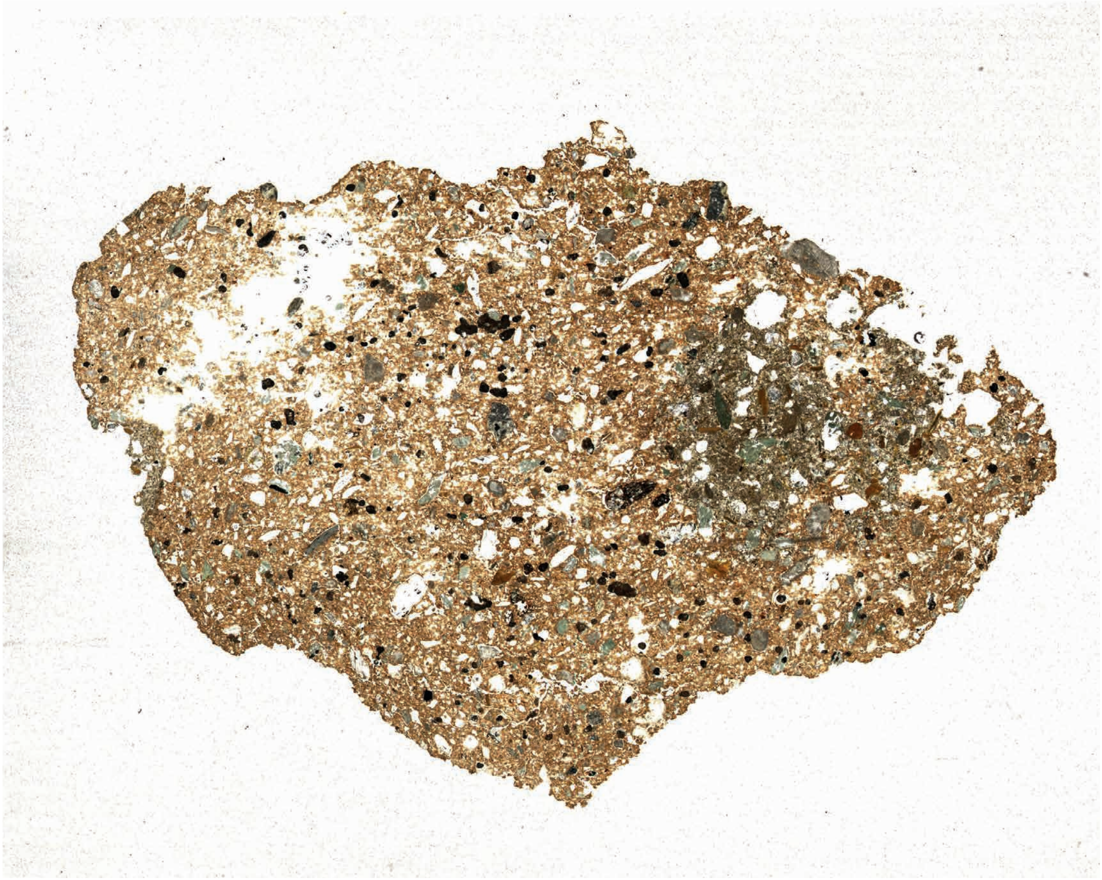


Fig. 43
Sample 1 of clay artefact from Tapa Sardar, Afghanistan. X-ray diffraction (XRD) analysis.

Fig. 44
Sample 2 of clay artefact from Tepe Narenj, Afghanistan. This sample is characterized by a sand fraction in which the grains are poorly attached to each other. Loose sand just from normal handling (photo T. Theye).

Fig. 45
Sample 2 of clay artefact from Tepe Narenj, Afghanistan: thin section of sample. The width of the image is 48 mm. A brownish component forms the majority of the brick. Note the presence of sand grains embedded in a fine-grained reddish matrix. Small grains of white matter is also present consisting of gypsum, as verified by Raman spectroscopy and electron microprobe.





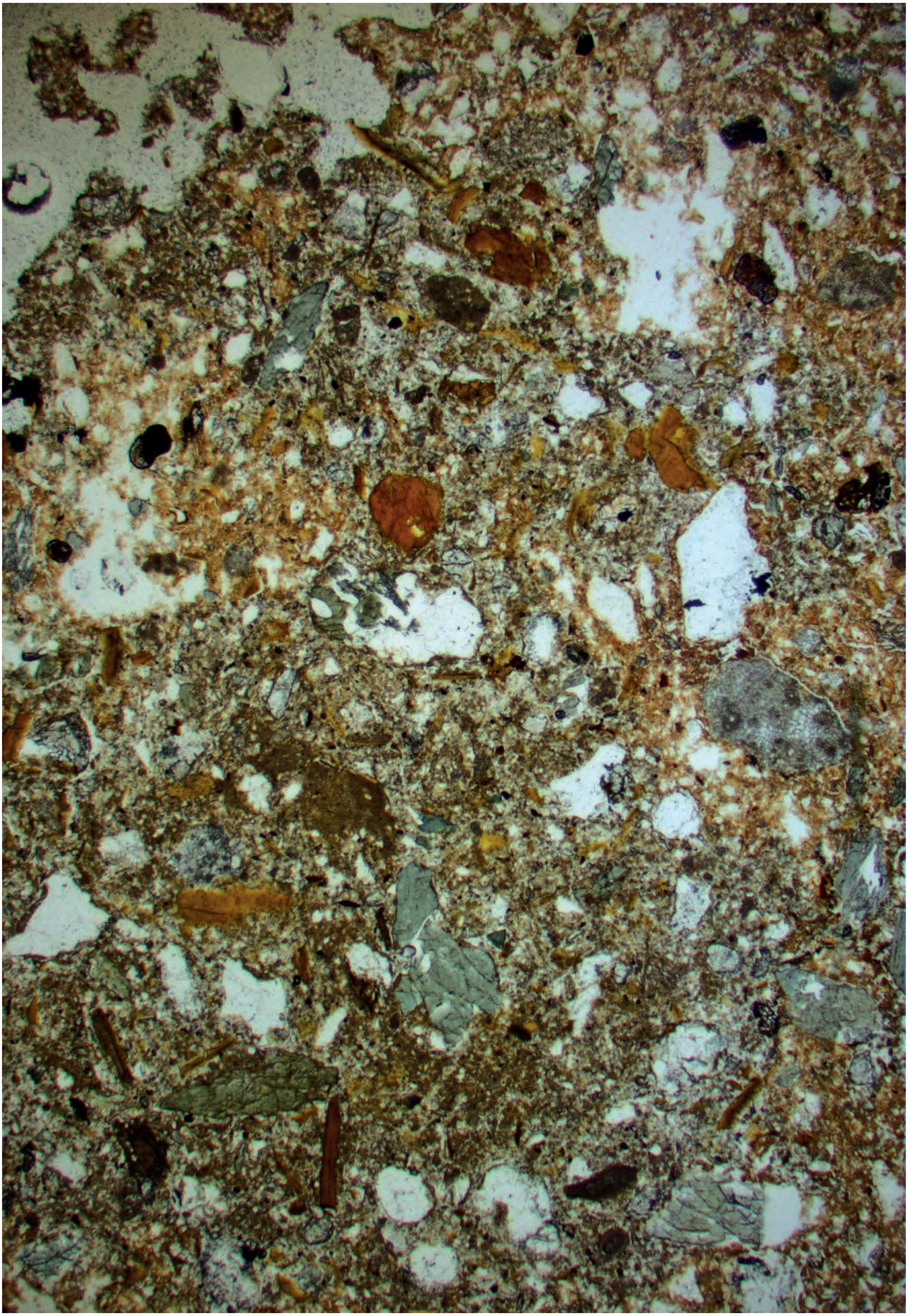


Fig. 47 a, b
Sample 2 of clay artefact from Tepe Narenj, Afghanistan: back-scattered electron image, detail of the microstructure of sample. Pores appear in black. The chemical composition of the binding clay fraction is shown in spectrum no. AAA(3) that shows higher concentrations of the elements O, Si, Al, Mg, Fe, Ca, and K typical for clay minerals. Chlorine is a component of the resin.

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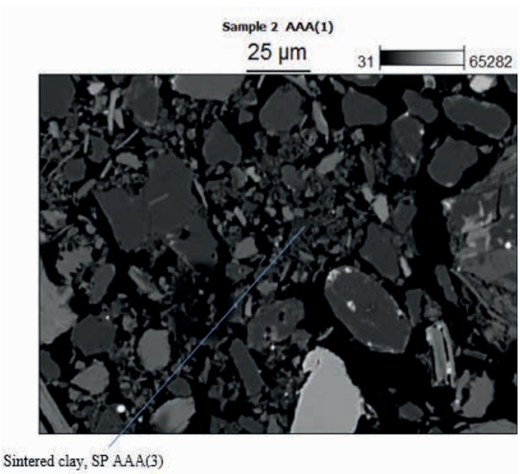

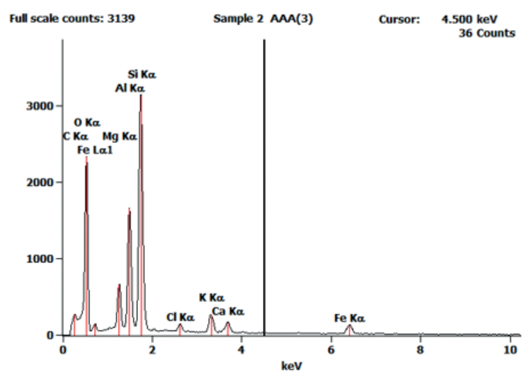

Live Time: 6.6 sec.

Acc.Voltage: 15.0 kV Take Off Angle: 40.0 deg.

Quantitative Results for: Sample 2, AAA(1)

Element	Weight %	Atom %	Atom % Error	Compnd %
O	45.55S	61.66	+/- 0.70	---
Mg	4.03	3.59	+/- 0.10	6.69
Al	10.73	8.61	+/- 0.14	20.27
Si	24.90	19.20	+/- 0.16	53.27
Cl	1.16	0.71	+/- 0.03	1.16
K	3.56	1.97	+/- 0.05	4.29
Ca	2.30	1.24	+/- 0.04	3.22
Fe	7.76	3.01	+/- 0.18	11.10
Total	100.00	100.00		100.00

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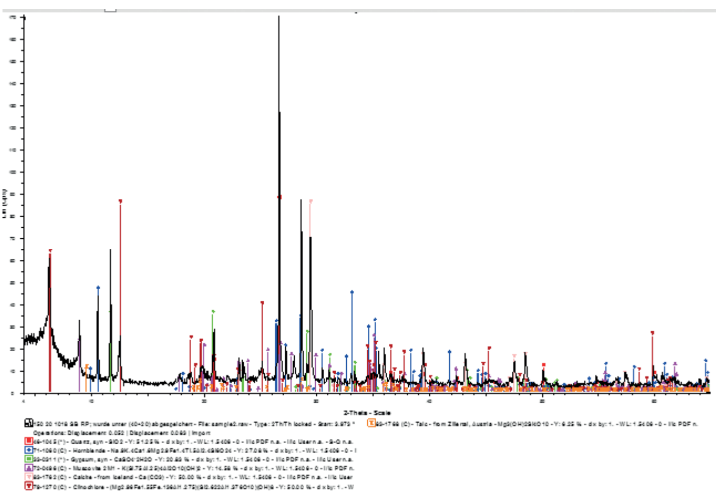

Fig. 48
Sample 2 of clay artefact from Tepe Narenj, Afghanistan: X-ray diffractogram of sample. The following phases can be recognized: quartz, plagioclase (albite), K-feldspar, hornblende, muscovite, calcite, and gypsum.

Polychromy and gilding in the Gandharan sculptures from Pakistan and Afghanistan: samplings from Museum Guimet in Paris, Civic Archaeological Museum of Milan and Museum of Oriental Art of Turin

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MIBAC, Istituto Superiore per la Conservazione ed il Restauro

Carlo Rosa
Sigea Lazio, Istituto Italiano di Paleontologia Umana

opposite page

Stucco Buddha head from Milan Museum (A 987.03.1, sample 32): the red colour is clearly visible (photo S.Pannuzi).

Abstract
This paper will discuss the scientific results of a recent sampling of the polychrome and gilded stone, stucco and clay sculptures of Gandharan art not yet published. Four years ago, we had the opportunity to begin an articulated research project focused on the Gandharan polychrome stone and stucco sculptures, and in the last two years, thanks to a very limited grant, offered by the Italian Government to the Istituto Superiore per la Conservazione ed il Restauro (ISCR), we had the opportunity to develop a new research. This allowed us to investigate some important artefacts displayed in these Museums: the Archaeological Museum of Milan, the Museum of Oriental Art of Turin, the Museum Guimet in Paris. Moreover, we had the opportunity to take some archaeological samples from the new excavations of the Italian Archaeological Mission in Pakistan and the Italian Archaeological Mission in Afghanistan.
In this new research we analysed the artistic technique of painting and gilding on sculptures of Gandharan art made in different materials (stone, stucco and clay).
The results discussed in this paper comes from a notable number of chemical analyses (optical stero-microscope, SEM-EDS, micro-FTIR, micro-XRD and micro-Raman).

Keywords
polychromy, gilding, stucco arteworks, stone arteworks, clay arteworks, chemical analyses, Gandharan art.

Materials, polychromies and gildings of the Gandhara sculptures and the results of recent scientific investigations

This paper will discuss the scientific results of a recent sampling of the polychrome and gilded stone, stucco and clay sculptures of Gandharan art not yet published. Four years ago, we had the opportunity to begin an articulated research project focused on the Gandharan polychrome stone and stucco sculptures, in collaboration with the Museum of Oriental Art "Giuseppe Tucci" of Rome (ex MNAO, now merged into the *Museo delle Civiltà*) and the Italian Archaeological Mission in Pakistan (MAI), now led by Luca M. Olivieri. In the last two years, thanks to a very limited grant offered by the Italian Government to the Istituto Superiore per la Conservazione ed il Restauro (ISCR), we had the opportunity to develop this research. Our study aimed to clarify some issues, already highlighted in the preliminary

RA 2 | 2019, pagg. 36 | 77
ISSN 1724-9686 (print) | ISSN 2465-2377 (online)

opposite page
Fig. 1a, 1b
Elephant schist statue from Museum Guimet. SEM image of cross section of sample 1 with a thick ground layer on the surface.

research. We had the chance to cooperate with several European Museums of Oriental Art: the Museum Guimet in Paris, the Civic Archaeological Museum of Milan (Oriental Art Collection) and the Museum of Oriental Art of Turin (MAO).

This new research allowed to investigate on some important artefacts displayed in these Museums: the Archaeological Museum of Milan has an interesting collection acquired on antique market and the Museum of Oriental Art of Turin exhibits a part of the artefacts discovered during the excavations by Domenico Faccenna, chief of the Italian Archaeological Mission in Pakistan from the Fifties to the Nineties.

Moreover, we had the opportunity to take some samples from the famous statues with polychromy and gilding from the Gandharan sites in Pakisthan and Afghanistan preserved in Museum Guimet in Paris.

Thanks to this funding, we kept cooperating with the Italian Archaeological Mission in Pakistan and we increased the number of samples of different materials, including a series of plaster samples, some of which with polychromy, found in the recent archaeological excavations of the Italian Mission (2014-15)[1].

Recently, we have also begun to cooperate with Italian Archaeological Mission in Afghanistan, led by Anna Filigenzi, and we had the possibility to analyze some samples from Tapa Sardar, near Gazhni, and Tepe Narenj, near Kabul, two important Buddhist sites of the Gandharan culture.

In the frame of these studies, it has been fundamental to cooperate for the scientific investigations, especially about the binders, with Ilaria Bonaduce and Anna Lluveras Tenorio of Chemical Department team of Pisa University, led by M. Perla Colombini.

The first phase of our study (2014-2015) was focused on technological and conservative issues, concerning, in particular, the polychrome stone sculptures of the Rome Museum collection (ex MNAO)[2]. Only a few petrographic studies were carried in the past on the Gandharan stone and stucco sculptures and on the composition of the stucco; the polychromy and the gilding layers on these artworks were not analysed[3].

In the past geological studies on Gandharan metamorphic schists were scarcely supported by specialized geological mappings[4]. Lithological-petrographic studies were carried out in order to find out if the use of different stones was owed to the proximity of the caves or to political-economic reasons, that changed according to different periods, as in the site of Taxila in Pakistan[5]; but simply, the use of different stones could be depended on the different types and employment of the artefacts.

In our first research, carried out in ISCR in cooperation with Roma 3 University on the samples taken from Rome Museum (ex MNAO), information on the lithotypes on record was considered in the perspective of the local outcrops and the general archaeological and cultural contexts[6].

Petrographic and mineralogical analyses of the samples [carried out with Scanning Electronic Microscope/Energy Dispersive X-Ray Analysis (SEM-EDS) and with X-rays diffraction (XRD)] verified that the main lithotype of

[1] The samples were allowed by MAI in Pakistan/ACT-Field School Project (Cooperazione Italiana allo Sviluppo, UTL Pakistan) with export licence of Directorate of Archaeology and Museums Government of Khyber Pakhtunkhwa/Department of Archaeology and Museums Government of Pakistan. We thank L.M.Olivieri for this.

[2] Pannuzi 2015; Talarico 2015; Pannuzi, Talarico 2018.

[3] About bibliography on this theme, see: Pannuzi 2015, pp.10 and 14, footnotes 8-10). In the latter researches, little attention was given to the polchromy and the gilding of the artworks, although Alexander Cunningham and Alfred Foucher, famous explorers of the late nineteenth century, had already commented on the presence of gilded and polychrome sculptures (Foucher, 1918; Faccenna, 1980, pp. 719-720, note 6).

[4] See for these themes: Rosa, Theye, Pannuzi in this issue.

[5] A search for the schists caves and the technology of architectural stone carving was organized in 1990 by Domenico Faccenna, together with Peter Rockwell (Rockwell, 2006, pp.157-159) and the University of Bari (see e.g.: Di Florio et al., 1993, pp. 357-372; Faccenna et al., 1993, pp. 257-270; Olivieri, 2006, pp. 137-156.
As regards the use of lithotypes in different historical periods in Taxila site: Marshall, 1951, pp. 476-481 and 671-699.

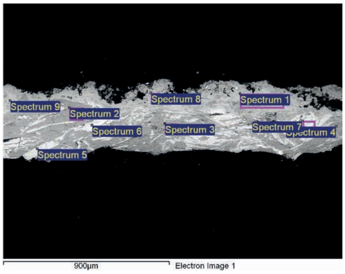
Swat is not a schist, as previously stated, but *serpentinite*. Other less common lithotypes were found such as *talcoschist* and *serpentinoschist*[7]. In the future we hope to implement geochemical studies: we will compare these samples with a stone sampling to be carried out in Swat schist mines. Our aim will be to identify — if possible — the provenance of the stone used for the sculptures in the Gandharan region of Pakistan and whether some stones were preferred because of the vicinity of the quarry to the religious sites or because of the different carving methods.

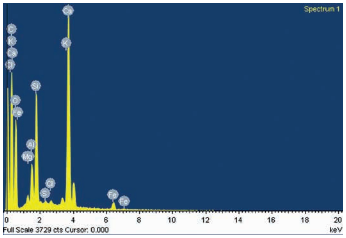
We are planning to carry on this research about the stone of the Gandharan artefacts, adding other samples taken from reliefs of the Milan Museum, that were acquired through the antique trade. In this latter case, the comparison with already acquired results, could help to establish a geological origin of these stones. Through this comparison we might also understand if an artefact is original or not.

During our new research we decided to extend our investigations also to stucco and clay polychrome and gilded artworks. The selection of samples, from Paris, Milan and Turin Museums[8], was based on the characteristics of the raw materials (stone, stucco and clay) and the polychromy covering with gilding or pigments. In these phase, as well as in the past, micro samples were taken from the back of artefacts preserved in the museums, or in spots where the surface films were already detached.

Moreover, our interest was devoted to the stucco architectural decorations of the religious monuments of Buddhist sites in Swat (Amluk-dara, Barikot and Gumbat), discovered during the recent archaeological excavations[9]. These stucco samples come from the walls of some collapsed buildings, decorated with coloured patterns on the stucco coatings and on the polychrome stucco architectural and figurative elements; the coloured surfaces of the walls were damaged by weathering. These samples are very important for their precise dating elements, deriving from the stratigraphic contexts, even though they are not fine artefacts as the sculptures kept in the Museums. We developed a growing interest in detecting the precise composition of stucco artefacts from archaeological excavations and from Museums, the kind of pigments and the binders used on the stucco artefacts. Moreover, it was interesting to compare the various type of stucco used to made artworks, come from different sites of Gandhara. These new scientific data could be compared with the few others highlighted in the past about stucco in Gandharan art[10].

By scientific investigations (optical microscope, FTIR, SEM-EDS analyses) on artworks kept in the Museums, we noted the presence of calcite, gypsum and clay in the plaster of Head of Salabhanjika from Hadda (near Jalalabd) preserved in Museum Guimet (samples 6, 7)[11]. Indeed, also in the plaster of an important artwork of Milan Museum, the painted monk statue (sample 22), we detected the high presence of the gypsum in the plaster, while another stucco Bodhisattva statue of Milan Museum reveals a calcium carbonate matrix with heterogeneous grains (iron, potassium, sodium, silicon-aluminate) (sample 23).





[6] Petrographic studies followed the standards of stone identification of the International Union of Geological Sciences (IUGS): see Guida et al., 2015.

[7] Guida G. et al. 2015.

[8] About the Gandhara sculptures of these Museums see e.g.: Verardi, 1991; Provenzali,2005 and in this periodical; Bartoux, 1933; Hackin, 1940; Cambon, 2004, 2010, 2013 and in this periodical.

[9] About this theme see e.g.: Faccenna, 1980; Faccenna, 1995; Callieri et al., 1992; Callieri et al., 2000, pp. 191-226; Faccenna, 2002a; Faccenna, 2002b; Faccenna and Spagnesi, 2015; Olivieri, 2015; Olivieri and Filigenzi, 2018.

[10] Barthoux, 1933, pp.45-47; Faccenna, 1980, pp.703-718; Varma, 1987, pp.13-16: the scholar precisely identified two type of stucco used in Gandhara art, a mixture of quick-lime and sand and a “gypsum compound”; Middleton and Gill, 1996; Ohlídalová et al., 2016, pp.124-131. About sculptures of North India see also: Kumar, 1984.

[11] Barthoux had already noted the presence of gypsum in the stucco statues discovered in his Hadda excavations: Barthoux, 1933, p. 46

opposite page
Fig. 2a, 2b
Schist statue of Maitreya from Museum Guimet. SEM image of cross section of sample 5: thick ground layer on the surface.

By petrographic microscope, SEM-EDS, XRD analyses, the fragments of stucco architectonic decoration from the archaeological excavations in Swat show mostly a plaster with calcite, and sometimes fragments of quartzite, granite, gneiss, garnet, marble and mica flakes, produced from limestone with a certain fraction of clay added, in which the gypsum is always absent.

The use of stucco decoration in the Swat valley is certainly notable but the "kanjur" stone – the limestone probably used for realised stucco artefacts, considering that the petrographic analyses have shown a chemical compatibility, belongs to another geological areas of Pakistan. The area of Taxila, other important Gandharan site, is one of the nearest (others are e.g. Buner, Swabi). Based on this we suppose that the Swat sites imported limestone from an external area, in order to build and to create stucco architectonic decoration and sculptures[12]. This import is a considerable change for the economy of Swat sites at the end of the 3th century A.D. In the future, the new historical and archaeological research about Gandharan culture will have to check why this stone was used in those times instead of the schist rock[13].

Instead, the artefacts from Hadda in Afghanistan were surely made with a local conglomerate and sandstone rocks, that it can easily find in that region, as also gypsum that in some cases was used in the plaster.

Then, we compared the pigments and their possible ground layers on stucco artefacts, both from excavations and Museums, with the polychromy of stone sculpture already analysed in the past to verify if the same polychrome technique was used for different materials or if in the Gandharan area two different methods were used to produce painted stone and stucco objects.

White ground layer for painting polychrome decoration is clearly visible on the schist artworks and it is sometimes very evident and thick as a base for painting over the raw stone surface of statues and reliefs (1, 3, 5 samples from Museum Guimet and 25-26, 27-28-29, 30-31 samples from Milan Museum)[14]. By SEM-EDS and FTIR analyses on the schist samples, the composition of this white ground layer shows a high amount of calcium carbonate and aluminum-silicate; in some cases, we also observed inclusions of iron, titanium, zirconium and gypsum[15].

Instead, this white ground layer is not usually visible on all stucco artefacts, probably because is not usually necessary for this material: on these artefacts we noted only a smoothing white surface and over the polychrome layer. We verified this lack of a real ground layer both on the stucco statues from different Museums[16] and on the fragments of the painted architectural decorations. Instead, in a stucco cornice from Butkara I stored in Rome Museum (ex MNAO) (n.1240), by Scanning Electron Microscopy (SEM-EDS) we verified the presence of four different ground layers for overlapping red pigment, containing calcium: in this case we suppose that these ground layers were the trace of successive ancient restorations of polychromy[17]. Therefore, it is possible to hypothesize that for par-

[12] See Rosa, Theye, Pannuzi, in this issue.

[13] This argument was examine by L.M.Olivieri during the last Conference at Courtauld Institute of Art in London (Spring 2016). Also see about it: Olivieri and Filigenzi, 2018, pp. 81-85.

[14] This ground layer was preserved when the incorrect restorations or the times did not destroy it.

[15] Moreover, we also noted the high presence of calcium, sometimes combined with coloured layers, on the surface of the limestone artefacts (e.g. sample 11 from Museum Guimet), a fair but permeable stone.

[16] It was very interesting the analysis of the cross section of a stucco artwork from Milan Museum (sample 22): it showed the lack of the ground layer and the absorption of red colour into the surface of stucco, as still not solidified.

ticular purposes, e.g. for restorations, even the stucco artefacts could have had a background under the colour layers.

Recently, for an exhibition in National Museum of Prague, Czech équipe analysed Afghanistan stucco artworks with a clay core: they noted that on the artworks made in lime stucco the thick polychrome layers are directly applied on the plaster, as in the cases that we studied[18].

Then, also on painted clay artworks we verified the possible presence of the ground layer.

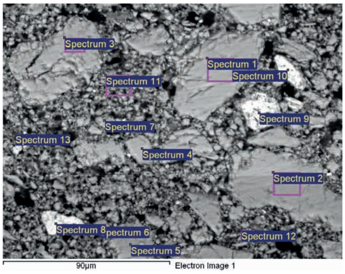
On some samples (15, 17 and 20, Two Naga Kings and Seated Buddha) from Museum Guimet, SEM-EDS analysis of the cross sections showed a lower red orange layer, characterised as red lead (minium) for the high presence of lead, under the blue (lapis lazuli), yellow (orpiment) and red (vermillion) pigments. Instead, on another artwork of the same Museum (samples 18 and 19, statue of Bodhisattva) under the blue ultramarine pigment we noted a red ground constituted by a red ochre mixed with calcite. On artwork from Milan Museum (sample 33, Brahma Head) yellow pigment (an ochre) was lied on a red layer achieved with a red ochre.

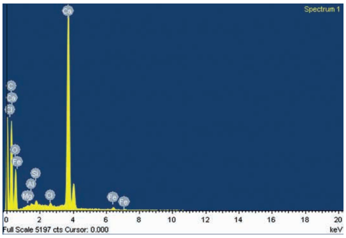
So, it would seem that also the clay artefacts had a kind of ground layer for the polychromy: above the red clay it was made with another coloured layer, always red, not white like that of stone artworks. Probably, we suppose that this red covering was laid on whole surface of clay artefacts also to make uniform those parts that should not have been painted later. We think that this is more a coloured surface finish than a real ground layer for the polychromy. It needs to verify this hypothesis in the future with other analyses.

Therefore, we always verified the need of a ground layer or a surface finish for painting on the Gandharan sculptures. The artists used these ground layers as a base with a uniform colour, on which they could then paint. Thus, these ground layers were made in different ways on different raw materials.

Moreover, we noted a various use of colours for painting the stone, stucco and clay artworks: red, with various hue, yellow, white, blue, with various hue, black. Thanks to scientific investigations we highlighted that the Gandharan artists used many pigments: ochre, red lead (minium), vermillion, orpiment, lead white, blue ultramarine, bone black. We also highlighted in some cases the particular techniques to stratify different pigments on the surface and to mix different chemical elements probably to obtain a colour with particular shades. Furthermore, it seems that red ochre from hematite (iron oxide) is the most used pigment for the polychrome decoration on stone and stucco artefacts, usually upon a white ground layer on the schist artworks[19], as we highlighted in our previous sampling in Rome Museum (ex MNAO)[20].

On stucco artifacts more colours are used perhaps than on those in stone. Domenico Faccenna noted in Butkara site (Swat Valley, Pakistan) the use of various pigment to paint on stucco works, both ornamental and figured, and on schist sculptures[21]: red, with different shade (red ochre), yellow (yel-





[17] Talarico 2015, pp.55-5 and 59.

[18] Ohlídalová et al., 2016, pp.127-128. This équipe studied a different type of stucco artefacts with inside a clay core: lime stucco (statues) and gypsum stucco artworks (heads of Buddha with a gilded covering of the whitish gypsum stucco, in the latter case). Some details of these heads, e.g. the eyes, are painted, but in the Czech work it is not explained the stratigraphic relationship between coloured layers, gilding and stucco surface.
In our research we didn't analysed stucco artefacts with inside a clay core, a more elaborated technical and decoration, that Varma well described (Varma, 1987, pp.41 and 63-75). Therefore, in the next future we would also examine in depth this type of artworks and compare the use of pigment and gilding with the stucco alone artefacts.

[19] By new sampling only one a schist sample from Milan Museum (simple 30) preserved the traces of red polychromy (probably hematite) upon a white ground layer.

[20] Talarico, 2015, pp.55, 56, 59. The prevalence of the use of the red colour was also highlighted on coloured patterns of paintings from ancient sites of Central Asia (Lapierre, 1990, pp.33-34), in Indian sculptures and reliefs (Giuliano, 2015, p. 22, 24) and also in Greek and Roman wall paintings and coloured architectures and sculptures. Certainly, this colour, when made with red ochre, shows a great stability over time.

low ochre), blue (lapis lazuli) and black (ivory black), and also green, though these pigments were identified by microscopic preliminary analysis without more precise scientific investigations[22].

In his important research about Gandhara stuccos K. M. Varma examined the mode of colouring stucco artworks and listed the colour used in order of frequency of employment: red, red-brown, black, grey black, crimson and blue. The scholar did not chemically analyse the pigment but only related the colour vision verified on many artefacts. Thus, he supposed the use of some pigments (e.g. vermillion, lac, lampblack), some of which we've not found in our analyses about Gandhara stucco artworks[23].

Successively, some studies were carry out on polychromy of stucco sculptures of British Museum but it seems without specific analyses, only using binocular microscope: they noted that "many of piece present very smooth, well-finished surfaces (...) achieved by the application of a thin layer of fine plaster, termed slip", with a similar composition of the body of the stucco[24]. Sometimes this slip was pale bluff or yellow due to the presence of ochre. In this paper is not clear if we have to consider this slip as a finish of the stucco surface or a real polychromy.

However, the scholars noted that the "polychrome decoration" (generally with the use of black, red-brown, blue and also gilding) was limited only on some part of the sculptures examined (e.g. hairs, eyes, lips and dresses)[25]. By some scientific investigations (optical microscopy, SEM-EDS, XRD, Raman spectroscopy, FTIR, XRF) Czech équipe highlighted on lime stucco artefacts the presence of hematite, sometimes perhaps in combination with gypsum and a red dye to achieve a pink colour; to made black they suppose a mixture of bone, carbon black, gypsum and plant fibres. They verified on the gypsum stucco artworks the use of lampblack and of orpiment in grains under the gilding[26]; they also found cinnabar on the red painted lips of the Buddha head[27].

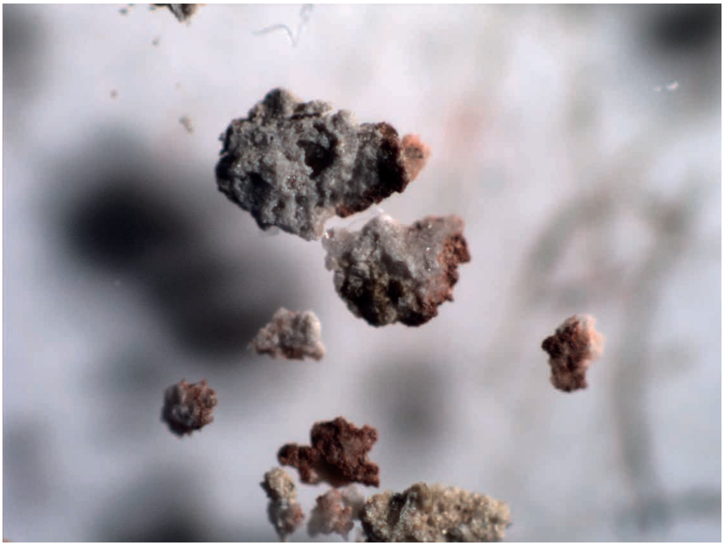


Fig. 3
Hadda's head from Museum Guimet, sample from headgear: microphotography of sample 6 (red layer and stucco mixture) (25x).

[21] Faccenna, 1980, pp.719-721. During the restorations, by microscopic preliminary analysis the restorer Franca Callori di Vignale, verified the use of tempera and fresco techniques to paint in successive times the Buddhist buildings: Faccenna, 1980, pp.704, 707. They noted that the pigments were applied directly on the surface of the stone artefacts or "laid on a red bole" (for gildings), not better specified (Faccenna, 1980, p. 720).

[22] It has already been highlighted that the green colour was rarely preserved, and probably used, in wall paintings found in ancient settlements of Central Asia (Bactria, Sogdiana and Parthia) and in Indian art. Probably its absence, or limited presence, was due to the discolouring of the green colour (also Varma noted that this colour was not employed in Indo-Afghan stuccos: Varma, 1987, pp.122-123); according to some scholars, this scarce use of the green colour was perhaps due to its lack in the palette of five main colours mentioned in some Sanskrit texts (Lapierre, 1990, pp.34, 37. Giuliano reports its presence in some of more ancient texts: Giuliano, 2012, pp. 58, 62; Giuliano, 2013, p.96). However, these texts were written in more recent time than the Gandharan period, but they show the ancient artistic tradition; about the relationship between these texts and the real artistic practise: Giuliano, 2013, pp. 108-113.

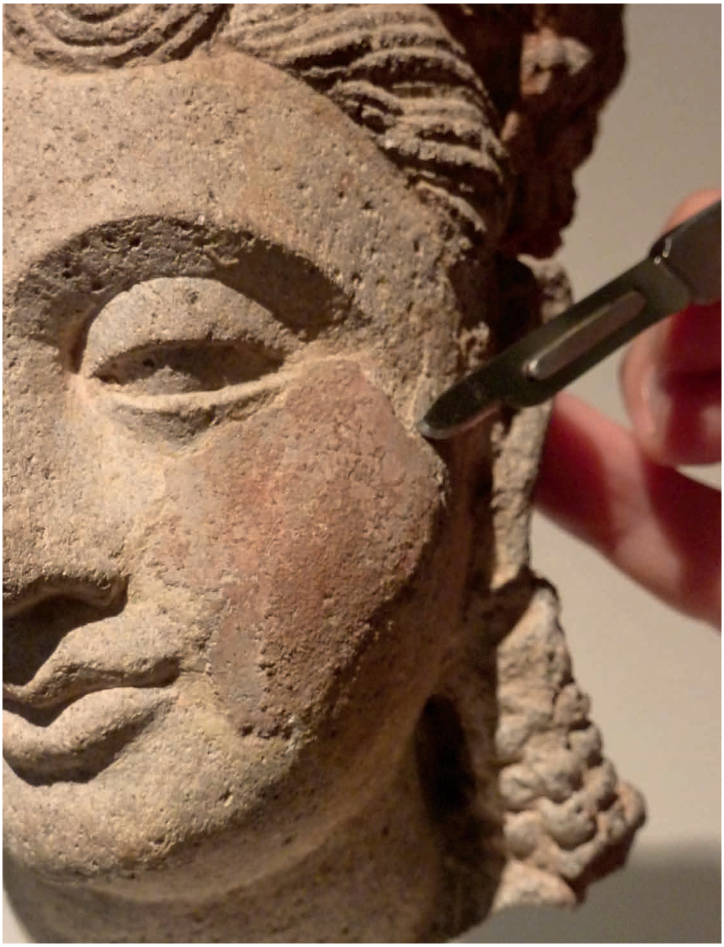


Fig. 4
Stucco Buddha head with traces of colour from the Civic Archaeological Museum of Milan (A.987.03.1) (photo S.Pannuzi).

About the palette of the colours used interesting comparisons can be verify with the ancient Central Asia and Indian paintings and sculptures[28].
By SEM-EDS analyses we examined the traces of red ochre, (samples 22, 23 and 32) and yellow ochre from samples of Milan Museum (samples 32, 33). The cross section of the sample from Hadda Head of Museum Guimet (sample 7) shows over the stucco a red layer of ochre and then another layer of red lead (minium): in this case we suppose that, perhaps, this overlapping was an ancient restoration of the polychromy or a refined way to achieve a pinkish colour. Moreover, we analysed another sample from a limestone Hadda relief with a particular polychrome covering: the blue ultramarine, made by lapis lazuli, was mixed to a few grains of red pigment (hematite) and lead white to get a pale blue colour (sample 10 from Museum Guimet). Certainly, this latter polychrome covering reveals a high artistic level and a great experience to use the different pigments.
We verified that the Gandharan artists usually spread the colours on the surface when the stucco plaster was solidified, but in one case (sample 22 from Milan Museum) our analyses showed that the red colour was

It needs to rectify that the colour visible on the stucco artifact of the ex MNAO (inv.1240) was not green but a blackish colour not identified in that research (Talarico, 2015, p. 53; Giuliano, 2015, p. 22).

[23] Varma 1987, pp. 113-126. Thus far, e.g., we never found lac, although this pigment was use in ancient Indian art: see e.g. Giuliano, 2012, p. 59.

[24] Middleton and Gill, 1996, p. 367. The research on the stucco sculptures of the British Museum highlighted a different compositions and modelling tools and the use of polychromy and gilding (Middleton and Gill, 1996, pp. 363-368).

[25] Middleton and Gill, 1996, pp.363-368.

[26] Yellow colour under the gilding was also noted on clay artworks from Nisa: Bollati 2008, p. 180.

[27] Ohlídalová et al., 2016, pp. 128-131.

[28] About these themes see e.g.: Varma, 1970, pp.106-108; Kumar, 1984, pp. 199,203; Lapierre, 1990; Bollati, 2008; Appolonia et al., 2008; Capanna et al., 2012; Giuliano, 2012 (in particular for the use of lead white and orpiment in Ajaṇṭā painting: pp. 61, 63); Capanna, 2013; Giuliano, 2013; Giovagnoli et al.,2013; Iole, Giovagnoli, Mariottini, 2013; Iole, Giovagnoli, Artioli, 2013.

absorbed into the surface of stucco: we can suppose that the plaster was heterogeneous and the pigment was fluid or, most probably, that the stucco mixture was not still solidified. Thus, we can reasonably hypothesize not a hastily work to make this artefact, but on the contrary, the aim to achieve on purpose a better duration of the painted covering, through an integration between colour and stucco similar to a fresco technique.

On the surface of some samples from stucco architectural decorations form Swat, we noted a few traces of very pale, faint and dilute red colour: by preliminary investigations (Raman analysis) we verified the use of the red ochre (hematite)[29]. We hope in next future to analyse thoroughly.

Concerning the clay artworks of Gandharan art, found in Afghan sites, their loamy composition and the type of pigments used for the polychromy we have little bibliographic informations[30]. Unbaked polychrome clay sculptures, mostly Buddhas and Bodhisattvas, were recently found in Mes Aynak excavations: the colours preserved are red, black, blue, white and gilding on the Buddha heads[31]. In comparison with these our investigations we analysed the data about clay polychrome sculptures from Nisa excavations in Turkmenistan[32]. There it was used cinnabar and red ochre for red colour, red ochre with kaolin for pale pink, lac for pink, yellow ochre for yellow colour, blue Egyptian and lapis lazuli for blue colour, lampblack for black colour and kaolin and gypsum for white ground layer for painting[33]. In that site it was noted a very developed processing techniques to make pigments.

The results obtained in our research on clay sculptures will need further analyses regarding the production of the clay mixture, always unbaked but in some cases baked at low temperatures, as we are checking with our analyses[34]. On clay artworks we highlighted the presence of different pigment for polychromy, also with a stratification: by SEM-EDS analyses on the cross section of sample taken from Two Naga Kings statue of the Museum Guimet (from hair) we found on the clay surface a red orange layer with lead (minium) (sample 15) with overlapping lapis lazuli layer (blue ultramarine); in another sample taken from the same artworks (sample 17) (from ear) under the yellow colour (orpiment) the analysis showed a lower red orange layer (minium), already found in the first sample. Moreover, on the surface of clay statue of Bodhisattva from Fundukistan (from hair) we found a red layer with iron (red ochre) with an overlapping blue ultramarine layer, that visually turned to a black colour (sample 18); instead on

Fig. 5
Hadda's head from Museum Guimet, sample from cheek: micro-photography of sample 7 (100x).

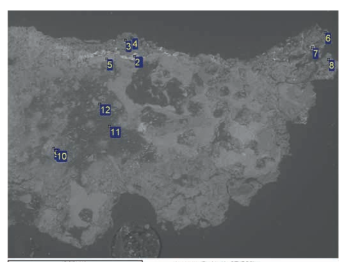


Fig.6
Hadda's head from Museum Guimet, sample from cheek: SEM image of sample 7.

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Fig. 7
Sampling of Hadda's relief from Museum Guimet (sample 10) (photo S.Pannuzi).
Fig. 8
Hadda's relief from Museum Guimet: micro-photography of sample 10.

[29] See Rosa, Theye, Pannuzi in this issue.

[30] A few hints about this theme in: Fussman, Le Berre, 1976, p.78; Verardi, 1983, pp.479-502; Tarzi, 1990, pp.57-93. About the Gandharan art in Afghanistan settlements see e.g.: Taddei and Verardi,1978, pp.33-135; Taddei and Verardi, 1981, Taddei, 1993, pp.118-122; Filigenzi, 2008.

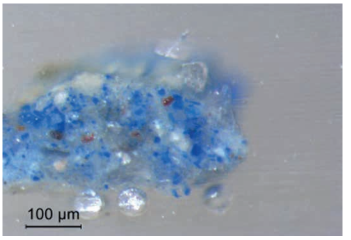
[31] The clay sculptures were compared to the artworks from Kabul area (IV-IX century A.D.). In Mes Aynak excavations the archaeologists also found stone and plaster sculptures (AA.VV., 2011, p. 32).

[32] Bollati, 2008, pp. 188-189; Appolonia et al., 2008, pp. 197-209.

[33] As indicated before, on clay sculptures analysed from Paris and Milan Museum we found under the polychromy a red layer, not white as on Nisa clay sculptures.

[34] By polarized optical microscope, preliminary analysis on Tapa Sardar sample indicated that this clay mixture baked with low temperatures, because calcite, still well-formed, indicates surely temperatures below 600°C. I thank Anna Lluveras Tenorio for this important information. See also Rosa, Theye, Pannuzi in this issue.

the garland of this same statue (sample 19) we found a complex stratification: a layer with lead compound mixed with calcium silicate and lapis lazuli covered a layer with lead white (cerussite/hydrocerussite) mixed with bone black (calcium phosphate) spread on red ochre layer visible on the clay surface. On clay seated Buddha from Museum Guimet (sample 20) we saw two different red layers overlapping: with lead the lower one and with cinnabar (vermillion pigment) the upper one. Then, a clay Brahma Head from Milan Museum (sample 33) showed the presence of two different coloured layers, red below and yellow above, together made with ochres.
By this overlapping of colour layers, always with the red below, we suppose that this is more a clay surface finish than a real ground layer for the polychromy (see above). We suppose that on the clay artworks this red layer, with red lead (minium) or red ochre, was used as a ground layer, spread on the artwork surface to paint over with other different colours (see above).
Moreover, very interesting results are issued by analyses on schist sculptures with visible and now invisible traces of gilding. The investigated gildings were always constituted of a gold leaf made with a high percentage of gold and little copper and silver (indicatively by our analyses, the amount of gold is between 93.04% and 97.26%, copper between 1.27% and 5.14%, silver between 0.78% and 2.26%.). In all cases the gildings were put on different ground layers: a bolus composed by hematite, gypsum and clay, similar to the typical technique for gildings in Mediterranean area (sample 13 from Museum Guimet and sample from Saidu Sharif excavation[35]); a red layer composed by calcium and lead (probably minium) (sample 14 from Museum Guimet); a ground layer was composed by a whitish mixture of clay, red ochre and mainly with the presence of calcium (standing Buddha from Milan Museum, sample 21); a mixture of silicon, aluminum and calcium (samples 34,35 from Turin Museum).
On sample 12 from a very famous statue of Buddha from Paitava monastery in Afghanistan, kept in Museum Guimet, SEM-EDS analysis showed a different chemical composition in different fragments of the leaf: one of these had less gold and more copper percent, while the silver was a similar percentage to other fragments. We supposed that this part of the gilding could have been restored in ancient time, as we already noted for other Gandharan artworks[36]. These data clarify the presence of continuous maintenances, carried out by artists to preserve the beauty of the sacred images.
Finally, by FTIR analysis, GC-MS and MS proteomics analysis[37] we thoroughly examined the type of binders used for stucco and clay polychrome artworks and the technique used to achieve gilded stone artworks. These investigations clearly showed different types of binders for polychromy and gildings, especially proteinaceous materials: only animal glue[38] [sample 21 (gilding), sample 22 (polychrome stucco) and sample 25 (polychrome clay) from Milan Museum]; animal glue, milk[39] and eggs together (samples 15-17 and 18-19 from Museum Guimet); a protein binder, probably eggs[40] (samples 12-13 from Museum Guimet)[41]. On one clay fragment from Tapa



[35] See the results discussed in Zaminga et al., in this issue.
In Butkara site Domenico Faccenna already highlighted the presence of typical bolus under the gildings; in other cases the gilding was laid directly on the surface of the stucco artefacts (Faccenna, 1980, p.720).
[36] Pannuzi, 2015, p.12; Talarico et al., 2015, p.59; Zaminga et al., in this issue.
[37] The proteomics analysis is one of the most promising analytical approaches to identify proteins, introduced in the field of cultural heritage about eleven years ago See the results of GC-MS and proteomics analysys discussed in Bonaduce et al., in this issue.
[38] Animal glue is obtained by boiling bones, hide or other cartilaginous parts of animals; it is made of, collagen partially hydrolysed.

opposite page
Table 1
Sample 1, SEM-EDS spot analysis by the cross section. All results in weight %.
Table 2
Sample 5, SEM-EDS spot analysis by the cross section.
Table 3
Sample 9, SEM-EDS spot analysis by the cross section.

Sardar in Afghanistan it is very interesting the identification of tragacanth gum as the polysaccharide binder used in the clay mixture and a proteinaceous binder in painted layer[42]. Vegetable gum was noted also by analyses recently achieved on stucco artworks by Czech équipe[43] and on painted layers of clay samples from the lost Giant Buddhas of Bāmiyān in Afghanistan (6th-7th century AD)[44].
By GC-MS analysis on samples of architectural decoration from Swat excavations (Amlukdara, Gumbat and Barikot) traces of proteinaceous material have been highlighted as binder in the red painted layers (not animal glue, perhaps egg)[45]. Very interesting was the analyses on a sample collected from a polychrome decoration on plaster coming from Amlukdara in Pakistan (sample AKD14C): on ground layer of colour GC- MS analysis showed the presence of proteins, most likely milk or egg white. By proteomics analysis on the painted layer the identification of 26 peptides ascribable to collagen allows us to ascertain the presence of animal glue in the sample. Moreover, a comparison of the peptide sequences with the available databases allowed us also to identify the specific biological source of the collagen: bovine[46]. In next future, we would understand if different binders have been purposely used on different raw materials or if the choice of the binder was connected to the costs and to the natural resources available to the artists in different sites.
In conclusion, in Gandharan sculptures we highlight the use of different ground layers, pigments and gildings with various, refined and expensive technology to paint and to gild the artworks. Indeed, although lapis lazuli[47], lead, iron, gold[48], silver and copper are present in large amount in the Afghan and in Pakistani regions, we have to consider the costs of the different productions of the pigments, the gildings and especially the binders with eggs and milks. Thus, in the future, we will try to understand if these different artistic modalities to work were due to different and not local traditions, come to the Gandharan sites through trades or invasions of foreign people, or if these various artistic technologies were specific creations of Gandhara artists in different times[49] and sites, linked with the local different resources.
(S. P.)

Gandharan artworks from Guimet Museum in Paris: chemical analyses on polychromies (see Sampling List)

Sample 1

By SEM-EDS spot analysis by the cross section of the sample, taken from an Elephant schist sculpture, the spectra 1, 8, 9 show the presence of a high amount of calcium carbonate (figg.1A and 1B, tab. 1), to be referred to a white substance applied over the schist stone and used for a polychrome decoration that is now lost. Considering the geo-archaeological origin of the land in the Ghandara area, there is no reason to presume that this layer has a natural origin due to the presence of water, rich in carbonates, in the earth where the objects were found.

[39] Milk is a water emulsion of proteins and lipids.

[40] Eggs can be used whole, or using only one of its components: yolk or glair.

[41] It is very interesting the presence of saccharidic and proteinaceous materials in subsequent painted layers of the lost Giant Buddhas of Bāmiyān, Afghanistan, (6th-7th century AD) (Lluveras Tenorio et al., 2017).

[42] See the results about clay of sample 1 from Afghanistan: Rosa, Theye, Pannuzi, in this issue.

[43] Ohlídalová et al., 2016, pp. 128-130. Moreover, on gilded gypsum stucco artwork the Czech équipe noted the presence of a binder probably based on polysaccharides (p.131). The presence of this type of binder (polysaccharides) has also been identified on polychrome clay artefacts from Nisa excavations (Bollati, 2008, p.188, n.134).

[44] The tragacanth gum was found in the clay modelling of the sculptures and in the following restorations of the painted covering (with egg) (Lluveras Tenorio et al., 2017, pp.8, 12-13). Instead milk and egg were found as binder of original polychromy and of first historical restorations.
On Central Asian paintings the binder with vegetable origin, probably a gum, was discovered (Lapierre, 1990, p.35). The use of gum was report by Sanskrit texts (Giuliano, 2012, pp.59-60; Giuliano, 2013, pp.101-104).

[45] Report of Pisa University (20-10-2015) to ISCR.

[46] See Bonaduce et al. in this issue.

[47] About lapis lazuli quarries see, e.g.: Varma, 1970, p.165 note 76.

[48] Chinese pilgrims reported that the Gandharan monasteries in Swat possessed mines of gold and iron (Tucci, 1958, pp-280-281).

Table 1

Spectrum	Na	Mg	Al	Si	S	Cl	K	Ca	Mn	Fe	Total
Spectrum 1	0,00	2,06	7,29	20,37	0,60	0,90	1,89	61,19	0,00	5,70	100
Spectrum 2	0,00	0,00	4,88	84,05	0,00	0,72	0,58	5,94	0,00	3,82	100
Spectrum 3	0,00	0,76	4,85	82,36	0,00	0,76	0,81	5,56	0,00	4,90	100
Spectrum 4	0,90	0,00	13,81	64,61	0,00	1,20	3,55	10,81	0,09	4,55	99,54
Spectrum 5	0,00	2,1	31,9	29,3	0,00	0,79	0,88	2,56	0,35	31,16	99,05
Spectrum 6	0,68	1,4	29,02	32,31	0,00	0,81	0,54	4,24	0,00	31,00	100
Spectrum 7	0,00	1,65	29,84	26,53	0,00	1,00	0,87	7,26	0,28	31,62	99,06
Spectrum 8	1,14	1,43	7,45	23,74	0,59	1,14	3,45	56,4	0,00	4,67	100
Spectrum 9	0,00	1,66	5,19	15,98	0,00	1,14	1,01	71,85	0,00	3,16	100

Table 2

Spectrum	Mg	Al	Si	Cl	K	Ca	Fe	Total
Spectrum 1	0,37	0,54	1,27	1,27	0,00	93,27	3,28	100,00
Spectrum 2	0,74	0,68	1,05	0,85	0,00	94,45	2,23	100,00
Spectrum 3	0,00	0,58	1,09	0,96	0,00	95,39	1,98	100,00
Spectrum 4	0,48	0,62	1,49	0,73	0,00	94,61	2,07	100,00
Spectrum 5	0,00	0,00	1,65	1,10	0,00	95,42	1,83	100,00
Spectrum 6	0,00	0,00	1,26	0,98	0,00	94,88	2,88	100,00
Spectrum 7	0,40	0,97	1,66	1,26	0,00	91,63	4,08	100,00
Spectrum 8	0,00	2,38	3,97	0,74	0,00	36,12	56,79	100,00
Spectrum 9	0,00	1,83	3,03	1,20	0,67	38,53	54,74	100,00
Spectrum 10	0,89	2,49	3,45	0,89	0,78	36,32	55,18	100,00
Spectrum 11	0,00	1,04	1,96	1,61	0,00	91,86	3,53	100,00
Spectrum 12	0,00	0,98	3,24	1,72	0,00	90,80	3,28	100,00
Spectrum 13	0,00	1,18	2,24	3,38	0,00	89,62	3,58	100,00

Table 3

Processing option: All elements analysed (Normalised)

Spectrum	Na	Mg	Al	Si	P	S	Cl	K	Ca	Fe	As	Pb	Total
Spectrum 1	1,25	0,00	1,37	4,04	4,04	0,00	4,77	1,31	13,72	0,00	9,20	60,30	100
Spectrum 2	0,00	0,00	0,00	6,50	5,26	0,00	4,85	1,20	21,88	0,00	8,88	51,43	100
Spectrum 3	0,00	0,00	1,39	4,20	4,68	0,00	5,55	1,32	23,34	0,00	9,62	49,90	100
Spectrum 4	2,49	11,92	4,21	36,80	1,13	1,67	2,53	1,79	28,70	1,17	0,51	7,09	100
Spectrum 5	4,49	6,71	8,13	31,29	0,00	4,67	3,78	2,67	27,29	0,00	2,09	8,89	100
Spectrum 6	1,97	4,27	8,37	16,32	3,04	3,68	6,51	4,05	14,03	5,39	3,41	28,96	100
Spectrum 7	0,83	3,42	1,68	7,12	0,73	0,86	1,68	1,35	5,01	67,99	1,01	8,32	100

In the lower layer of the cross section, the presence of Ce, Nd, and Th (group of Lantanidi) is common in the schist stone, as well as the presence of Ti, often combined with iron.

Sample 2

This sample was taken to an Elephant schist sculpture (see sample 1). SEM EDS analysis is only referring to the schist stone. Zr is contained in the sam-

[49] We hope that it will be possible to clarify the chronology of the various Gandharan artefacts (see Ingholt, 1960), especially with the help of new historical and archaeological researches.

opposite page
Table 4
Sample 11, SEM-EDS spot analysis by the cross section.
Table 5
EDS analyses of gilding from sample 12. Elements are expressed as atomic percent.
Table 6
EDS analyses of gilding from sample 14. Elements are expressed as atomic percent.
All results in weight%.

ple, as commonly in the schist stones. Inclusions of Ti combined with iron are observed.

Sample 3
By SEM EDS analysis the sample, taken from a white layer on the surface of Pakistani schist relief from Buner Valley, shows the presence of a high amount of calcium. Inclusions of iron and Ti are observed too. This layer has to be referred to a white substance applied over the stone and used for a polychrome decoration that is now lost. The analyses do not include the schist.

Sample 4
SEM EDS analyses achieved on sample from Pakistani relief see above (see sample 3) are only referring to the schist stone (with a silico-alluminate matrix). Inclusions of Ti combined with iron are observed too. Thanks to the thin section, despite the small amount of material, it is possible in next future to deepen the petrographic investigation aiming at the definition of the lithotipe.

Sample 5
The sample was taken from a white surface, preserved on the right foot, of the schist statue of Bodhisattva Maitreya from Pakistan. SEM-EDS analyses of highlighted the presence in the spectra of an abundant amount of calcium, probably in combination with calcium carbonate, owed to a white preparation layer, put on the surface of the stone and used for a polychrome decoration that it has now been lost (figg.2A and 2B, tab. 2).
(G. G., C. R.)

Sample 6
This sample was taken from the headgear of stucco head of Salabhanjika from Hadda (Afghanistan). Micro-FTIR analyses on the powders identified calcite and gypsum in the plaster (fig. 3). As known FTIR technique is unable to detect oxides (e.g. hematite, a red oxide). Micro-XRD analysis detected quartz, calcite and albite (NaAlSi3O8 – plagioclase feldspar mineral) as main components of plaster.

Sample 7
This sample was taken from the pinkish cheek of Hadda's stucco head (see sample 6). Micro-FTIR analyses on the powders identified calcite and gypsum in the plaster (fig. 4). The result of the analyses about the pigments used on this artwork to achieve a pinkish colour is very difficult to understand. Optical microscope images of the cross-section matched with SEM-EDS analyses seems to show a very thin, discontinuous red layer of ochre; a second red orange layer, slightly more thick, is over imposed to the previous one. Its chemical composition reveals the presence of lead, probably minium. This evidence may be explained as an ancient inter-

Table 4

Processing option: All elements analysed (Normalised)

Spectrum	Na	Mg	Al	Si	P	S	Cl	K	Ca	Fe	As	Pb	Total
Spectrum 1	1,25	0,00	1,37	4,04	4,04	0,00	4,77	1,31	13,72	0,00	9,20	60,30	100,00
Spectrum 2	0,00	0,00	0,00	6,50	5,26	0,00	4,85	1,20	21,88	0,00	8,88	51,43	100,00
Spectrum 3	0,00	0,00	1,39	4,20	4,68	0,00	5,55	1,32	23,34	0,00	9,62	49,90	100,00
Spectrum 4	2,49	11,92	4,21	36,80	1,13	1,67	2,53	1,79	28,70	1,17	0,51	7,09	100,00
Spectrum 5	4,49	6,71	8,13	31,29	0,00	4,67	3,78	2,67	27,29	0,00	2,09	8,89	100,00
Spectrum 6	1,97	4,27	8,37	16,32	3,04	3,68	6,51	4,05	14,03	5,39	3,41	28,96	100,00
Spectrum 7	0,83	3,42	1,68	7,12	0,73	0,86	1,68	1,35	5,01	67,99	1,01	8,32	100,00

Table 5

Spectrum Label	1	2	3	4	5	6	7	8	9	10
Cu	4.58	4.74	3.87	5.14	42.14	29.02	2.74	3.25	1.27	4.86
Ag	1.52	2.22	0.78	1.47	0	5.31	0	1.26	2.26	1.63
Au	93.9	93.04	95.36	93.39	57.86	65.67	97.26	95.5	96.47	93.51
Total	100	100	100	100	100	100	100	100	100	100

Table 6

Processing option: All elements analysed (Normalised)

Spectrum	Mg	Al	Si	P	S	Cl	K	Ca	Fe	As	Au	Pb	Total
Spectrum 1	0,00	2,45	9,93	8,48	2,74	5,32	1,58	14,67	13,92	0,00	0,00	40,90	100,00
Spectrum 2	0,00	1,47	5,99	9,88	0,00	5,55	1,36	19,98	2,79	0,00	0,00	52,99	100,00
Spectrum 3	1,44	3,75	8,62	6,92	0,00	4,84	1,73	14,16	5,03	0,00	0,00	53,52	100,00
Spectrum 4	0,00	0,85	2,43	5,78	0,00	5,44	0,00	11,61	1,53	3,50	0,00	68,85	100,00
Spectrum 5	1,03	3,38	9,87	7,78	0,00	5,66	2,01	15,57	6,19	0,00	0,00	48,52	100,00
Spectrum 6	0,00	0,00	0,00	0,00	0,00	0,00	0,75	5,94	2,63	0,00	90,68	0,00	100,00

vention on the artifact, required to regain the chromatic integrity, or as a device to obtain a pinkish colour (figg. 5, 6). The chemical composition of the greater part of the cross-section is mainly silicon, aluminium, calcium and potassium. The most of calcium is present as carbonate, only a little part is gypsum, thus confirming FTIR analyses. Silicon, aluminum and potassium confirm the presence of clays in the stucco mixture. Spare grains of silica were identified too. EDS map shows iron grains, to refer to red and yellow ochres.

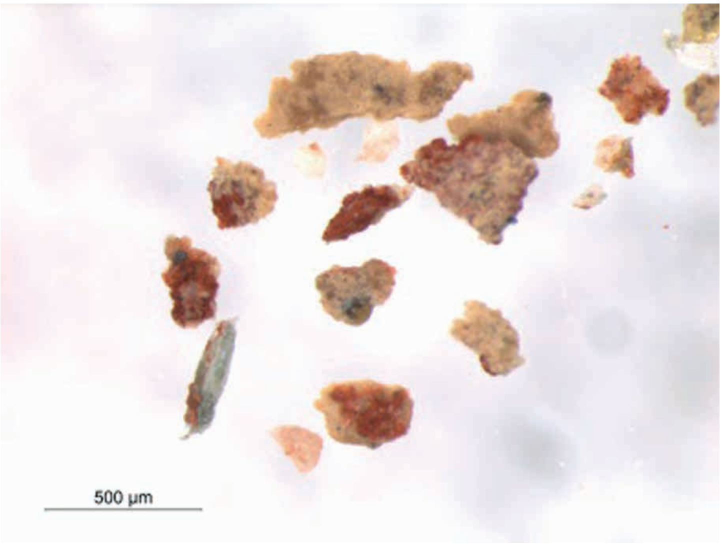
Sample 8 (n. 9 sampling)

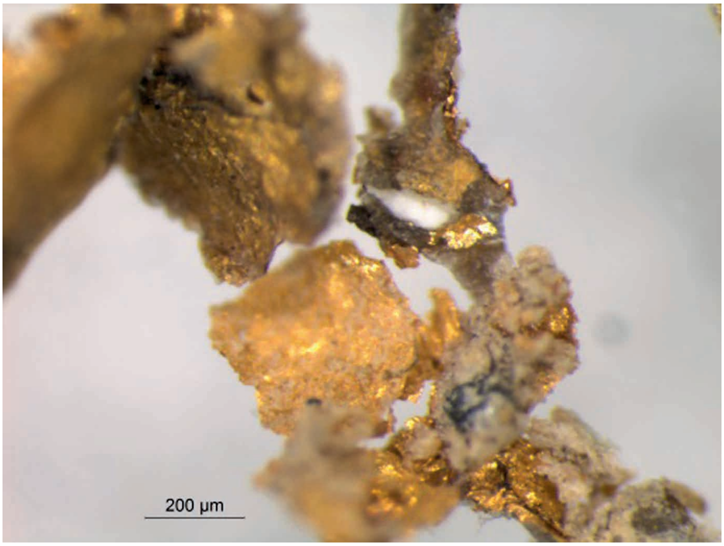
This sample, taken from a figure of red painted limestone relief from Hadda, Tapa-i-Kafariha monastery (Afghanistan), was examined only by micro-FTIR. The main evidences of limestone are the presence of calcium carbonate and silicates. We noted also the presence of calcium oxalate: a

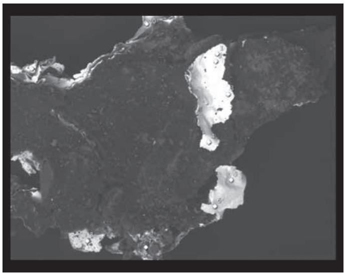
Fig. 9
Buddha statue of Paitava from Museum Guimet (sample 13): micro-photography. You can see the bolus.

Fig. 10
Buddha statue of Paitava from Museum Guimet (sample 12), gilding micro-photography. You can see the gilding.

Fig. 11
Buddha statue of Paitava from Museum Guimet (sample 12): SEM image of sample.







by-product of the deterioration of organic materials. As known, this technique is unable to detect oxide compounds, we cannot therefore say more about the red pigment. Micro-XRD analysis confirmed the presence of calcite and quartz raw material of the artefact.
(F. T.)

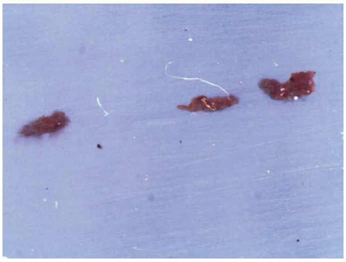
Sample 9 (n.10 sampling)
The SEM-EDS analyses are referring to the limestone of the same relief of Hadda (see sample 8). Spectra 1, 2, 3, carried out on the surface, highlight a high amount of Pb (probably minium) owed to a surface painting of the

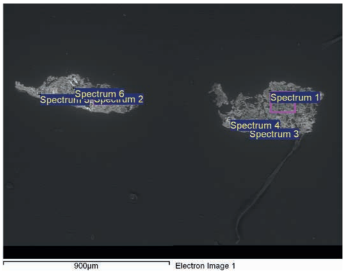
artefact. The spectrum 7 indicates a high amount of iron (probably hematite): it must be referred to the composition of the raw material (with a silicon-aluminate matrix) of the relief (tab. 3).
(G.G., C.R.)

Sample 10 (n.11 sampling)
The sample was a greyish blue pigment taken from the same relief of Hadda see above (samples 8 and 9) (fig.7). We realized SEM-EDS analyses. Blue grains are made of lapis lazuli, characterized by a very good relation among the elemental maps of silicon, aluminum, sodium and sulphur, thus confirmed by spot analyses. A greyish component is associated to silicon-aluminates of magnesium; calcium carbonate is diffused on the whole sample, probably as a component of the raw material of the artefact. White grains contain mainly lead, probably as carbonate (lead white, i.e. cerussite / hydrocerussite). Note that arsenic is associated to lead, but at the moment a satisfying explanation for this cannot be given. Observing the micro-photo of this sample, we can suppose that lead white was mixed to the lapis lazuli, in order to obtain a pale blue colour (fig.8).
Phosphorus was detected in spot EDS analyses corresponding to lead. Some hypothesis may be proposed: it could be associated to the mineral composition or it could be a marker of a casein glue, but it is necessary to deepen this problem through specific analyses.
Few grains of red pigment are mixed to the ultramarine blue; EDS elemental maps and spot analyses report only iron, with no other chemical element, we can therefore suppose the presence of hematite (Fe_2O_3).
(F. T.)

Sample 11 (n.12 sampling)
The sample is only representative of the surface of the artefact, a limestone relief from Hadda, Chakhil-i-Ghoundi monastery, stairway of stupa C1 (Afghanistan). The SEM-EDS analysis shows a high amount of calcium, perhaps owed to the ground layer of a polychrome decoration or a raw material of the artefact (tab. 4). Other analyses will carry out to investigate this issue.
(G. G., C. R.)

Samples 12 and 13 [n.13 sampling (gilding and bolus on schist) and n.14 (bolus and schist)]
Some analyses were carried out on some samples of gilding and on an evident underlying bolus of a famous gilded statue in schist of *Buddha* in the *Miracle of Sravasti*, from Paitava monastery (Afghanistan). The results are very interesting, because micro-FTIR analyses detected a protein, probably egg, in the bolus. The red bolus, analysed by micro-Raman technique, is mainly composed by hematite (Fe_2O_3), with some gypsum ($CaSO_4 \cdot 2H_2O$) and clay as silicon-aluminate (fig.9). This result reminds the typical technique for gilding sculptures and paintings in the Mediterranean area.





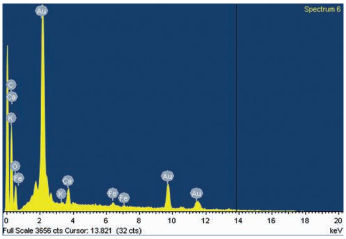


Fig. 12
Shotorak relief from Museum Guimet (sample 14): microphotography of gilded sample.

Fig. 13a
Shotorak relief from Museum Guimet (sample 14): SEM image of some fragments.

Fig. 13b
Shotorak relief from Museum Guimet (sample 14): EDS analysis of Spectrum 6 (see Fig.13a).

Fig. 14
Sampling of Statue of two Naga Kings (from hair) from Museum Guimet (sample 15) (photo S.Pannuzi).

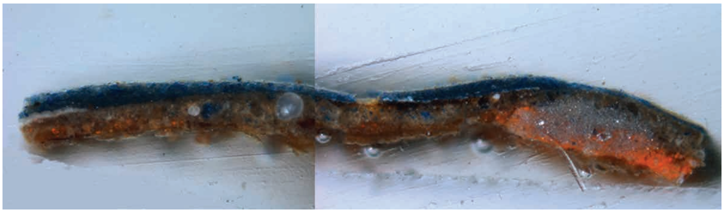


Fig. 15
Statue of two Naga Kings statue (from hair) from Museum Guimet (sample 15): micro-photography of cross section (100x).

FTIR analyses carried out on several spots of the same sample shows the probable presence of egg glue as binder of the red colour. In some of the analyzed points we found a synthetic vinyl acetate based adhesive, certainly related to a recent intervention.

Analyses were performed after selecting one fragment of gilding, directly on the sample without any process to embed the sample in a cross section (fig.10). All analysed gildings are constituted of a gold leaf. SEM image clearly highlights the presence of three fragments of gilding on the *bolus* (fig.11). EDS analyses show a different chemical composition: two fragments have a very similar composition (see tab. 5, measurement nn. 1, 2, 3,

4, 7, 8, 9, 10): the amount of gold is between 93.04% and 97.26%, copper between 1.27% and 5.14%, silver between 0.78% and 2.26%. The third one, unlike the previous ones, has a very different chemical composition (measurements nn. 5 and 6): it was poor in gold (57.86% and 65.87%), rich in copper (29.2% and 42.14%,); silver varied from 0% to 5.31%. The great difference in chemical composition in this part of gilding suggests a probable ancient restauration.
It is interesting to highlight the heterogeneous chemical composition in the same gold alloy; we suppose that this evidence could be related to the technique of purification and production of the gold leaf. Observing under microscope the gilded fragments we often note some roughness of the surface.
(F. T.)

Sample 14 (n.15 sampling)
The sample has been taken from a schist relief from Shotorak monastery (Afghanistan) with visible traces of a red colour. By optical microscope a golden guilding, not visible to the naked eye, has been detected (fig. 12). By SEM EDS analysis the presence of Pb might be referred to the red colour (minium ?). The presence of calcium (in varying amounts) might be owed to a preparation layer of gilding (figg.13A and 13B, tab. 6).
(G. G., C. R.)

Sample 15 (n.16 sampling)
A sample of blue color was taken from the hair of one of two clay figures of the two Naga Kings sculptures from Fundukistan (Afghanistan) (fig.14). Observing under a microscope the cross-section obtained from the sample, a very interesting sequence of layers of paint appeared (fig.15). In the lower part of the cross-section an orange coloured heterogeneous layer, with various thickness, is characterized by the presence of lead; by SEM-

Fig. 16
Sampling of two Naga Kings statue (from arm) from Museum Guimet (sample 16) (photo S.Pannuzi).

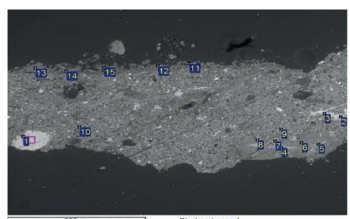


Fig. 17
Statue of two Naga Kings statue (from arm) from Museum Guimet (sample 16): SEM image of cross section.

Fig. 18
Sampling of two Naga Kings statue (from hear) from Museum Guimet (sample 17) (photo S.Pannuzi).

EDS analysis we assume that it was minium. In the middle of the cross section elemental maps of silicon, aluminum and magnesium show a very good overlapping. A discontinuous white layer was observed on the left of the cross section, under the blue pigment. Blue ultramarine was used in the upper layer.

Sample 16 (n.17 sampling)

This sample was taken from the arm of one of two clay figures of the two Naga Kings sculptures from Fundukistan (Afghanistan) (fig.16). By SEM-EDS analysis the maps of elements of this cross-section show the overlapping of cobalt and tin (fig.17). The only possible explanation for this is the presence of stannous cobalt, a modern pigment synthesized in the second half of the 19th century. So its presence is due to a modern restoration. On the upper layer of the cross-section Cobalt is not related to tin, (point 12) so we suppose that the pigment cobalt blue has been used ($CoAl_2O_4$). Spot analyses on point 12 show a good connection between calcium and phosphorus, probably due to the presence of calcium phosphate, typical of bone black.

The lower part of the cross-section reveals the presence of silicon, aluminum and iron, related to the clay material of the statue.

Sample 17 (n.18 sampling)

The sample has been taken from one ear of one of Naga kings (see samples 15 and 16) (fig.18). The cross-section has a complex stratigraphy, at least four layers have been detected. The most interesting layers show, under visible light, a well-defined yellow pigment, applied on a red-orange layer (fig.19). The red-orange layer, indeed, when observed under UV light, is almost split into two layers not well defined (fig.20). Indeed, the lower red-orange layer of the cross-section appears heterogeneous and incoherent.

Fig. 19
Statue of two Naga Kings (sample from hear) from Museum Guimet: microphotography of cross section of sample 18 (visible light).

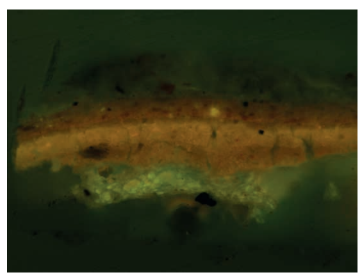


Fig. 20
Statue of two Naga Kings (sample from hear) from Museum Guimet: microphotography of cross section of sample 18 (UV light).

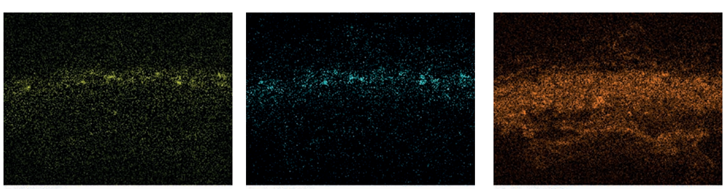


Fig. 21a, b, c
Statue of two Naga Kings (sample from hear) from Museum Guimet: EDS elemental maps of Sulphur, Arsenic and Lead on cross section of sample 18.

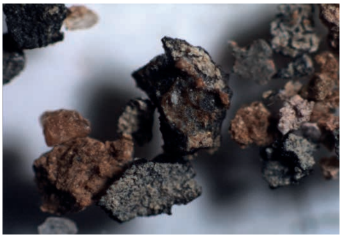


Fig. 22
Sampling of Statue of Bodhisattva (from hair) from Museum Guimet (sample 18) (photo S. Pannuzi).

Fig. 23
Statue of Bodhisattva (from hair) from Museum Guimet: microphotography of sample 18 (25x).

Fig. 24
Sampling of Statue of Bodhisattva (from garland) from Museum Guimet (sampling 19) (photo S. Pannuzi).

Another superficial and incoherent layer, over the yellow layer, was chemically characterized by silicon, aluminum, calcium and potassium and may be explained as dirt or as a restoration ground layer.

A more complex description is necessary to describe the red-orange and the yellow layers. These layers, as seen above, are clearly visible under UV light. Both layers, however, do not have a different chemical composition: both maps and spot analyses reveal the presence of lead as main element. No silicon, nor aluminum or iron have been detected in these layers, we therefore exclude the presence of a clay and we can attribute them to two painted layers. Lead is the most plentiful chemical element, both in the red-orange layer than in the upper yellow layer.

The presence of lead may be owed to the presence of different pigments, according to their color: in the lower layer, the red-orange colour, may be related to the pigment minium.

SEM-EDS elemental maps and spot analyses of the upper yellow layer show a very good fit between arsenic and sulphur, related to the pigment orpiment (fig.21). Moreover, the presence of lead in this layer, may be inferred to the use of massicot/litharge pigment, mixed with the orpiment pigment.

Micro-FTIR analyses highlighted the presence of an animal glue as binder of the pigments.

Table 7
EDS analyses of gilding from sample 19. Elements are expressed as atomic percent.

Table 8
EDS analyses from sample 20. Elements are expressed as atomic percent.

Samples 18 (n.19 sampling)
This sample was taken from the hair of clay Bodhisattwa statue from Fundukistan monastery (Afghanistan) (figg. 22, 23). It was constituted of a powder and it was analyzed by micro-FTIR. The FTIR spectrum of the black-blueish pigment well fits with the pigment ultramarine blue. The underlying red ground was constituted by red ochre mixed with calcite. At the moment we are not able to state if this red layer comes from to the clay material or it is a ground for the blue pigment; we are presently working on this issue and hope to be able to answer soon.

opposite page
Fig. 25
Statue of Bodhisattva (from garland) from Museum Guimet: micro-photography of cross section of sample 19 (100x).

Fig. 26
Statue of Bodhisattva (from garland) from Museum Guimet: SEM image of cross section of sample 19.

Sample 19 (n. 20 sampling)
This sample was got from the garland of the same clay Bodhisattva statue (see sample 18) (fig.24). The cross-section highlights two different layers made by a blue-greyish colour and a red colour. The cross-section was analyzed by SEM-EDS. Note that the photo is upside down, so the red color is the inner layer, while the blue-greyish is the upper one (fig.25).
The upper blue-greyish layer was obtained by mixing a blue pigment and a greyish one. Elemental maps highlight a lead compound mixed with calcium silicate (see maps of lead, silicon and calcium). Spot analyses on blue

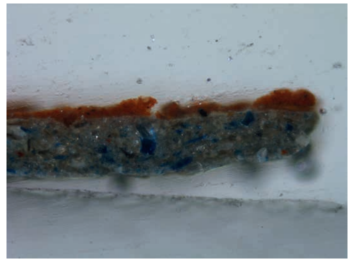
Table 7

Spectrum	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Fe	Br	Pb	
1	3,07	5,14	10,79	45,06	0,00	0,00	2,59	2,28	28,34	0,00	0,00	0,00	2,72	100
2	0,00	7,89	4,82	48,93	0,00	0,00	0,00	1,35	35,46	0,00	0,00	0,00	1,55	100
3	6,32	1,43	21,22	43,82	0,00	0,00	3,62	3,65	16,14	0,00	0,00	0,00	3,81	100
4	0,00	0,77	0,95	92,36	0,00	0,00	0,00	1,16	2,84	0,00	0,00	0,00	1,92	100
5	0,00	14,32	9,70	43,36	0,00	0,00	1,41	22,64	4,23	1,97	0,00	0,00	2,38	100
6	0,00	1,69	21,04	46,57	0,00	0,00	2,34	14,56	4,74	1,23	5,51	0,00	2,31	100
7	0,00	0,00	4,33	15,79	0,00	0,00	0,00	1,55	2,65	0,00	74,19	0,00	1,49	100
8	0,00	0,00	0,00	24,30	0,00	0,00	1,32	1,02	4,12	0,00	59,50	8,04	1,70	100
9	0,00	1,63	8,18	29,78	0,00	0,00	2,60	1,34	5,00	0,00	49,91	0,00	1,57	100
10	0,00	1,74	14,87	47,94	0,00	0,00	3,03	4,92	10,00	0,00	13,84	0,00	3,66	100
11	0,00	3,09	3,28	14,63	0,00	0,00	0,00	1,12	4,77	0,00	73,11	0,00	0,00	100
12	0,00	3,63	5,02	27,93	0,00	0,00	0,00	2,75	20,57	0,00	0,00	0,00	40,11	100
13	0,00	3,58	3,96	17,71	0,00	0,00	0,00	0,00	11,01	0,00	0,00	0,00	63,74	100
14	0,00	8,30	3,79	47,11	0,00	0,00	0,00	0,83	38,14	0,00	0,00	0,00	1,84	100
15	0,00	3,24	0,00	31,27	5,46	0,00	7,91	5,25	18,18	0,00	3,61	4,86	20,23	100
16	0,00	2,55	6,85	24,70	8,69	0,00	10,00	5,07	19,40	0,00	3,03	0,00	19,71	100
17	0,00	0,00	3,69	22,53	9,27	0,00	9,74	0,00	22,60	0,00	3,06	0,00	29,11	100
18	0,00	2,02	4,45	18,35	11,12	0,00	9,63	0,00	25,17	0,00	4,14	0,00	25,11	100
19	0,00	2,23	3,55	14,17	0,00	0,00	1,20	1,53	4,25	12,39	59,07	0,00	1,61	100
20	0,00	8,62	1,86	47,15	0,00	1,51	0,00	1,03	38,46	0,00	0,00	0,00	1,38	100

grains (see fig. 26 and tab. 7, point 3: silicon, aluminum, sodium) and related elemental maps are congruent with ultramarine blue (fig.27). The greyish grains were analyzed by SEM-EDS too, in order to determine if the grey color was originated from the discoloration of the ultramarine blue pigment. As known, this pigment, in acidic conditions, may decay in a discoloured greyish pigment. This event was not confirmed, because the chemical composition of the greyish grains differs from the blue grains one. Lead could be formerly related to the lead white pigment; if this hypothesis is confirmed, we might suppose a chemical deterioration to lead oxide (plattnerite).

Under the blue-blackish layer, a white thin area in SEM image is related to the presence of lead. It is interesting to notice that in the thin white layer a good correspondence was among lead, calcium and phosphorous; we suppose that lead white (cerussite/hydrocerussite) was used, mixed with bone black (calcium phosphate), and applied directly on the red material.

The red material is characterized by a very good overlapping among the elemental maps of iron, silicon and aluminum, corresponding probably to a red ochre; some granules of silica were observed. It seems to be a "painted" red layer above the clay material of the statue.



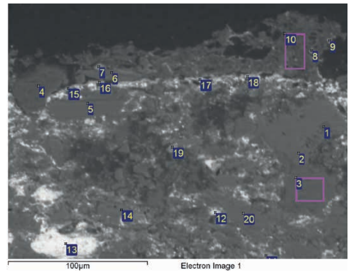


Table 8

Spectrum	Na	Mg	Al	Si	P	S	Cl	K	Ca	Ti	Fe	Br	Pb
1	3,07	5,14	10,79	45,06	0,00	0,00	2,59	2,28	28,34	0,00	0,00	0,00	2,72
2	0,00	7,9	4,83	48,98	0,00	0,00	0,00	1,35	35,5	0,00	0,00	0,00	1,55
3	6,32	1,43	21,22	43,82	0,00	0,00	3,62	3,65	16,14	0,00	0,00	0,00	3,81
4	0,00	0,77	0,95	92,36	0,00	0,00	0,00	1,16	2,84	0,00	0,00	0,00	1,92
5	0,00	14,37	9,73	43,5	0,00	0,00	1,41	22,71	4,24	1,98	0,00	0,00	2,39
6	0,00	1,69	21,04	46,57	0,00	0,00	2,34	14,56	4,74	1,23	5,51	0,00	2,31
7	0,00	0,00	4,33	15,79	0,00	0,00	0,00	1,55	2,65	0,00	74,19	0,00	1,49
8	0,00	0,00	0,00	24,3	0,00	0,00	1,32	1,02	4,12	0,00	59,5	8,04	1,7
9	0,00	1,63	8,18	29,78	0,00	0,00	2,6	1,34	5	0,00	49,91	0,00	1,57
10	0,00	1,74	14,88	47,97	0,00	0,00	3,03	4,92	10,01	0,00	13,85	0,00	3,66
11	0,00	3,09	3,28	14,63	0,00	0,00	0,00	1,12	4,77	0,00	73,11	0,00	0,00
12	0,00	3,63	5,02	27,93	0,00	0,00	0,00	2,75	20,57	0,00	0,00	0,00	40,11
13	0,00	3,58	3,96	17,71	0,00	0,00	0,00	0,00	11,01	0,00	0,00	0,00	63,74
14	0,00	8,3	3,79	47,11	0,00	0,00	0,00	0,83	38,14	0,00	0,00	0,00	1,84
15	0,00	3,24		31,27	5,46	0,00	7,91	5,25	18,18	0,00	3,61	4,86	20,23
16	0,00	2,55	6,85	24,7	8,69	0,00	10	5,07	19,4	0,00	3,03	0,00	19,71
17	0,00	0,00	3,69	22,53	9,27	0,00	9,74	0,00	22,6	0,00	3,06	0,00	29,11
18	0,00	2,02	4,45	18,35	11,12	0,00	9,63	0,00	25,17	0,00	4,14	0,00	25,11
19	0,00	2,23	3,55	14,17	0,00	0,00	1,2	1,53	4,25	12,39	59,06	0,00	1,61
20	0,00	8,62	1,86	47,15	0,00	1,51	0,00	1,03	38,46	0,00	0,00	0,00	1,38

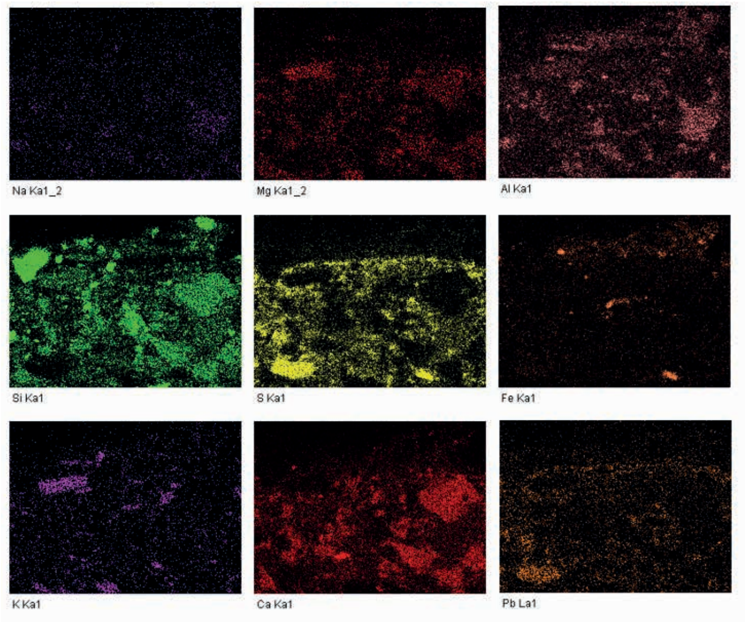


Fig. 27
Statue of Bodhisattva (from garland) from Museum Guimet (sample 19): EDS elemental maps of Sodium, Magnesium, Aluminium, Silicon, Sulphur, Iron, Potassium, Calcium and Lead.

opposite page

Table 9
EDS analyses of gilding from sample 21. Elements are expressed as atomic percent.

Table 10
EDS analyses of gilding from sample 21, *versus*: ground layer under the gilding. Elements are expressed as atomic percent.

Table 9

Spectrum Label	1	2	3	4	5	6	7	8
Cu	1,68	3,01	2,14	2,14	2,20	1,23	2,82	2,29
Ag	5,23	4,65	5,06	5,57	5,05	5,84	4,36	4,69
Au	93,09	92,34	92,80	92,29	92,75	92,93	92,81	93,03
Total	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00

Table 10

Spectrum Label	18	19	20	21	22	24
Mg	0,77	0,74	0,00	0,00	0,00	0,00
Al	2,41	2,63	1,76	3,12	1,89	2,32
Si	2,90	3,28	2,22	4,47	1,51	2,95
S	0,93	1,16	1,54	1,58	0,00	1,00
K	0,00	0,00	0,00	0,69	0,00	0,00
Ca	87,05	85,37	90,79	85,21	88,60	88,59
Fe	0,00	0,96	0,00	1,20	0,82	0,59
Au	5,95	5,85	3,68	3,73	7,19	4,55
Total	100,00	100,00	100,00	100,00	100,00	100,00

Sample 20 (n. 21 sampling)
This sample was picked up from the clay statue of seated Buddha (fig. 28). The micro-photo of the powder shows a sequence of four different painted layers: a brown-greysh layer, two different red painted layers (figg.29A and

29B). The cross-section obtained from one of the fragments clearly shows the sequence of layers (fig.30). SEM-EDS analyses of red layers show in the lower layer mainly lead probably as minium, a lead oxide (Pb_3O_4), and a little of chlorine. In the upper red layer mercury and sulphur are related to cinnabar (or vermillion); vermillion is mixed in the upper layer to red lead (see Pb vs. Cl and Hg vs. S elemental maps (figg. 31 A and 31 B, tab. 8).
The lower brown layer is characterized by a very good overlapping of the elemental maps of silicon, aluminum and potassium. Minor elements detected are iron, calcium and magnesium, not directly related to the main elements (K, Si, Al), probably as oxide (i.e. Fe_2O_3, hematite) or carbonates ($CaCO_3$, $MgCO_3$).
The chemical analyses may be explained as a clay (characterized by the main elements K, Al, Si) well mixed with iron oxides and calcium/magnesium carbonates, because the elemental maps of the main elements are not related to the minor elements (Fe, Ca, Mg).
Inside the clay ground some red-orange and black stripes on a red orange grain may be observed. The chemical spot analyses highlights iron, silicon, aluminum and potassium.
(F. T.)

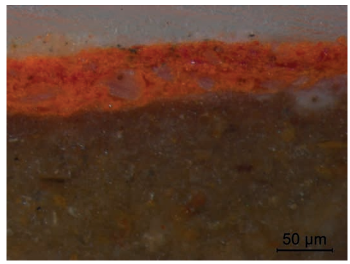


Fig. 28
Sampling of Statue of Seated Buddha from Museum Guimet: detail of the dress (sampling 20) (photo S.Pannuzi).

Fig. 29
Statue of Seated Buddha from Museum Guimet: micro-photography of sample 20 (12.5x).

Fig. 30
Statue of Seated Buddha from Museum Guimet: micro-photography of cross section of sample 20.

Gandharan artworks from Civic Archaeological Museum in Milan: chemical analyses on polychromies

Sample 21 (n. 4 sampling)

This sample has been taken from a gilded stone statue representing Budda, one of most important statues of the Milan Archaeological Museum (fig.32). The statue was made in shale and covered with a gilding; now only some spare traces of gold are preserved. This sample was representative of a gilding applied on its ground. The sample was analyzed by SEM-EDS on the *recto* (gilding) and *verso* (ground) (figg. 33, 34).
SEM-EDS analyses allowed us to understand the chemical composition of the gold leaf. Seven analyses were performed on the gold sample (see tab. 9). Gold (Au), Silver (Ag) and Copper (Cu) were found. The average (as atomic percentage) and the standard deviation (s.d.) were: Au 92.75% (s.d. = 0.3), Ag 5.06% (s.d. = 0.49), Cu 2.19% (s.d. = 2.19). The black material, partially covering the gilding, seems to be a superficial sediment, probably due to residues of excavation soil or atmospheric pollution. Its chemical composition (tab.: main elements, expressed as atomic percent) is Si (41,46%), Al (26,14%), Ca (16,58%), Fe (5,97%), K (5,78%).
The ground, *verso* side, representing the layers under the gilding the analyses revealed the presence mainly of calcium (Ca); minor elements were potassium (K), aluminium (Al), silicon (Si), iron (Fe), magnesium (Mg), sulphur (S) (tab. 10). The high content of calcium is due to calcium carbonate; gypsum, considering to the low amount of sulphur, is absent. Similar results were obtained on the EDS analyses, performed on *recto*. The high content of calcium highlights the absence of schist on this sample. Calcium carbonate has probably the function of the bolus: meant to make the gild-

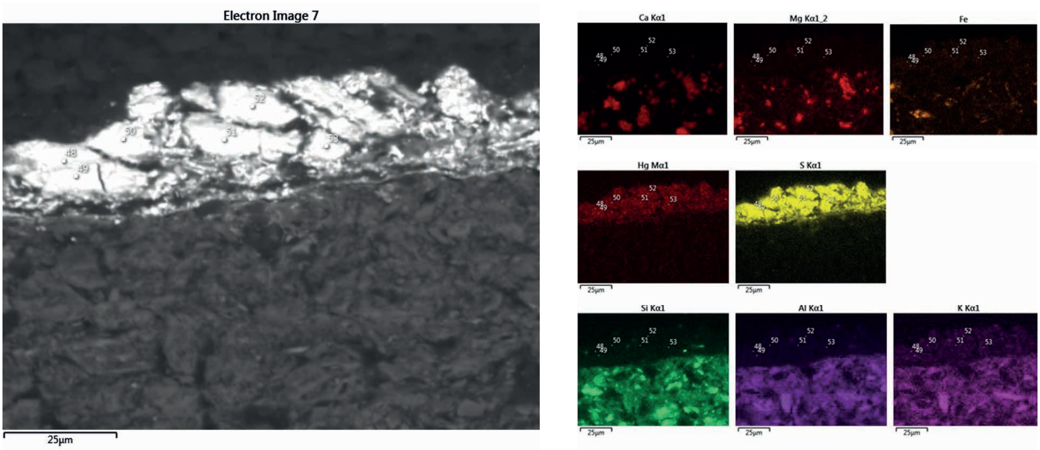


Fig. 31 a, b
Statue of Seated Buddha from Museum Guimet (sample 20).
31 a: SEM image of the cross section of the sample.
31 b: EDS elemental maps of Calcium, Magnesium, Iron, Mercury, Sulphur, Silicon, Aluminium, Potassium.

ing adhere to the schist surface of the statue. FTIR analyses confirmed the presence of a clay, perhaps a red ochre, along with calcite and dolomite.

Sample 22 (n. 5 sampling)

Sample 5 was taken from a lateral point of a painted stucco statue representing a Monk wearing a red dress (Fig. 35). Now it seems that the face and the hands of the monk were not covered with by red pigment.

The sample was analyzed by micro-FTIR and no relevant information was obtained. SEM-EDS analysis of the cross section gave more interesting results. Iron (Fe) was found in the upper part of the cross-section; Iron maps are superimposed to aluminum and silica maps. According to these result the red pigment is a red ochre. An interesting goal was observed. The cross section in visible light highlights that beneath the surface (the exterior red painted layer measures 40-50 µm) the iron concentration gradually diminished, till 400-500 µm (fig.36). This evidence may be explained relating this to the ancient painting technique of Gandharan art. The colour

Table 11
EDS analyses from sample 22. Elements are expressed as atomic percent.

Table 11

Spectrum Label	7	1	2	3	4	5	6
Na	1.86	2.97	1.32	0,00	1.31	0,00	1.53
Mg	2.06	2.65	0.94	2.93	1.76	1.57	1.61
Al	9.53	12.79	5.01	7.14	8.13	4.51	8.18
Si	19.65	25.01	9.12	10.68	14.61	8.65	15.80
S	0,00	1.43	1.05	0.54	0.87	0,00	0.91
K	1.53	2.08	0.85	0.92	0.97	0,00	1.22
Ca	60.71	48.99	79.31	73.97	68.00	83.69	66.04
Ti	0,00	0.66	0,00	0,00	0.84	0,00	0,00
Fe	3.94	3.44	2.41	3.83	3.50	1.59	4.72
Mo	0.72	0,00	0,00	0,00	0,00	0,00	0,00
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

Table 12

Spectrum Label	1	2	3	4	5	6	7	8	9
Na	1,76	1,52	1,42	1,18	1,56	2,65		1,44	
Mg	4,07	4,25	3,85	6,67	3,03	11,56	2,00	5,57	2,21
Al	7,17	4,29	1,93	9,49	10,51	15,93	0,76	11,50	0,95
Si	14,30	9,57	6,11	22,60	44,12	33,11	3,21	44,06	4,76
P				0,37					
S	1,39	2,66	0,88	0,72	1,25	0,22		0,28	
Cl	2,29	3,08	1,64	1,55	2,48	0,40	0,47	1,26	0,64
K	1,75	0,77	0,48	1,69	2,02	0,58		3,25	
Ca	62,40	69,72	82,47	50,85	32,61	15,32	93,30	28,41	91,04
Ti	0,55	1,47			0,61	4,16		0,36	
Mn						0,22			
Fe	3,85	1,97	1,23	4,89	1,41	15,84	0,27	3,86	0,40
Zn	0,46	0,72							
Mo									
Ba					0,40				
Total	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00

Spectrum Label	10	11	12	13	14	15	16	17	18	19
Na		1,70	1,88	2,18		1,80	1,04	1,35		1,44
Mg	2,00	5,28	4,96	3,97	3,52	6,65	4,28	5,26	4,29	3,55
Al	2,73	10,19	3,85	4,25	5,81	3,13	1,71	1,69	2,27	1,84
Si	12,36	40,40	16,38	13,63	58,34	11,25	12,65	8,41	8,56	7,02
P			0,44							
S		0,34	1,67	1,41	1,30	1,40	0,64	0,72	0,55	0,38
Cl	0,70	0,87	2,67	1,78	2,65	2,62	2,41	1,69	1,93	1,06
K	0,59	1,62	1,13	1,09	1,72	0,86	0,51	0,49		
Ca	80,72	34,33	58,93	68,35	24,07	71,43	75,86	78,90	81,59	84,23
Ti		0,75						0,78		
Mn										
Fe	0,67	4,51	7,54	3,35	2,22	0,87	0,91	0,72	0,81	0,49
Zn			0,53		0,37					
Mo	0,24									
Ba										
Total	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00

Table 12
EDS analyses from sample (23) (spectra 1-19). Elements are expressed as atomic percent.

is applied on a fresh layer of ground, so it diffused in the underlying stucco that is the raw material of this statue. The dough was obtained mainly by milled gypsum (more than 40%), mixed with silicates (figg. 37 A and 37 B, tab. 11). A large grain of dolomite [$(MgCaCO_3)_2$, see Ca/Mg maps] was observed. Despite of the refined execution of the statue, a simple technique was revealed by the heterogeneity of the materials and the coarse dough employed on this artifact.

Fig. 32 Sampling of schist statue of Buddha from Milan Museum (sample 21) (photo S.Pannuzi).

Fig. 33 Schist statue of Buddha from Milan Museum (sample 21): micro-photography, *recto* (10x).

Fig. 34 Schist statue of Buddha from Milan Museum (sample 21): micro-photography, *verso* (10 x).

Sample 23 (n. 6 sampling)

This sample was taken from a stucco statue representing a Bodhisattva, discontinuous traces of red pigment are visible (Fig. 38). The cross-section of this sample reveals a thin red layer 10-20 µm; its chemical composition shows the presence of red ochre for the presence of Fe, Si, Al in the upper layer of the cross-section (Fig.39). Unlike sample 5, the red pigment has not been found in the underlying layer, it is therefore probable that the pigment was applied over the dried base.

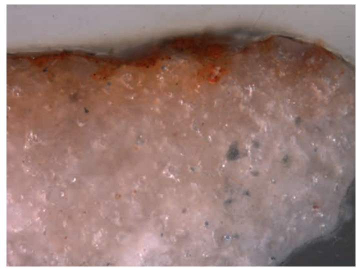
The ground too differs from the sample 5. Observing its cross-section under visible light, we observe the presence of black and red grains that characterize the ground. Grains of iron, potassium and sodium silico-aluminate sprinkled in a calcium carbonate matrix (Figg. 40, 41; tab. 12).

Elemental maps of iron, aluminum and silica are often superimposed, denoting the presence of ochres (Fig.42). We noted a very good relation among silicon, aluminum, strontium and potassium. The diffuse presence of calcium carbonate was confirmed by micro-FTIR analyses on the powder of the sample. The cross-section highlights the presence of large grains of calcium carbonate, approx. 0,2-0,3 mm, mixed inside the stucco.
Micro-XRD analyses were performed on a grounded sample: calcite, dolomite and quartz were detected; the same analysis on *tal quale* sample detected quartz, calcite and gold. This result is very interesting because gilding was not visible to the naked eye and on the cross section analyzed by SEM EDS. In next future other analyses will carry out to understand the presence of gold.

Sample 24 (n.7 sampling)
The sample was a powder picked up from a schist false corbel (*Nagadanta*) (fig.43). Micro FTIR analyses highlights the invasive presence of a synthetic adhesive, belonging to polyamides employed in a previous restoration. The strong signals of the adhesive hide the weak signals due to the original material. Only in a little fragment it was possible to observe weak signals, typical of the bands of silico-aluminate compounds.

Samples 25 and 26 (nn.8 and 9 sampling)
These samples were picked up from a relief in schist with Buddha life scenes, characterized by a superficial white layer (Fig.44). Observing the fragments under microscope and owing to the FTIR results we can assert that the upper white layer is not owed to the excavation soil or to the environment dust, it is something derived from human activity, most likely to be associated to a painting technique (Figg.45, 46).
Micro-FTIR analyses show the presence of Calcium carbonate and aluminum-silicate. Both samples were not suitable to get cross-sections.

Samples 27, 28 and 29 (nn. 10, 11 and 12 sampling)
These samples were taken from a stele, representing a Bodhisattva (Fig.47). The samples seem very similar to the samples 25 and 26, previously described: schist with a superficial white layer (fig.48). On sample 28 only the schist is visible, probably with some traces of the upper layer. Chemical analyses (FTIR) give similar results too: calcium carbonate and alumina-silicate.
(F. T.)



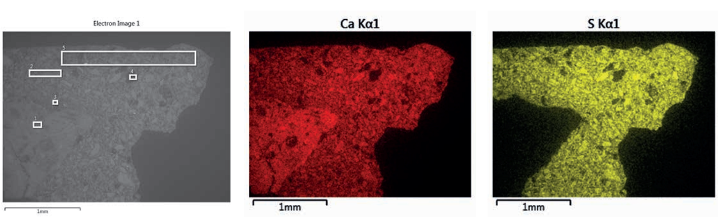


Fig. 35
Sampling of a stucco Monk statue from Milan Museum (sample 22) (photo S.Pannuzi).

Fig. 36
Statue of stucco Monk from Milan Museum: micro-photography of cross section sample 22 (50x).

Fig, 37
Statue of stucco Monk from Milan Museum (sample 22). SEM image of the sample and EDS elemental maps of Calcium and Sulphur.

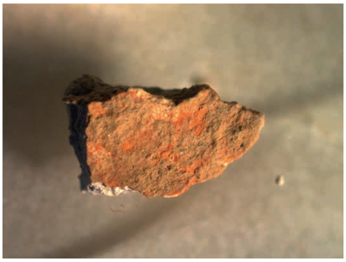


Fig. 38
Stucco statue, Bodhisattva from Milan Museum (sample 23): image of the sample 6 *tal quale* (8x).

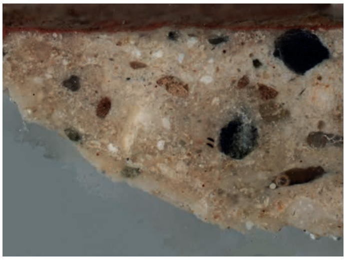


Fig. 39
Stucco statue, Bodhisattva from Milan Museum (sample 23): micro-photography of cross section (15x).

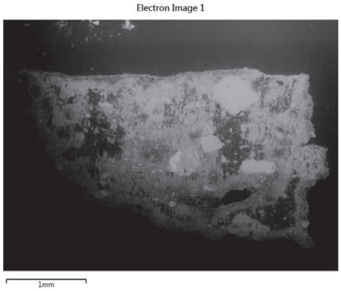


Fig. 40
Stucco statue, Bodhisattva from Milan Museum (sample 23): SEM image of cross section.

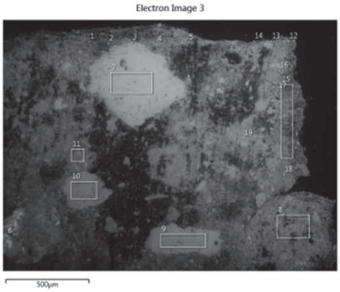


Fig. 41
Stucco statue, Bodhisattva from Milan Museum (sample 23): SEM blow up image of cross section.

Samples 30 and 31 (nn.14, 15 sampling)

These samples were taken from a schist capital of a lost pilaster (Fig.49). Grey schist and another whitish material are well shown in micro-photograph (fig. 50). The whitish material of sample 30 is analytically characterized by micro-FTIR analysis as calcite, gypsum and silicon-aluminate.
By SEM EDS analysis, in spectum 4, we noted a certain amount of calcium, probably matched to calcium carbonate, owed to a white superficial preparation layer, laid on the schist stone and used for a polychrome decoration that has now disappeared. A high amount of Fe, Ti and Zr were detected in the thin section.
Micro-Raman analyses on a red grain highlighted the presence of hematite, probably traces of ancient polychromy, not visible by naked eye.
(F. T., G. G., C. R.)

Sample 32 (n.17 sampling)

This sample was taken from the stucco Buddha's Head (Figg.51, 52). The cross-section obtained from this sample clearly shows on the right side the presence of a red layer, whereas on the left side the surface is quite orange (Fig. 53). Despite of this evidence, EDS analyses do not denote significant differences in chemical composition of the two colours: the presence of iron, aluminum, silicon as main chemical elements, in similar percent, are due to two chromatically different red colours, but chemically very similar ochres. According to FTIR and SEM-EDS analyses, the ground is mainly a mix of calcium (as carbonate) and silicon (as SiO_2). Note that magnesium was present mainly in red and orange ochres, as we can see in EDS maps of Ca and Mg.

Sample 33 (n.25 sampling)
This sample was taken from the hair of the clay head of Brahma (Fig.54). The cross section clearly highlights the sequences of the layers (Figg.55, 56). The clay plaster seems polished, in order to obtain a smooth surface coved by a thin layer of yellow paint.
Indeed, observing the cross-section at a greater magnification we notice in the upper part two layers of two very thin layers of different pigments over a rough clay plaster: a yellow pigment is applied on an underlying red pigment. EDS analyses show a good overlapping of the elemental maps of iron, magnesium and silicon, respectively due to two different ochres, a yellow and a red one.
The rough plaster was characterized by heterogeneous materials consisting in red, yellow, grey and black grains: a large red granule is observed on the right and greyish components characterize this sample. The chemical composition of the rough plaster was explained by SEM-EDS analyses: Silicon, Aluminium, Iron and Calcium and Magnesium are the main chemical elements found along the cross-section. The greyish component in the clay is composed by a calcium silicate.
(F. T)

Gandharan artworks from Museum of Oriental Art in Turin: chemical analyses on gildings

Samples 34 and 35 (nn.1 and 2 sampling)
Two samples of gilding were taken from two different sides of a schist corbel (MAO n. 4581), in order to analyse the chemical composition of gilding and its ground.
Looking at the micro-photos, the following superimposition of layers has been observed: 1) greenish grey of the schist; 2) a white ground; (3) partially browned in the upper; (4) gold leaf (Fig.57).
Sample 34 represents only the gilding and its underline layer (Fig.58).

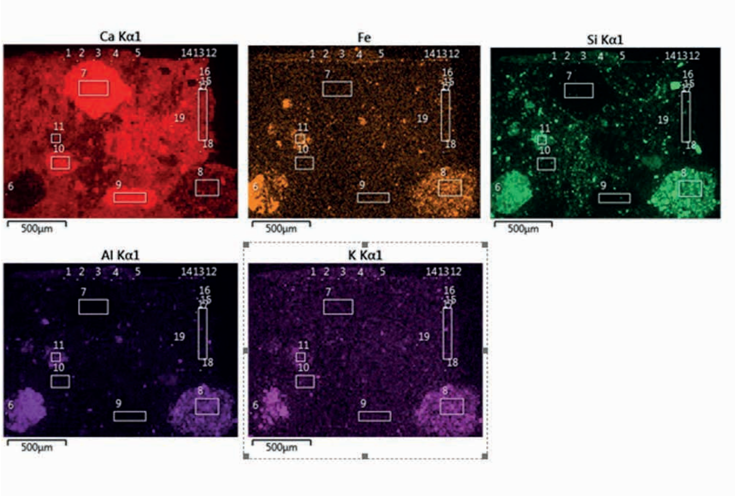


Fig. 42
Stucco statue, Bodhisattva from Milan Museum (sample 23): EDS elemental maps of Calcium, Iron, Silicon, Aluminium, Potassium.

The samples were arranged without any preliminary treatment on the *stub* and analyzed by SEM-EDS (Figg.59, 60). In sample 1 gilding is characterized by gold leaf with a little amount of copper (Au = 97,64%; Cu = 2,36%) (tab. 13). Under the leaf the browned ground is a silicate compound, characterized by variable amounts of silicon, calcium, aluminum, magnesium and iron.

Micro-photo of sample 35 shows the golden leaf with browned ground, similar to the previous one (Fig.61). Micro-photography highlights some traces of manufacturing of the gold leaf, such as the curved lines on the left of the micro-photo. Its chemical composition is very similar to the sample 1 (Au = 96,85%; Cu = 3,15%) (Figg.62, 63, tab. 14).

The only important difference between these two samples of gilding is a not negligible presence of lead (its amount is few less than 10%), only found upon some gilded areas. This occurrence is hard to explain. Observing micro-photos we are led to exclude the presence of red minium or other lead oxides, such as the lead white. A hypothesis might be made: the lead comes from air pollution.

EDS analyses on brownish ground give a good overlapping among the elemental maps of silicon, aluminum, calcium, magnesium, iron. These results are very similar to that obtained for sample 34.

(F. T)

Conclusive comment about the analyses

The results discussed in this new research comes from a notable number of chemical analyses. Micro-photos of sample were collected under opti-

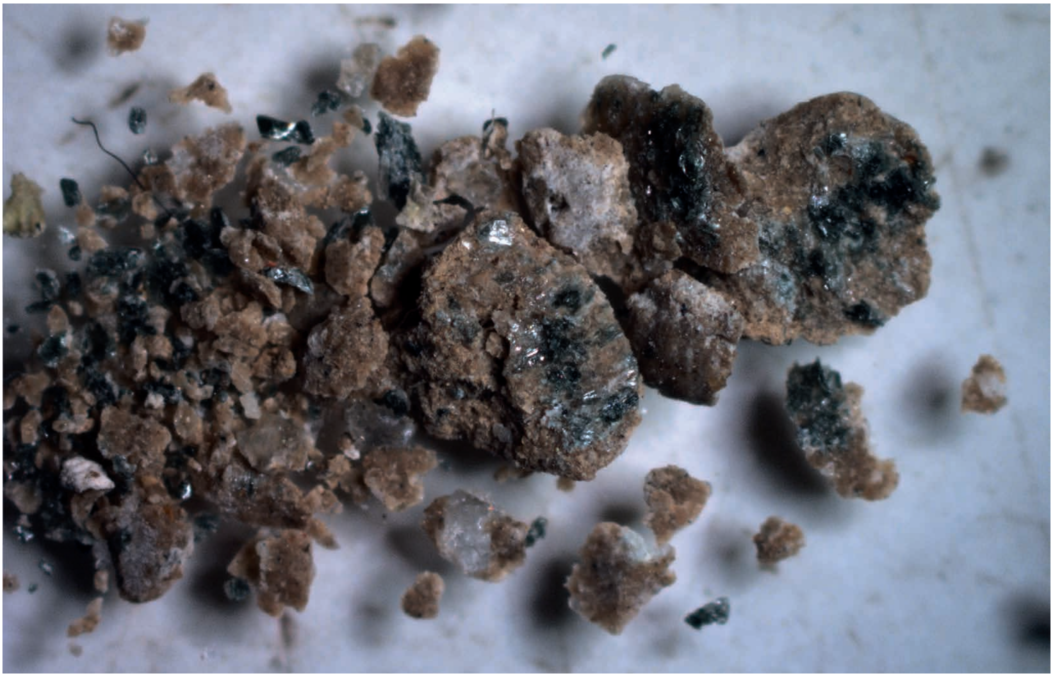


Fig. 43
Schist false corbel from Milan Museum: microphotography of sample 24 (8x).

Table 13

Spectrum Label	1		2		3		4	5	
O	15,24		15,37		14,98		18,97	15,06	
Na			0,31						
Mg	0,59		0,56		0,58		0,95	0,59	
Al	1,23		1,42		1,27		2,76	1,27	
Si	2,48		2,52		2,38		5,36	2,50	
S									
Cl									
K	0,45		0,52		0,45		1,35	0,44	
Ca	2,55		2,29		1,86		2,49	2,26	
Ti									
Fe	0,87		0,87		0,80		1,32	0,77	
Cu	1,87	2,50	1,57	2,11	1,79	2,36		0,74	0,99
Au	74,73	97,5	74,58	97,89	75,91	97,64	66,80	76,37	99,01
Total	100,00		100,00		100,00		100,00	100,00	

Spectrum Label	6	7	8	9	10	11	12
O	25,82	42,55	34,01	40,65	40,42	16,15	37,98
Na	0,55				0,48		
Mg	0,94	3,06	2,74	11,39	1,72	0,77	6,47
Al	2,93	4,83	5,11	9,29	13,15	1,74	5,62
Si	12,49	23,72	9,78	15,21	17,81	3,00	12,10
S		2,18	1,63	1,23	1,18		3,43
Cl		0,42	0,54	0,31	0,22		0,52
K	0,76	1,45	1,37	1,02	5,55	0,63	1,01
Ca	2,63	8,71	27,60	7,32	4,40	3,26	17,55
Ti	0,15				0,38		
Fe	1,48	3,52	3,91	5,67	2,58	1,09	4,45
Cu	0,63		0,38				
Au	51,61	9,56	12,94	7,91	12,11	73,36	10,88
Total	100,00	100,00	100,00	100,00	100,00	100,00	100,00

cal stero-microscope (Leica M125). Cross-sections of greater samples were achieved embedding any sample in polyester resin and observed and photographed under optical microscope (Leica DM-RXP). Samples (as micro-fragment, powder or cross sections) were analysed by SEM-EDS (Evo 60 Zeiss), collecting data as chemical maps and spot chemical analyses. Micro-FTIR analyses were performed after a preliminary study under optical microscope. After this preliminary selection, the samples were housed on a diamond cell and then analysed under micro-FTIR spot by spot. In addition, some micro-XRD and micro-Raman analyses were carried out.

Table 13
EDS analyses from sample 34 (spectra 1-12). Elements are expressed as atomic percent.

Fig. 44
Sampling of schist relief from Milan Museum (sample 25) (photo S.Pannuzi).

Fig. 45
Schist relief, micro-photography of sample 25 from Milan Museum (16x).

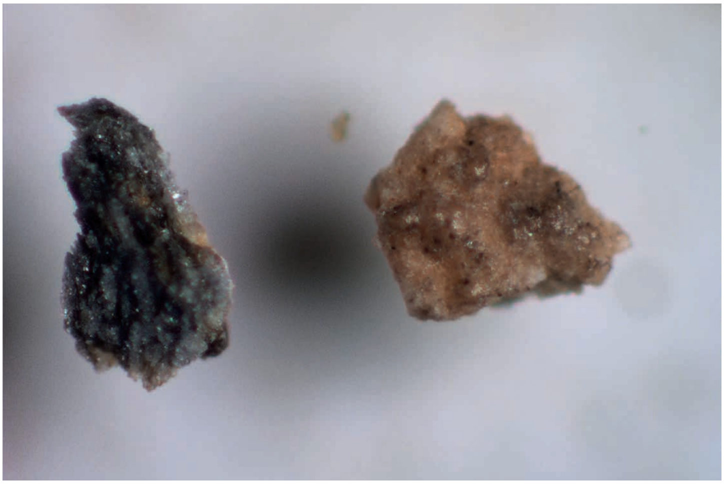


Table 14

Spectrum Label	1	2	3	4	5	6	7
Ca	0,00	1,38	1,34	2,38	2,84	0,55	0,67
Mg	0,00	0,65	0,77	0,59	0,67	0,00	0,33
Al	0,88	1,88	2,11	1,96	1,80	0,00	0,89
Si	1,10	2,83	3,36	2,98	2,85	0,98	1,33
Cl	0,00	0,00	0,00	0,00	0,00	0,00	0,00
K	0,00	0,48	0,58	0,59	0,57	0,16	0,25
Ti	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Fe	0,58	1,24	1,27	1,20	1,46	0,44	0,51
Cu	2,11	2,20	1,73	2,15	2,54	2,09	1,73
Au	85,34	81,36	88,84	81,39	80,50	85,01	85,52
Pb	9,99	7,98	0,00	6,76	6,77	10,77	8,76

Spectrum Label	8	9	10	11	12	13	14
Ca	12,35	6,31	8,39	3,29	13,79	17,71	3,29
Mg	2,01	2,19	3,71	2,08	2,23	4,61	1,66
Al	5,42	6,03	12,72	17,27	13,11	8,49	4,57
Si	8,98	9,08	27,46	23,30	18,07	17,47	7,59
Cl	0,00	0,00	0,00	0,00	0,64	6,80	0,00
K	2,81	2,24	5,52	7,67	5,06	2,65	1,29
Ti	0,52	0,52	0,00	0,46	0,00	0,00	0,00
Fe	14,85	17,52	6,55	3,90	3,39	5,48	2,70
Cu	1,95	2,31	1,25	1,07	0,00	0,00	2,02
Au	51,11	53,79	34,41	40,97	43,72	36,78	76,89
Pb	0,00	0,00	0,00	0,00	0,00	0,00	0,00

Table 14
EDS analyses from sample 35 (spectra 1-14). Elements are expressed as atomic percent.

In this research we analysed the artistic technique of painting on sculptures of Gandharan art made in different materials (stone, stucco and clay). A white layer was observed under the pigment in a lot of the artifacts analyzed, often in little amounts, as a residue of the lacked painting used to decorate the surface of the artworks. This layer in painting plays the role of "ground" for the pigments. Often in the past it was accidentally removed with the soil during the cleaning operations performed in the excavation operations.

As regarding the red pigments studied in this work, we found that ochre was the most frequently employed pigments. Ochre are characterized by the presence of iron oxides and aluminum-silicates; their colour may differ one to the other mainly by the chemical composition, the oxidation number of iron, and different amounts of crystallized water. In red ochre a strict relation among silicon, iron and magnesium was noted. More, a lead red-orange pigment was employed. As only EDS chemical analyses were carried out without mineralogical insights, we believe that minium, a red

Fig. 46
Schist relief, microphotography of sample 26 (16x).

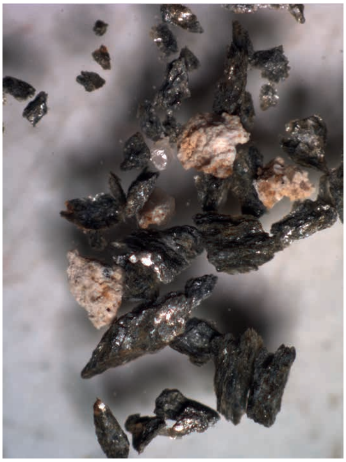


Fig. 47
Sampling of schist Bodhisattva (sample 27) from Milan Museum (photo S.Pannuzi).

Fig. 48
Schist Bodhisattva: micro-photography of sample 29.

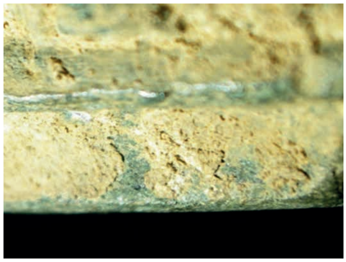


Fig. 49
Sampling of schist capital from Milan Museum (samples 30, 31) (photo S.Pannuzi).

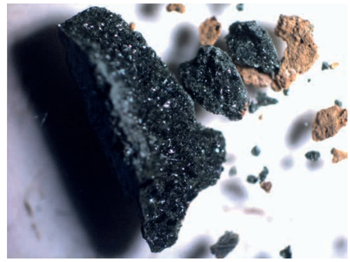


Fig. 50
Schist capital from Milan Museum: micro-photography of sample 30 (16x)

oxide, was used; however, we cannot be completely excluded other lead oxides, such as litharge and massicot.
In next future we will examine this issue. In a few cases, vermillion pigment, a mercury sulfide, was also found.
The technique of applying colours shows some differences in the artifacts studied. An interesting feature was observed on the head of Salabhanjika from Hadda, kept in Museum Guimet (samples 6 and 7), having a high level of manufacturing. Indeed, the cross-section of sample 7 shows red ochre mixed with yellow ochre. In the surface a very thick layer of lead oxide minium was superimposed to the ochre layer, that are not undamaged. This suggests that the head was re-painted with a different pigment, having a red-orange hue.
Ochre pigments were frequently employed in yellow hue too. Lead oxide pigments (massicot/litharge) and orpiment, an arsenic sulphide, were found.
Some blue hue was obtained with ultramarine blue (lapis lazuli). No copper pigments, as azurite and chrysocolla, were found. Some modern synthetic blue pigments containing cobalt and tin were found on an important sculpture (sample 18 from Museum Guimet). We can suppose that this is a trace of a modern restoration[50].
Black pigments were obtained from bone calcinations.
By micro-XRD we analysed the stucco sample form Bodhisattva statue kept in Milan Museum (sample 23): calcite, dolomite and quartz were identified. As calcite is the binder of the stucco, dolomite and quartz are the inert components of the plaster. It is very interesting the presence of dolomite in this stucco sample, that could be used as a marker to identify the source of the stone materials used into the stucco. This information is very important because the origin of this artwork is uncertain as it comes from antique market.

[50] See Cambon in this issue.

Some gildings and their different ground layers were studied. Gold was applied as a leaf. Its purity is around 98%, the remaining was copper, and very little silver.

In the case of the sample from the corbel of the Turin Museum micro-photos well describe the sequence of the overlapped layers: over the schist we observe a whitish layer of ground, partially browned in the upper. Its chemical composition is similar to a clay material: silicon, aluminum, calcium, magnesium, iron characterize this ground. Gold leaf was applied on this ground. The origin of the brownish layer is not clear. Probably it is due to a chemical decay of an organic binder, because we observe this colour even under the leaf gold. We exclude that the browning was originated by air pollution. We would examine this sample by other analyses about the binder (GC-MS and Proteomics analyses).

In the next future, we intend to carry on with other analyses on some of these samples to verify important issue showed by the investigations *supra* highlighted. Furthermore, we also hope to increase the sampling of the Gandharan artworks to verify some hyphoteses suggested in this our research.

(F. T., S. P.)

Acknowledgments

L. M. Olivieri, A. Filigenzi, P. Cambon, A. Provenzali, C. Ramasso, T. Theye, C. A. Garzonio, M.P. Colombini, I. Bonaduce, A. Lluveras Tenorio, M. Vidale, A. Gozzi, L. Giorgi, D. Mannetta, G. Forgione.

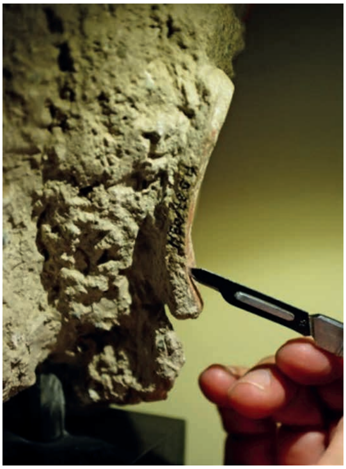


Fig. 51
Sampling of Stucco Buddha head from Milan Museum (sample 32) (photo S.Pannuzi).

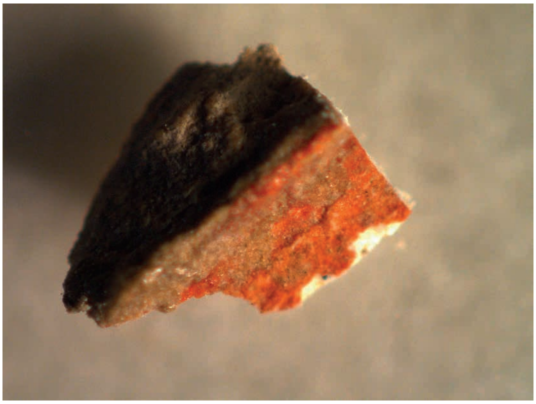


Fig. 52
Stucco Buddha head from Milan Museum: micro-photography of sample 32 (16x).

Fig. 53
Stucco Buddha head from Milan Museum (sample 32): micro-photography of cross section (25x).

Sampling list 2015-2016

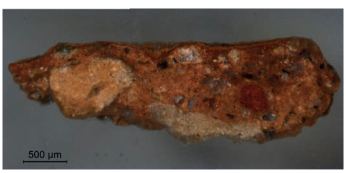
N.	N. sampling	Museum Inv.	Artwork	Sampling description
			Museum Guimet, Paris	
1	1	MA 6295	Elephant schist statue (M.G.Fremont gift 1996)	White ground layer from back
2	2	MA 6295	Elephant schist statue (M.G.Fremont gift 1996)	Schist from back
3	3	AO 2956	Schist relief from Buner Valley (Pakistan)	Pale yellow ground layer from base
4	4	AO 2956	Schist relief from Buner Valley (Pakistan)	Schist from the left side
5	5	AO 2908	Schist statue of Bodhisattva Maitreya from Pakistan, III-IV century A.D.	White ground layer from foot
6	6	MG 17203	Stucco head of Salabhanjika from Hadda, Tapa- i-Kafariha monastery (Afghanistan), III century A.D.	Red layer from headgear
7	7	MG 17203	Stucco head of Salabhanjika from Hadda, Tapa- i-Kafariha monastery (Afghanistan), III century A.D.	Pinkish layer from cheek
8	9	Barthoux mission (1928) no number	Limestone relief from Hadda, Tapa- i- Kafariha monastery (Afghanistan), II-III century A.D.	Red layer from a figure
9	10	Barthoux mission (1928) no number	Limestone relief from Hadda, Tapa- i- Kafariha monastery (Afghanistan), II-III century A.D.	Red layer from a figure
10	11	Barthoux mission (1928) no number	Limestone relief from Hadda,Tapa- i- Kafariha monastery (Afghanistan), II-III century A.D.	Blue-greyish layer from a hair of a figure
11	12	MG 17191	Limestone relief from Hadda, Chakhil- i- Ghoundi monastery- stairway of stupa C1 (Afghanistan), II-III century A.D.	White ground layer from a figure
12	13	MG 17478	Schist statue of Buddha from Paitava monastery (Afghanistan, Kapiça region), III century A.D.	Gilding with red ground (bolus) from arm
13	14	MG 17478	Schist statue of Buddha from Paitava monastery (Afghanistan, Kapiça region), III century A.D.	Red ground (bolus) from the left side
14	15	MG 22148	Schist relief from Shotorak monastery (Afghanistan), II-III century A.D.	Red ground (bolus) with traces of gilding from base
15	16	MG 18957	Clay statue of two Naga Kings from Fundukistan monastery Ghorband Valley (Afghanistan), VII century A.D.	Blue colour layer from hair
16	17	MG 18597	Clay statue of two Naga Kings from Fundukistan monastery Ghorband Valley (Afghanistan), VII century A.D.	Blue colour layer from arm
17	18	MG 18597	Clay statue of two Naga Kings from Fundukistan monastery Ghorband Valley (Afghanistan), VII century A.D.	Pale yellow layer from ear

N.	N. sampling	Museum Inv.	Artwork	Sampling description
18	19	MG 18959	Clay statue of Bodhisattva from Fundukistan monastery Ghorband Valley (Afghanistan), VII century A.D.	Blue-blackish colour layer from hair
19	20	MG 18959	Clay statue of Bodhisattva from Fundukistan monastery Ghorband Valley (Afghanistan), VII century A.D.	Blackish colour layer from garland
20	21	MG 18970	Clay statue of seated Buddha from Fundukistan monastery Ghorband Valley (Afghanistan), VII century A.D.	Orange layer with ground layer from drapery dress
			Civic Archaeological Museum of Milan	
21	4	A.09.10692	Schist standing Buddha, II-III century A.D.	Gilding with ground layer from drapery dress
22	5	A.988.02.1	Painted stucco Monk, IV-V century A.D.	Red layer and stucco from the right side
23	6	A.990.04.1	Painted stucco Bodhisattva, IV century A.D.	Red layer with ground layer from arm
24	7	A.996.01.3	Figurative schist false corbel (Nagadanta)	Whitish layer from drapery dress
25	8	A.09.21700	Schist relief with Buddha life scenes, I-II century A.D.	Whitish ground layer from architectural motif
26	9	A.09.21700	Schist relief with Buddha life scenes, I-II century A.D.	Whitish ground layer from figure
27	10	A.09.2921	Schist Bodhisattva stele, II-IV century A.D.	White ground layer from drapery dress
28	11	A.09.2921	Schist Bodhisattva stele, II-IV century A.D.	Schist with traces of ground layer from the top
29	12	A.09.2921	Schist Bodhisattva stele, II-IV century A.D.	White ground layer from drapery dress
30	14	A.990.05.1	Figured schist capital of a pillar, I-II century A.D.	Schist with whitish ground layer from base
31	15	A.990.05.1	Figured schist capital of a pillar, I-II century A.D.	Schist with whitish ground layer from base
32	17	A.987.03.1	Stucco Buddha head	Red layer from ear
33	25	A.09.9421	Clay Brahma head	Yellow layer from hair
			Oriental Art Museum of Turin	
34	1	4581	Schist corbel, probably I-II century A.D.	Gilding from bottom
35	2	4581	Schist corbel, probably I-II century A.D.	Gilding from the top

Fig. 54
Sampling of clay Brahma head from Milan Museum (sample 33) (photo S.Pannuzi).

Fig. 55
Clay Brahma head from Milan Museum (sample 33): micro-photography of cross section of the sample.

Fig. 56
Clay Brahma head from Milan Museum, micro-photography: blow up of cross section of the sample.



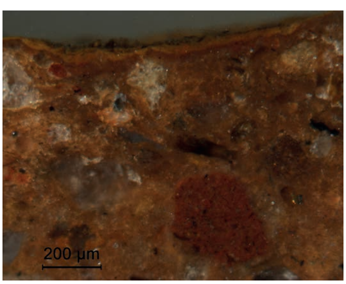


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Fig.57
Schist gilded corbel from MAO of Turin, detail of the sampling (photo S.Pannuzi).

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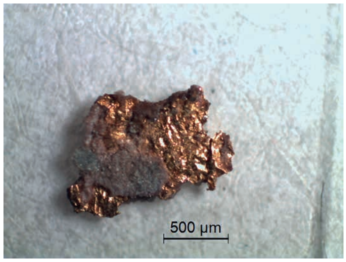
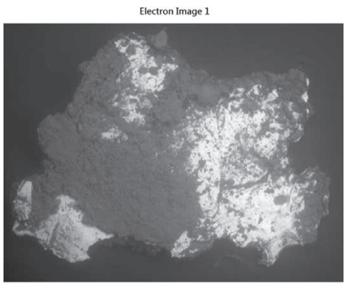
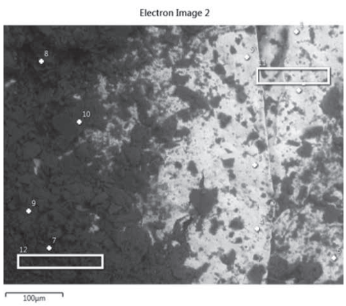
Fig. 58
Schist gilded corbel from MAO of Turin: microphotography of sample 34.

Fig. 59
Schist gilded corbel from MAO of Turin: SEM image of sample 34.

Fig. 60
Schist gilded corbel from MAO of Turin: SEM blow up image of sample 34.







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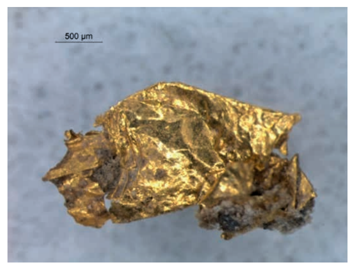

Fig. 61
Schist gilded corbel from MAO of Turin: microphotography of sample 35.

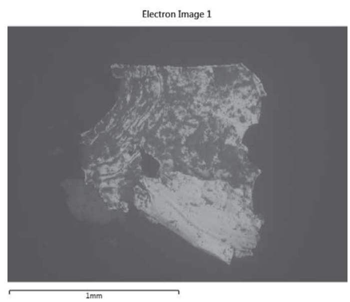

Fig. 62
Schist gilded corbel from MAO of Turin: SEM image of sample 35.

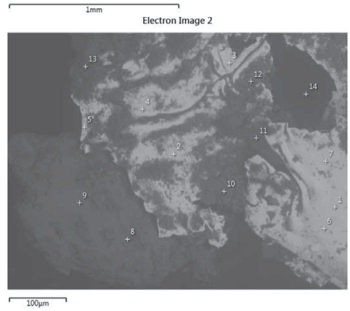

Fig. 63
Schist gilded corbel from MAO of Turin: SEM blow up image of sample 35.

The characterisation of paint binders in the polychromies and gildings of the Gandharan artworks

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pagina a fronte

Fig. 3
Painted clay Brahma head from Milan Museum (A.09.9421, sample 25) (photo Simona Pannuzi).

Abstract

In a polychrome artefact, coloured paint layers are applied on architectural elements or sculptures. Paint layers are made up of the colour, which is most typically an inorganic pigment and, with the exception of frescos, an organic binder, which enables the pigment to be dispersed and applied with a brush. From an analytical point of view the characterisation of organic paint binders is very challenging: the organic matter represents a very small amount of the total weight of the sample which is very small and aged. In this paper we describe the analytical approach applied for the characterisation of samples collected from a selection Gandhara polychromies. The analytical strategies and techniques employed are described and examples of the results obtained are presented.

Introduction

In a polychrome artefact, coloured paint layers are applied on architectural elements, sculptures, etc (Harris, 1977). Paint layers are always made up of the same fundamental components: the colour, which is most typically an inorganic pigment — a fine powder of inorganic coloured material — and, with the exception of frescos, an organic binder, which enables the pigment to be dispersed and applied with a brush. The organic binder is a fluid material that, upon drying and curing, produces a solid and elastic film, which keeps the pigment particles together, and ensures the adhesion of the coloured layer on the support. In the course of the centuries, artists have always experimented with a variety of organic natural materials to be used as paint binders, alone or in mixture, which are all based on four main classes of natural occurring organic compounds - proteins, lipids, carbohydrates and terpenoids (Mills and White, 2012). In most cases artists used many layers of paint to produce the wanted aesthetical effects, making a polychromy a complex, highly heterogeneous, multi-material and a multi-layered structure.

RA 2 | 2019, pagg. 80 | 87
ISSN 1724-9686 (print) | ISSN 2465-2377 (online)

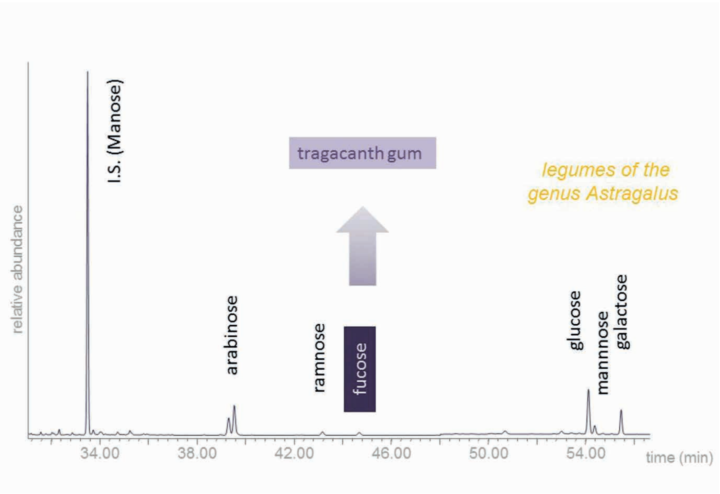
The chemical analysis of organic paint binders

From an analytical point of view the characterisation of organic paint binders is very challenging (Colombini et al., 2010). Several organic materials are often simultaneously present in the layered structure, mixed with inorganic materials. In these mixtures, the organic matter represents a very small amount of the total weight of the sample (a few percentage points in the overall weight, or even lower), and the sample is, for obvious reasons, very small (0.1-100 mg). Moreover, non-original compounds, which have formed as a result of curing and ageing, interaction with the environment as well as other materials simultaneously present, or which were introduced during past restoration treatments, are also present.
As a result of all this, analytical approaches must be specifically developed for the characterisation of organic materials in the field of cultural heritage, and much research has been devoted at this task by the scientific community (Colombini et al., 2010; Vinciguerra et al., 2016; Bonaduce et al., 2016; Cartechini et al., 2010; Dallongeville et al. 2015;, Calvano et al., 2016).
Among the paint binders used in ancient polychromies, saccharidic and proteinaceous materials are the most commonly found, from the Far East to the Mediterranean Basin (Bonaduce, Ribechini et al. 2016), as for example the polychromy of the Terracotta Army, Xi'an, China (3^{rd} century BC (Bonaduce et al., 2008)), that of the lost Giant Buddhas of Bāmiyān, Aghanistan, (6th-7th century AD) (Lluveras-Tenorio et al., 2017), and the murals of the Palace of Nestor, Pylos, Greece (13^{th} century BC (Brécoulaki et al., 2012)).
Saccharidic and proteinaceous materials were both identified in the samples collected from a selection Gandhara polychromies, and in the following paragraphs their analysis is discussed and examples are presented.

Saccharide materials

Plant gums are the most commonly used saccharide materials as paint binders. These are naturally occurring polysaccharides, exuded from several species of plants or extracted from the endosperm of some seeds, in-

Fig. 1 Chromatogram in the SIM mode relative to the fraction containing the saccharide material of a polychrome sample coming from an excavation site in Afghanistan (Tapa Sardar, bulk sample), and dated to Late Gandharan period. Chromatographic peaks correspond to the different sugars identified. I.S. corresponds to internal standard of derivatisation (mannitol).



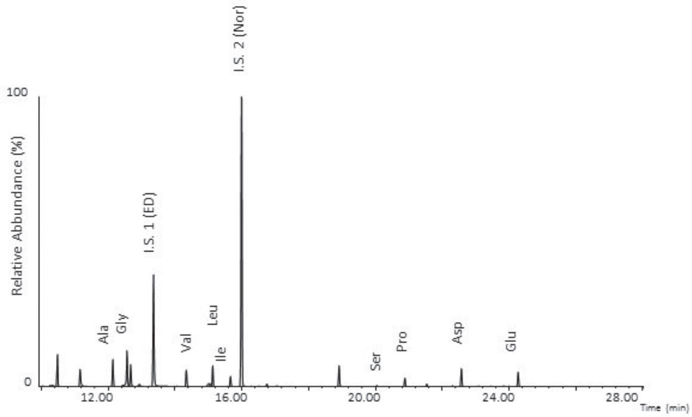


Fig. 2
Chromatogram in the SIM mode relative to the fraction containing the proteinaceous material of a polychrome sample coming from an excavation site in Pakistan, and dating back to the 3rd century AD (sample AKD14C, preparation layer). Chromatographic peaks correspond to: S.I.1 corresponds to internal standard of injection (Hexadecane), S.I.2 corresponds to internal standard of derivatization (norleucine).
Amino acids:
Ala=alanine; Gly=glycine; Val=valine; Leu=leucine; Ile=isoleucine; Prot=proline; Ser =serine; Phe=phenylalanine; Asp=aspartic acid; Glu=glutamic acid.

cluding arabic gum, exuded from *Acacia Senegal* and *Acacia Seyal* plants, tragacanth gum, exuded from *Astragalus genus* plants, and fruit tree gum, obtained mainly from cherry, apricot, peach and plum trees. Honey is also a saccharide material, which has been used as additive to increase the cohesion of paint layers in ancient polychromies (Lluveras-Tenorio et al., 2017). From the chemical point of view, plant gums are made up of aldoses (xylose, arabinose, fucose, rhamnose, mannose, galactose) and uronic acids (glucuronic and galacturonic acids) - polymerised thought the glycoside bond, while honey contains free ketose (fructose) and aldose (glucose). The most common approach for the analysis of saccharide materials aimed at their identification in a paint sample is based on the use of gas chromatography coupled to mass spectrometry (Colombini et al., 2010). The analysis of polysaccharides by gas chromatography requires an initial chemolysis step to free the sugars, that is a chemical reaction to decompose the original polymer into the constituting building blocks: the sugars (Andreotti et al., 2008). The choice of GC is driven by the fact that several sugars are isomers and thus the resolution and determination of the molecular profile is essential in order to identify the source of the saccharide material. The identification of the source of the saccharide material is then based on the evaluation of molecular profiles, and on the comparison between the chromatographic sugar profile of the sample with that of reference gums (Bonaduce et al., 2007). The presence of mixtures of saccharide materials, the effect of ageing, interaction with inorganic materials, biological and environmental contaminations can all affect the sugar profile of a sample from a paint or polychromy, seriously challenging the data interpretation (Lluveras-Tenorio et al., 2012).
A sample scraped from one of the paint layers of a polychrome fragment coming from an excavation site in Afghanistan (Tapa Sardar bulk sample), probably dated to Late Gandharan period, showed the presence of aldoses above the detection limit of the procedure used, indicating that they did not originate from environmental contamination (Lluveras et al., 2009).

The saccharide profile comprised arabinose, rhamnose, fucose, glucose, mannose and galactose (Figure 1). The evaluation of the saccharide profile, its comparison with a database of reference materials (Lluveras-Tenorio et al., 2012), and an evaluation of its level of contamination, suggests the possible identification of tragacanth gum as the polysaccharide binder used in this paint layer materials (Lluveras-Tenorio et al., 2012).

Proteinaceous materials

Among the proteinaceous materials, those that most commonly have been used as paint binders (Mills and White, 2012) are:

animal glue, obtained by boiling bones, hide or other cartilaginous parts of animals. It is made of (partially hydrolysed) collagen;

egg, which can be used whole, or using only one of its components: the yolk or the glair. Dry whole hen's egg contains 45% of proteins, 41% of fats, and 2% of cholesterol. Ovoalbumin (54%), conalbumin (12%), ovomucoid (11%), e lysozyme (3.4%) are the most abundant proteins;

milk. Milk is a water emulsion of proteins and lipids. Dry cow milk contains 26% of proteins (casein, lactalbumin, lactoglobulin), 26% lipids, and sugars.

From the chemical point of view, a protein is made up of amino acids. Twenty are the natural amino acids, which are biosynthesised in cells: alanine - ala; arginine - arg; asparagine - asn; aspartic acid - asp; cysteine - cys; glutamine - gln; glutamic acid - glu; glycine - gly; histidine - his; isoleucine - ile; leucine - leu; lysine - lys; methionine - met; phenylalanine - phe; proline - pro; serine - ser; threonine - thr; tryptophan - trp; tyrosine - tyr; valine - val. In proteins of our interest, another amino acid is very imprortant, hydroxyproline (hyp), which can be found in animal glue, and is produced in a post-translational modification. In a protein, amino acids are bonded one to the other through the peptide bond, constituting natural high molecular weight polymers. From the analytical point of view, several analytical approaches have been proposed, which can be used to identify and characterise proteins in samples from paintings and polychromies (Dallongeville et al., 2015). They can be based on spectroscopic, immunochemical or mass spectrometric approaches. Proteinaceous materials can be analysed by GC-MS after decomposition of the polymer into its constituent building-blocks, the amino acids (Colombini et al., 2010). The sequence of the amino acids (relative abundances and order) determines the characteristics of each protein. For this reason, a way of distinguishing a protein from the other after GC-MS analysis, is to compare relative amino acidic composition of the sample to a database of amino acid profiles of reference materials (Dallongeville et al., 2015).

A sample collected from a polychrome decoration on plaster coming from an excavation site in Pakistan, and dating back to the 3rd century AD (sample AKD14C, preparation layer) showed the presence of amino acids above the limit of detection, indicating that they were not originating from environmental contamination. The chromatogram is show in Figure 2.

Protein name	Matching peptides	Sequence coverage
collagen alpha-1(I)	11	10%
collagen alpha-2(I)	10	12%
collagen alpha-1(III)	5	5%

Table 1
Results of the proteomics analysis of a sample from an excavation site in Pakistan, and dating back to the 3rd century AD (sample AKD14C, paint layer).

Source	Sample codes	Results
Milan Museum (2-3rd A.D.)	A.09.10692	animal glue
Milan Museum (4-5rd A.D.)	A.988.02.1	animal glue
Milan Museum	A.09.9421	animal glue
Paris, Museum Guimet (7rd A.D.)	MG 18957	animal glue, milk, egg
	MG 18959	animal glue, milk, egg
Pakistan, Swat, Barikot (second half of 3rd A.D.)	BKG 1123A BKG 1123B	traces of proteins – source not identified
Afghanistan,Tapa Sardar (probably Late Gandhara)	no code	tragacanth gum traces of proteins – source not identified in the paint layer
Pakistan, Swat, Amluk-dara (late 3rd AD)	AKD14C	animal glue in the paint layer and egg in the preparation

Table 2
Results of all investigation performed so far using both GC-MS and MS proteomics approaches on samples from Gandhāra polychromies.

As amino acids were only present at the trace level (that is below the level of quantitation), quantitative comparisons between the sample amino acid profile, and the databases of profiles of reference materials was thus not possible. The absence of hydroxyproline, though allows us to asses that animal glue is absent, and possibly milk or egg were used.

One of the most promising analytical approaches to identify proteins currently available is that based on proteomics, and most commonly bottom-up proteomics. Proteomic was introduced in the field of cultural heritage about thirteen years ago (Tokarski et al., 2006), and was imported from the clinical and biological research. In a bottom-up proteomic approach, proteins are extracted from the sample and subsequently treated with an enzyme -trypsin in the vast majority of the cases - to obtain specific peptides. These peptides are then analysed by mass spectrometry (Dallongeville et al., 2015). Unlike GC-MS, this approach allows to retain information on the amino acid sequence in the peptide, resulting in the fact that, proteomics enables us to unequivocally identifying a protein, and, in some cases, even the biological source of the protein.

Proteomics was used to analyse also a selection of the polychrome samples from Gandhara (fig.3). As an example, the results of the proteomics analysis of another sample from an excavation site in Pakistan, and dating back to the 3rd century AD (sample AKD14C, paint layer), are reported in Table 1.

The identification of 26 peptides ascribable to collagen allows us to ascertain the presence of animal glue in the sample. Moreover, a comparison of the peptide sequences with the available databases, allowed us also to identify the biological source of the collagen: bovine.
Results of all investigation performed so far using both GC-MS and MS proteomics approaches to determine organic binders in samples from Gandhāra polychromies are summarised in Table 2.

Conclusions

Scientific investigations of organic materials in polychrome objects may help us to unravel the complex, structured mixtures of aged natural materials that constitute paint layers. Identifying the materials present in polychrome objects, organic binders and pigments, is also fundamental to reconstruct the original appearance of the artifact, and can also contribute to the selection of suitable preservation strategies to be put in place in the course of a conservation treatment. Moreover, such knowledge is of great use in improving our understanding of cultural traditions, technical know-how, knowledge circulation of a certain period of time in a specific geographical area, finally helping to recreate a more accurate picture of our past. It has to be kept in mind, though, that each analytical technique gave us information only on a specific chemical aspect of the investigated material; thus, complex problems may be solved by using a wide range of techniques and exploiting the synergy of complimentary data and knowledge. In this context it is important to stress that, when planning an analysis, the questions to be answered are the key in determining the analytical approaches to be used. This entails a detailed discussion of the problematics between the conservator, the archaeologist and the analytical chemist. Also, scientific investigation should take place before conservation treatments are undertaken, in order to avoid the loss and/or contamination of the residual polychromies remaining on the object, irredeemably loosing forever such inestimable traces of our past.

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

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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

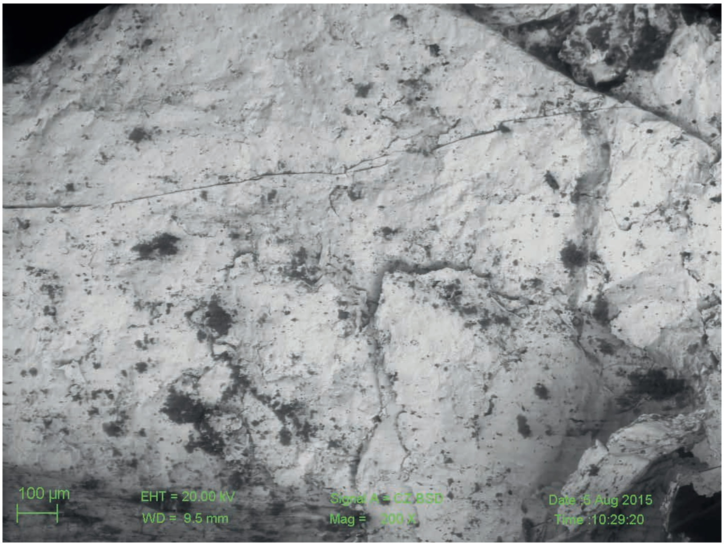

Fig. 1.
ESEM view of Sample BKG-107, a cluster of gold sheet microfragments probably detached from the surface of an object made of a decayed organic material (G. Guida, ISCR, Roma). Note the double layer of gold foil (200 X).

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-

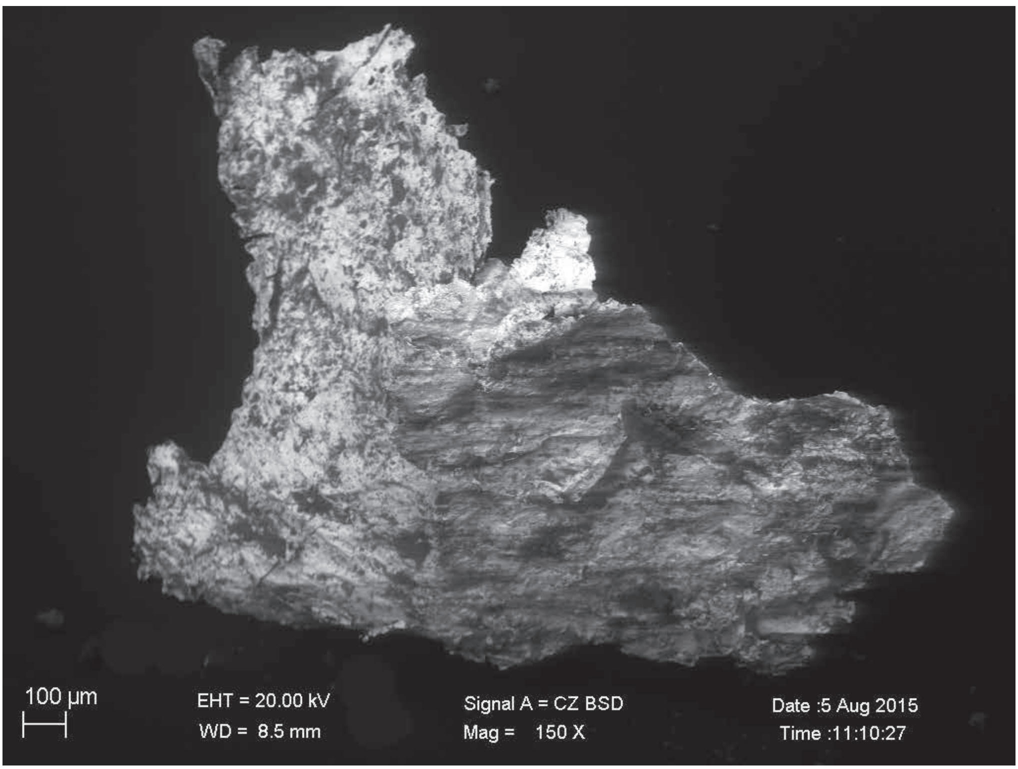

Fig. 2
ESEM view of Sample BKG-107, a cluster of gold leaf micro-fragments probably detached from the surface of an organic object (G. Guida, ISCR, Roma). The left side of the sheet fragment shows parallel striations due to the application of pressing/burnishing movements (150 X).

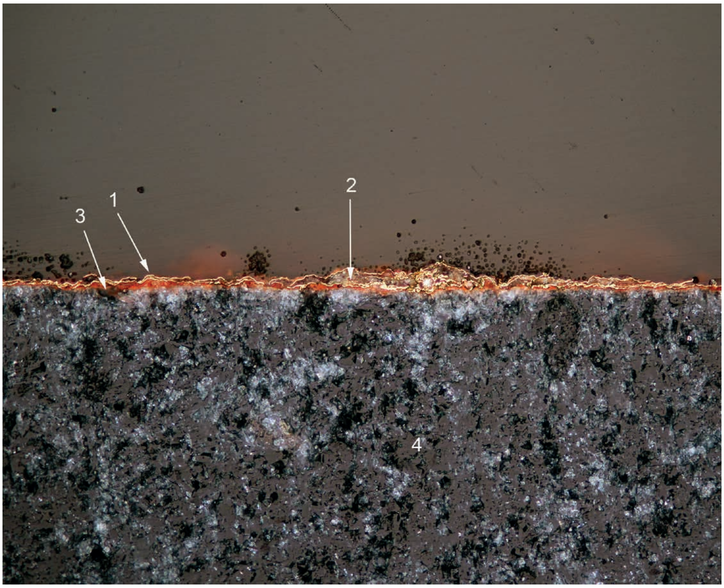

Fig. 3
Polished section of Sample SS1, observed at the optical microscope in reflected light, with crossed nichols. 1, gold sheet in two parallel layers. 2, discontinuous whitish layers containing alumino-silicates, quartz and calcite. 3,a thin layer of red bole-clay, mainly preserved in pockets on the 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.

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Conservative data on polychrome stucco, stone and clay sculptures and architectonical decoration of Gandharan art

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opposite page

Paris, Museum Guimet, Schist statue of Buddha in the Miracle of Sravasti, from Paitava monastery (Afghanistan, Kapiça region) (MG 17478, sample 12), detail of gilding (photo S. Pannuzi).

Abstract

In the first phase of study on Gandharan artefacts (2014-15), the Istituto Superiore per la Conservazione ed il Restauro (ISCR) was focused on technological and conservative issues of some schist stone and stucco sculptures belonging to the collection of the Museum of Oriental Art of Rome (ex MNAO, now merged into the *Museo delle Civiltà*). Experts of different disciplines evaluated the conditions of the stone artworks, to define the best conservation approaches and treatments. Chemists and restorers compared cleaning methods and evaluated consolidation and sticking practices.
In our further studies we also consider stucco and clay artworks, deepening our research through scientific analyses and observation carried out on both archaeological founds (Afghanistan, Pakistan) and musealized sculptures (Civic Archaeological Museum of Milan, Oriental Art Museum of Turin and Guimet Museum of Paris).
This further work allowed, through the characterization of the materials and the observation of the working techniques, to deepen the study of the Gandharan stone, stucco and clay artworks and to formulate operational hypothesis for their conservation.

Keywords
Stone artefacts, stucco artefacts, clay artefacts, Gandharan art, conservation, guidelines.

Introduction

In the first phase of study (2014-15) our Institute was focused on technological and conservative issues of some sculptures of Rome Museum of Oriental Art (ex MNAO, now merged into the *Museo delle Civiltà*). In most cases the sculptures and reliefs (schist, stucco and clay) were still covered by residues of the excavation dirt; both were rather fragile materials, as there were traces of pigments. Because of this problem, experts of different disciplines evaluated only the conditions of the stone artworks, to define the best conservation approaches and treatments. Chemists and restorers compared cleaning methods and evaluated consolidation and sticking practices.
In our further studies we also consider stucco and clay artworks, deepening our research through scientific analyses and observation carried out

RA 1 | 2019, pagg. 98 | 109
ISSN 1724-9686 (print) | ISSN 2465-2377 (online)

Fig. 1
Paris, Museum Guimet, Bodhisattva Maitreya, detail (AO 2908, sample 5): white layer on the schist statue (photo S. Pannuzi).

Fig. 2
Paris, Museum Guimet, Elephant, detail (MA 6295, sample 1): white layer on the schist statue (photo S. Pannuzi).

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Fig. 3
Milan, Civic Archaeological Museum, Capital of a pillar, detail (A.990.05.1, samples 30, 31): white layer on the schist sculpture (photo S. Pannuzi).

Fig. 4
Paris, Museum Guimet, Relief from Shotorak monastery (Afghanistan), detail (MG 22148, sample 14): traces of red bolus on schist relief (photo S. Pannuzi).

Fig. 5
Milan, Civic Archaeological Museum, Standing Buddha, detail (A.09.10692, sample 21): traces of gilding on drapery dress of schist statue (photo S. Pannuzi).

on both archaeological finds (Afghanistan, Pakistan) and musealized sculptures (Civic Archaeological Museum of Milan, Oriental Art Museum of Turin and Guimet Museum of Paris). We noted that some artworks kept in museums were subjected to previous restoration (bonding, consolidations, cleaning), also with incorrect or unsuitable products and methodology.

In such holistic perspective, the use of the materials (stone, stucco and clay artefacts), the sculpting process with the polychrome decoration of the surfaces and the conservative intervention were considered in a unified framework. Moreover, we highlight the need of precise guidelines to restore these fragile artefacts. During the restoration it is very important to have a collaboration with the diagnostic research, so a series of focused analyses could help to understand the compositional materials of the artworks and to identify the appropriate methodology and the suitable restoration products to use for the conservative intervention.

Stone artworks

Materials and processing technique

After the first analyses about the Gandharan artwoks of the Rome Museum (ex MNAO), our research carried on comparing the data related to artworks of other Museums and examining in depth the new analyses.

Analyses on the artefacts of the Museum Guimet and the Milan Museum allow to ascertain that the schist artworks can be covered by a whitish layer that we have to consider a ground layer for the polychrome decoration. After further analyses we identified different pigments and traces of gildings over different ground layers; furthermore, we found different kinds of binder.

Conservative conditions

Generally, all the examinated artefacts preserved in the Museums have a fair conservative condition, although they were fragmentary, worn and covered by different whitish layers, more or less tough, often due to long deposition in the earth. In many cases these white layers are more evident after cleaning and are discontinuous and fragile, but quite joined to stone surface and sometimes thick (Figg. 1, 2, 3). The polychrome decorations are always preserved very partially, and it's often difficult to see them. Usually the red colour is the most evident: it is often due to red ochre[1], sometimes it is a bolus, but the overlapping gilding is lost[2] (Fig. 4).

[1] For artworks from Rome Museum see: Talarico et al., 2015, tab. 1 and p. 59.

[2] See Pannuzi, Talarico, Guida, Rosa in this issue.

Some small traces of gilding are preserved on the surface of the artefacts; sometimes the gilding is more evident but always very thin. We can observe by microscope that it is easily chipped and not smooth.
Little traces of gilding are sometimes visible only by optical microscope (Figg. 5, 6, 7). When the ground layer of gilding is red bolus, this is better preserved. The lime ground layers are often lost with the gilding and less evident.

Conservative intervention

During our previous studies, for the removal of residual films of excavation sediments on Gandharan sculptures of Rome Museum, carved in different types of schist, the ISCR équipe compared the results of two different conservation approaches, both with low environmental impact and safe for the operators and the artworks: a chemical one, involving the use of aqueous solutions with carbon dioxide (CO_2) and a physical one employing Laser, used for removing lime-rich concretions on sculptures whose fragility required an extreme care. The results were positive for both: the two approaches are complementary, as they can be combined in the same cleaning procedure. Otherwise, the characteristics of stone, that tends to split in parallel layers, made impossible the most common chemical cleanings[3].
Our team also evaluated the methodological issues about consolidating and joining fragmentary stone sculptures: we tested some products for consolidation, both water-soluble or soluble in organic solvents, particularly in terms of concentration, application method and chromatic changes. We also considered various adhesives for refitting the schist flakes or more substantial fragments, evaluating their mechanical behaviour in the adhesive process, their sensibility to water and superficial colour changes.
The use of the laser cleaning is actually not usual for cleaning polychrome and gilded stone artworks, because the study about these particular artworks has recently begun. During the last research of ISCR on Gandharan archaeological sculptures the restorer M.Gigliola Patrizi successfully removed carbonate layers from polychrome artefacts by laser[4]. The laser was particularly useful cleaning very friable and fragile artefacts that could be damaged by water solution cleaning. On polychromy (red ochre in that case) a Nd:YAG with wavelength of 1064 nm (El.En. "EOS 1000") in Short Free-Running was used, because its action is more delicate and gradual than the Long Q-Switch mode, used for strong earth concretions.
Laser cleaning is also recommended in case of presence of gilding, as recently tested in ISCR on stone gilded sculptures of the Renaissance age with excellent results[5].
During the next interventions the white ground layer for polychromy, now well identified[6], has to be absolutely preserved with the use of suitable cleaning and consolidation methodologies.
In the next future new tests with innovative products will be carried on fragments of the schist sculptures. The recent researches about nanoma-

[3] Sidoti and Patrizi, 2015; Patrizi, 2015, pp.70-72.

[4] Patrizi,2015, pp. 69-74.

[5] See the conservative intervention on the gilded altar dossal of the Orte Cathedral (VT): Pannuzi, Montemaggiori, Galanti, 2018..

[6] See for these theme: Pannuzi, Talarico, Guida, Rosa, in this issue.

terials have given a very good results on porous stones, but these products must undergo further tests because in a first experimentation on the Gandharan sculptures the results were not optimal[7].
Also the ground layer for the polychromy, the traces of the pigments, the bolus and the traces of gildings absolutely require consolidation: it would be recommended the use of micro and nanoacrylic emulsions, because it's necessary to join the consolidation and adhesive effect with a deep infiltration.
An acrylic stucco with microsphere (Stuccoforte light, Max Meyer) with adequate characteristics of mechanical resistance and reversibility can be used for filling the gaps on the surface: it was recently used in ISCR on frescoes, stucco and gypsum artworks[8].

Stucco artworks

Materials and processing tecnique

In our last research about Gandharan sculpture we examined stucco architectural decorations from Italian excavations in Swat, Pakistan (MAI), also with traces of polychromy. These stucco samples come from the external walls of some collapsed buildings of Buddhist sites in Swat (Amluk-dara, Barikot and Gumbat). Moreover, samples from important artworks preserved in Museum Guimet and in Civic Archaeological Museum of Milan has been analyzed.
These artworks show evident traces of colours (red and blue). By petrographic analyses, the stucco samples from the archaeological excavations in Swat show mostly a calcite plaster produced from limestone where the gypsum is always absent. Scientific investigations carried out on some art-

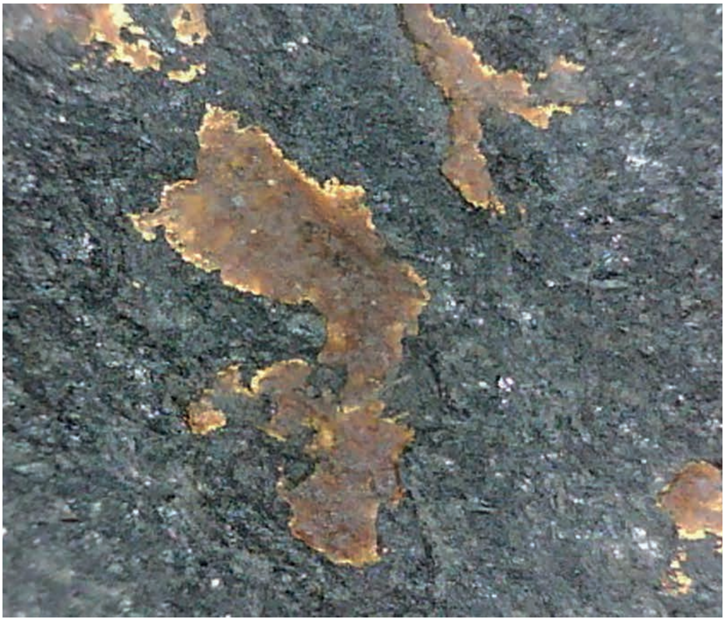


Fig. 6
Milan, Civic Archaeological Museum, Standing Buddha (A.09.10692, sample 21): traces of gilding on schist statue by Dinolite.

[7] Sidoti and Patrizi, 2015, pp. 65-68.
[8] Giovannoni et al. 2015, pp. 89-102.

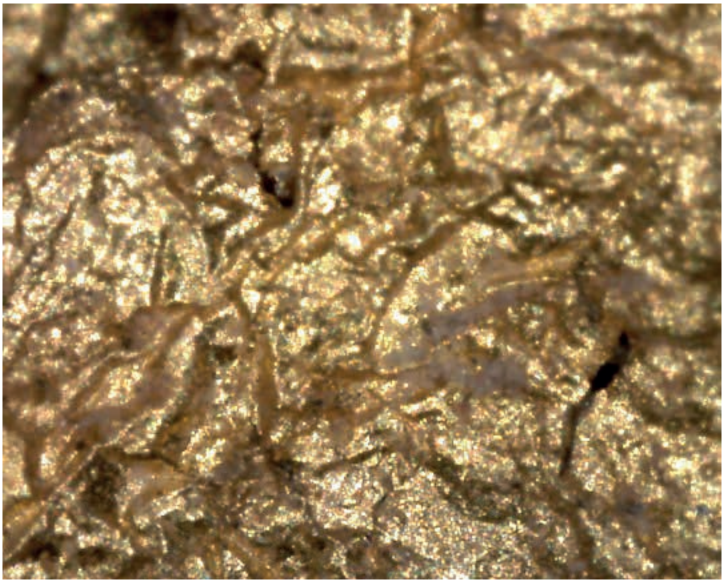


Fig. 7
Turin, Oriental Art Museum, Schist corbel (4581, samples 34-35): particular of the gilding by Dinolite.

works from the Museum Guimet (samples 6, 7) and Milan Museum (sample 22), show otherwise the presence of gypsum in the plasters.
Sometimes in the plaster of the Swat samples fragments of quartzite, granite, gneiss, garnet, marble and mica flakes are present, with the addition of a fraction of clay[9]; the artworks from the Museums revealed instead the presence of calcite, gypsum and clay (Museum Guimet, samples 6, 7) and a calcium carbonate matrix with heterogeneous grains (iron, potassium, sodium, silicon-aluminate) (Milan Museum, sample 23)[10].
In a sample from Gumbat (GBK 17A) in a matrix of fine grained calcite, fibre-like pore structures of unknown origin are visible[11]. All the plasters show large and angular grains, well visible to the naked eye, very granulose, unrefined and often with irregular fractures.
About the architectural decorations, we noted that the stucco in the malleable and plastic state was laid on the wall with 1,5-2 cm of the thickness; then it was smoothed on the surface with different instruments, including a wet brush (on the surface of a sample from Amluk-dara, AKD 14B, it is possible to see traces of the bristles) (Fig. 8). Decorative and relief parts were carried out with moulds or with modine on the wet stucco surface to create cornices and capitals, (see the sample from Gumbat, GBK 18 C) (Fig. 9 a, b). These decorative parts were added when the surface of the stucco was still wet and not completely carbonated.
Probably the granulose plaster of many artefacts was smoothed with the addition of lime without inerts (grassello); later the surface could be painted with pigments. In the sample from Gumbat, GBK 17 B, we noted that the finishing layer is rather thick (1 mm), made with lime but almost completely lost, spread dry (a secco) on the surface and then smoothed (Fig. 10).
On all the artefacts that preserved colour layer, it seems that the colour was laid dry on the already harden surface. In the architectural samples the col-

[9] See Rosa, Theye, Pannuzi, in this issue
[10] Pannuzi, Talarico, Guida, Rosa, in this issue.
[11] See Rosa, Theye, Pannuzi, in this issue.

our visible is always red, thin, vanished, not cohesive and with serious decay, due to the weathering of the external surface of the walls (Figg.11, 12, 13). Fortunately, the stucco sculptures conserved in the museums showed a better preserved surface and in a case by scientific investigations has been noticed that the red pigment, without a ground layer, was absorbed into the stucco surface, before the carbonation (sample 22 from Milan Museum)[12] (Fig. 14).

Conservative state

The architectural stuccos, from Italian excavations, served as decorations and protection of the walls of the buildings. Due to the wheatering, with the decay of the painted layers, the stucco covering detached from the walls.

However, this stucco covering is not crumble, because the cohesion of the plaster is very strong; the painted surface is instead very consumed and sometimes the mineral components of the plaster are visible.

Moreover, over the surface of the architectural samples has been noted the presence of excavation earth, often very adherent to the surface: these earthy layers compromise the visibility of the sample and the conservation of the painted layers, but they did not cause the breaking of the plaster. The stucco artworks, kept in the museums, certainly show a good or a decent conservative condition, because certainly in the past they were subjected to a cleaning treatment. We noted that the stucco is solid and tenacious but for these artworks of the painted decorations are also only present in traces and their surfaces appear corroded.

In the previous research about the artworks of the Rome Museum (ex MNAO), we observed on a stucco cornice (n. 1240) the presence of successive ground layers of the painted decoration, to be considered as ancient maintenances[13].

Fig. 8
Stucco artefact from Amluk-dara (Swat, Pakistan), sample 14 B (photo E. Loliva ©ISCR).

[12] See Pannuzi, Talarico, Guida, Rosa in this issue.

[13] Talarico et al., 2015, pp.55 e 59. Instead, we supposed a modern maintenance, due to the presence of a modern pigment, for another artwork of the Rome Museum (Talarico et al., 2015, pp. 58-59).

Based on our new investigations we can assume that in ancient time these maintenances were periodically carried out on the outdoors walls, consumed by the atmospheric agents[14].

Conservative intervention

Before the cleaning of stucco artefacts it's necessary to ascertain with appropriate analyses their composition and to verify the presence of layers of preparation or pigments.

If no surface finishing is present, the lime based stucco can be cleaned with aqueous systems.

In the opposite case, or when there is the presence of gypsum in the composition of plaster, a dry cleaning is needed, for example a laser cleaning, to be applied after testing the appropriate parameters.

In case of stucco with gypsum, the aqueous cleaning can be also performed using as supportant a rigid gel (Gellano, Agar-agar), that avoid the absorption of water.

In any case, a preliminary mechanical cleaning performed with scalpels and brushes can be effective removing earth and dust deposits and incrustations.

As the cohesion condition observed on the stucco artefacts so far examined is very good, a consolidation does not seem necessary. In case of very delicate polychrome artefacts, the finishing must be consolidated and fixed to the surface as previously described for stone materials.

The fragments can be reassembled with epoxy resins and reintegrated with the same material used for stone, the acrylic plaster with microspheres (Stuccoforte light, MaxMeyer).

If pins or supports are needed, fiberglass bars can be used, both for musealized and in situ objects.

In the last case, at the end of the intervention, the application of a surfactant (siloxanes or nanometric products) is recommended.

Clay objects

Materials and work techniques

Clay processing includes a big variety of materials and work techniques: from rough manufactures to very fine productions that needed a very high execution skill.

The objects examined are very different, belonging both to unidentifiable archaeological fragments (from Afghan excavations) and very fine artifacts exposed in very important museums such as Guimet Museum in Paris (from Fundukistan site) and the Civic Archaeological Museum of Milan (without provenance indication).

a) Fragments from archaeological excavations

The clay is very fragile, due to the addiction of various kinds of aggregates, broken in irregular and angled grains. The observation with optical and WDS scanning microscope evidenced the presence of various minerals and rock fragments inside the clay mixture.

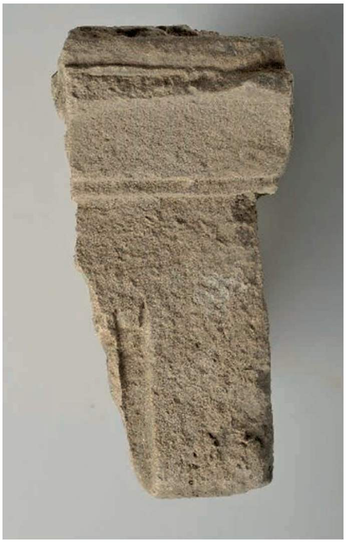


Fig. 9A, 9B
Stucco artefact from Gumbat (Swat, Pakistan), sample GBK 18 C (photo E. Loliva ©ISCR).

[14] See Rosa, Theye, Pannuzi, in this issue (sample AKD 14C).

These minerals (feldspar, quartz) and rock fragments (phyllite, limestone, quartzite) are bounded by a low cohesion clay that works as binder.

In the composition of one of the samples (from Tapa Sardar, Afghanistan) has been also observed the tragacanth gum, used to add cohesion to the very fragile mixture (Fig. 15).

Mineral powders with degreasing properties were added to the very soft clay.

The small dimensions of the samples didn't allow any other valutation on the work techniques.

From the observation performed and a preliminary analysis, waiting for the results of specific thermal analysis to be carried out in the next future, is possible to hypothesize that the objects were cooked, probably at low temperature[15]. This cooking process allowed the clay to function as a binder, including the heterogeneous aggregates but not achieving a high mechanical strength.

Regarding the artistic context of the late Gandhara, where the clay was largely used for artworks, we noticed that clay artifacts have been often classifieds as raw clay, based on the friable consistence of the mixture without any specific characterization. It would be necessary deepen the problem clarifying case by case the executive modalities.

From various samples examined has been possible to observe the presence of a layer of painting on the surface, probably given after the cooking process. Some samples from Afghan archaeological excavation have a superficial black coloration; in one of them has been identified a protein binder used to fix the color, to be deepen with further scientific investigations.

b) Musealized artworks

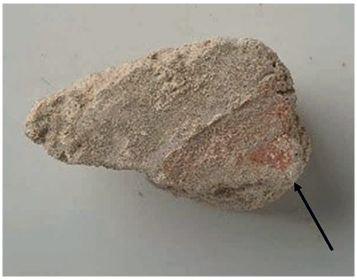
Samples from clay sculptures of the Paris and Milan Museums allow to observe that the clay used is better in quality and consistence, as it has been employed for works of particular value. Inside the mixture can in any case be noticed the presence of different components, even vegetal fibers visible to the naked eye. Based on the SEM EDS and FTR analysis carried on by ISCR, it has been possible recognize gypsum and calcium particles, used as degreaser.

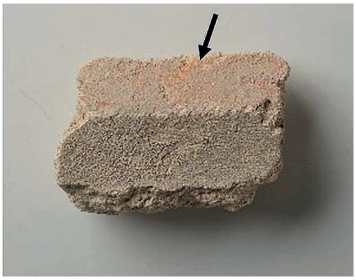
Fig. 10
Stucco artefact from Gumbat (Swat, Pakistan), sample GBK 17 B (photo E. Loliva ©ISCR).

Fig. 11
Stucco artefact from Barikot (Swat, Pakistan), sample BKG 1123, 15 A: traces of red colour are visible (photo E. Loliva ©ISCR).

Fig. 12
Stucco artefact from Barikot (Swat, Pakistan), sample BKG 1123, 16 B: traces of red colour are visible (photo E. Loliva ©ISCR).

[15] See Rosa, Theye, Pannuzi and Pannuzi, Talarico, Guida, Rosa in this issue.





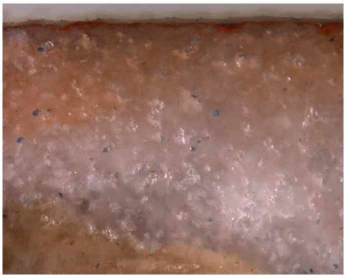


Fig. 13
Stucco artefact from Amluk-dara (Swat, Pakistan), sample 14 C: traces of red colour are visible (photo E. Loliva ©ISCR).

Fig. 14
Milan, Civic Archaeological Museum, Painted stucco Monk (A.988.02.1, sample 22): detail of the red layer on the stucco surface by optical microscope (05_050x_part 2).

Fig.15
Clay artefact from Tapa Sardar (Afghanistan), sample 1 (photo E. Loliva ©ISCR).

Some sculptures seem to be realized with a mould (Fig. 16), others freely shaped with plastic clay. The protruding parts were made separately and in some cases assembled with pins, not found (Fig. 17).

The surface has a very fine finishing realized before cooking, giving a very smooth and compact aspect and evidencing details obtained separately with plastic clay.

A complex decorative technique with preparation layers and colors, like natural ultramarine blue (lapis lazuli), of which considerable deposits are in the Himalayan area, has been also observed.

The superficial color layer could be given on a preparation of minio and was constituted of various minerals (lapis lazuli, ochre, orpiment, vermillion). Cobalt stannate, found in traces, is related to recent intervention.

Proteinaceous binders (animal glue, milk and eggs together) in some cases are presented in the colored superficial finishing.

Conservation Conditions

a) Fragments from archaeological excavations

The clay samples are in very bad conditions: the heterogeneity of the material and the low content of clay binder, join to the unsufficient cooking and the degradation due to the burial, caused fragmentations and hard disintegration. The original shape is visible only in very small areas (Fig. 18).

b) Musealized artworks

The clay sculptures of Paris and Milan Museums are in good or decent conditions, even with some missing parts, localized erosion, loss of pictorial film (Fig. 19). Some of the artworks have been recently restored to enhance the faded polychromy, using the same modern pigment (cerulean blue) used for the restoration of the stucco object from Rome Museum (ex MNAO)[16].

Intervention

In case of very delicate artefact, before cleaning is essential to perform a consolidation with microacrylic resins to give greater mechanical resistance to the clay.

When a colored finishing is present the cleaning must be performed very carefully to avoid the loss of superficial layers, after a consolidation of the

[16] Talarico *et al.*, 2015, pp. 58-59.

Fig. 16
Paris, Museum Guimet, Seated Buddha in *vajrasana* from Fundukistan monastery, Ghorband Valley (Afghanistan) (MG 21444): versus of the statue (photo S.Pannuzi).

Fig. 17
Paris, Museum Guimet, Seated Buddha from Fundukistan monastery, Ghorband Valley (Afghanistan) (MG 18970, sample 20): detail of the arm (photo S.Pannuzi).

most delicate and fragile areas carried on with microacrylic resins by brush. The superficial deposits can be eliminated with brushes, scalpel, dental stylets or laser with adequate setting.
The reintegration of the polychromy missing part is not appropriate, not to add different materials and to preserve the appearance of the original artifacts.

Conclusion

This work allowed, through the characterization of the materials and the observation of the working techniques, to deepen the study of the Gandharan stone, stucco and clay artworks and to formulate operational hypotheses for their conservation.
Some methodologies, for example on stone artworks, have been already tested, others need further studies that we hope will be performed during next restorations, both on musealized artworks and in situ.
Attention is drawn to the safeguard of the very delicate superficial finishing layers during the archaeological recovery. The conservation and the study of these finishes can allow further studies on the Gandharan work techniques that will shed light on this artistic context still today not well known.
In particular, during the recovery of a painted artefact, is recommended not to wash the fragment or use brushes to remove earth deposits. It's eventually possible to use carefully a soft brush paying a special attention to preserve delicate layers of finishing. Waiting for a targeted cleaning per-

formed by specialized restorers, the object must be stored in a dry place, avoiding the contact with other finds that can scratch the surface. During the transport the fragment must be protected against accidental bumps by positioning in containers with adequate shock absorbers.

As regards the artworks exposed in private or public collections, a periodic visual inspection, followed by a delicate dust removal performed by specialized restorer, is warmly recommended.

Critical situations or worsening of conservation conditions must be immediately reported.

The objects stored in deposits must be preserved respecting the microclimatic conditions already indicated and providing protection against accidental bumps and contacts with other artefacts.

Acknowledgments
Carla Giovannone, Wilma Basilissi, Angelica Pujia, Giovanni Verri, Stefano Ridolfi.

Fig. 18
Clay artefacts from Tapa Sardar (Afghanistan) (photo E. Loliva ©ISCR).

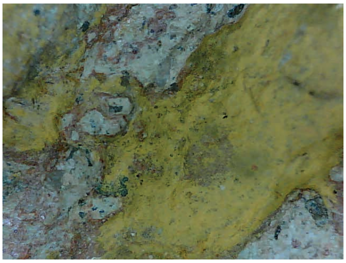


Fig. 19
Milan, Civic Archaeological Museum, Clay Brahma Head (A.09.9421, sample 33): detail of yellow layer on the hair by Dinolite.

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A short note on contexts and chronology of the materials from Saidu Sharif, Amluk-dara, Gumbat and Barikot (Swat)

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opposite page
Fig. 6
Stucco decoration of Stupa 61 (Period II) (photo by L. M. Olivieri; courtesy ISMEO).

Abstract
The following note is meant to integrate the data of the materials discussed in three contributions published in this issue of «Restauro Archeologico» (Bonaduce et al., this issue; Festa, Pannuzi, this issue; Rosa et al., this issue; Zaminga et al., this issue)). The analysed materials were sampled from three Buddhist cultic complexes in the Swat Valley in the outer Gandharan region (nowadays in Pakistan). The three sites are Saidu Sharif I, Amluk-dara, and Gumbat. Other samples were taken from a votive chapel (Shrine 1023) of the urban settlement of Barikot in the Swat Valley. All the samples belong to the same chronological phase (3rd century CE).

Introduction
The information here briefly presented, are meant to provide the contexts of the samples analysed in four contributions published in this issue of «Restauro Archeologico». Interestingly, all the samples considered belong to same late Kushan/Kushano-Sasanian acculturation phase (or Macrophase 5; second half of the 3rd century CE).
Three of the four sites described here (Amluk-dara, Gumbat and Barikot), two Buddhist sacred areas and a large settlement, lie at five km distance on the middle stretch of the Swat valley (left bank) (Fig. 1). The fourth site (Saidu Sharif I), a Buddhist sacred area, is located a little bit further N (c. 20 km from Barikot).
Most of the descriptions here presented, as well as the discussion on the technical issues related to the Main Stupa of Amluk-dara, are modified and abridged versions of my previous contributions (Olivieri, 2011 [2015]; Olivieri, 2016; Olivieri, 2018; Olivieri et al., 2014). At the end of the text I have also briefly elaborated on some some specific aspects connected to the complex processes of building, decorating and painting Buddhist monuments in Swat.

RA 2 | 2019, pagg. 110 | 127
ISSN 1724-9686 (print) | ISSN 2465-2377 (online)

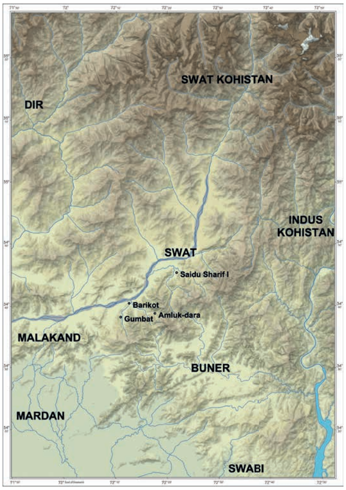


Fig. 1
Map of Swat (Courtesy ISMEO; Map by K. Kriz an D. Nell, University of Vienna, Department of Geography and Regional Research).

Saidu Sharif (Fig. 2)

The Buddhist sanctuary of Saidu Sharif I was excavated between 1963 and 1982 by Domenico Faccenna (1995). Some sectors were left unexcavated in 1982. After 30 years these surviving stratigraphies were nothing but shapeless eroded amount of debris (Olivieri 2016) (Fig. 3). It was therefore decid-

ed to dig them up in order to clear the area and control the stratigraphical deposit of these sectors. One of the areas left unexcavated was immediately to the W side of Vihara 54. The latter is located at the N end of the Stupa Terrace (Faccenna, 1995, pp. 360-368). The two tiny fragments discussed by Zaminga et al. (see *infra* this issue) were recovered in layer (6) between the

Fig. 2
The Stupa Terrace of Saidu Sharif I (photo by Fazal Khaliq).

Fig. 3
Vihara 54 before the excavation (photo by L. M. Olivieri; courtesy ISMEO).

Fig. 4
Vihara 54 after the excavation (photo by L.M. Olivieri; courtesy ISMEO).

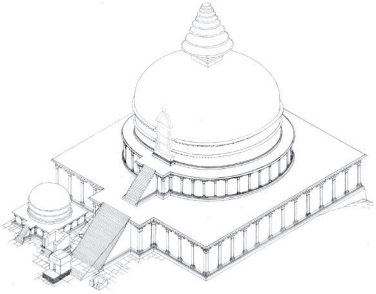


Fig. 5
AKD I sacred area: axonometry (from WNW) (drawings by F. Martore; courtesy ISMEO).

collapse of Structure 82 (Faccenna, 1995, pp. 401-402) and Floor F3R, in a phase corresponding to the end of Period II/beginning of Period III (c. second half of the 3rd century CE) (Faccenna, 1995, p. 426) (Fig. 4). Both fragments can be tentatively reconstructed as parts of a miniature stupa originally housed inside Vihara 54.

Amluk-dara (Fig. 5)

The Buddhist sanctuary of Amluk-dara has been extensively discussed in recent publications (Olivieri, 2018; Whitfied, 2018). The site has an extension of approx. 25,000 m^2. Near the SE limit of the area, a cluster of boulders were in ancient times arranged in order to dam up a stream so as to create an artificial water reservoir. The site is divided into four terraces. The monastery was possibly in the uppermost terrace, while the Main Stupa is located on the westernmost of the three lower terraces. The extension (200 m^2) of the excavated area, roughly corresponds to 1/6 of the total surface of that terrace. Three ancient quarry areas were found nearby the site (phyllite and granite).

For a review of the site and its role in the ancient pilgrimage's network, see the contribution by S. Whitfield (2018). A revised version of the final excavation report has been recently published (Olivieri, 2018).

The Main Stupa (Rosa et al., this issue)

The monument is a stupa square in plan with a stairway on its N side, with a 2nd stairway with the 2nd storey along the same axis. The monument was more than 30 m high (including the chattravali).

The podium or the 1st storey is 32 m long and 6.5 high. The base is decorated with a low plynth with a torus-type moulding. The cornice is decorated with a series of plain pilasters with Gandharan-Corinthian type capitals supporting modillons. The upper cornice is formed by a row of false brackets (cyme reversa type) supporting projecting slabs. The same decoration (pilasters with Gandharan-Corinthian capitals, modillons, brackets and coping slabs) is used in the first cylindrical body of the stupa (2nd storey). The 3rd and 4th storeys show only a row of false-brackets supporting the coping slabs. The presence of these coping slabs, instead of a simple cornice, may be explained by the fact that the surfaces underneath were not only plastered, but also painted.

The masonry is completely made of isodomic blocks of local granite arranged in ashlar technique, with spaces filled with schist flakes. Pilasters (bases, shafts, capitals), modillons, and brackets are made in kanjur (organogenic limestone, not local); projecting slabs are in schist. The original granite pillars survive in some elements of the 2nd storey. The entire surface of the Main Stupa was plastered (and ample traces of plaster still survive).

Table 1
List of Samples with calibrated dates (CEDAD, Università del Salento).

Source	Description	Code	Radiocarbon Age (BP)	δ13C (‰)	Calibrated dates (confidence level 2σ)	Calibrated dates (OxcCal 4.2.2)	AKD Period
AKD I SU (66)	Charcoal	LTL12769A	1771 ± 45	-19.8 ± 0.4	130AD (95.4%) 390AD		II-III
AKD I SU (116)	Charcoal	LTL12771A	1690 ± 45	-20.0 ± 0.3	230AD (95.4%) 440AD		IV-V
AKD I SU (136)	Charcoal/ animal bones	LTL12770A	1227 ± 40	-18.3 ± 0.6	680AD (95.4%) 890AD	685 – 895cal AD	VI-VII
AKD I SU (110)	Animal bones	LTL12766A	1354 ± 30	-19.3 ± 0.5	620AD (89.4%) 720AD 740AD (6.0%) 770AD		VII
AKD I SU (66)	Animal bones	LTL12773A	1291 ± 35	-15.5 ± 0.5	650AD (94.0%) 780AD 790AD (1.4%) 810AD	660 – 825cal AD	VII
AKD I SU (76)	Animal bones	LTL12767A	1102 ± 35	-21.8 ± 0.5	870AD (95.4%) 1020AD	835 – 1015cal AD	VII (final)

Fig. 7
Sampling area of sample AKD 2: stairway, side E (photo by L. M. Olivieri; courtesy ISMEO).

The core of the monument is composed of horizontal courses of stones and horizontal thick courses of mortar (c. 0.10-0.15 t). The mortar is made of compact layers of yellow purified clay with thick inclusions (mostly limestone or *kanjur*).
Sample AKD 2 was sampled from the plastered surface of the E side of the 1st stairway (Figs. 7, 9). From the W side of the same were sampled Samples 4 and 5 (Fig. 8).

Shrine 60 (Bonaduce at al., this issue; Festa, Pannuzi, this issue; Rosa et al., this issue)
The monument (see Figs. 5 and 9) is coeval to the Main Stupa. "The monument [60] is a square shrine with door opened to NNE. The external surface is practically all covered by a plaster with stuccoed colored surface. It is composed of a podium with base, torus, projecting fillet, reverse sloping fillet, and a band, with a superimposed second torus with cavetto on fillet. The cornice of the podium (lower part) is composed of a band with upper fillet, cyma recta and final band. The upper fillet is decorated with a row of bead-and-reels; the cyma recta, with lattice with oblique fillets and oblique parallel rows (straight and curvilinear, alternating); the fields between the fillets is colored red. The upper part of the cornice is decorated with a row

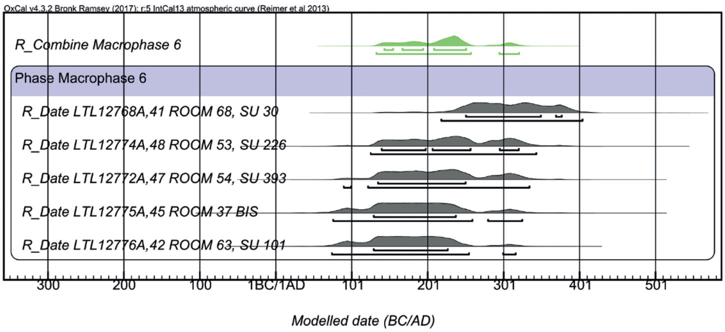


Table 2
BKG Period IX = Macrophase 6 (modelled by CIRCE/Innova, Università della Campania "Luigi Vanvitelli"; data generated by CEDAD, Università del Salento).

of Gandharan-Corinthian S-shaped pillar type brackets supporting a flat band surmounted by a reverse ovolo and a fillet. The fields between the brackets are colored yellow. The base of the body is marked with a band surmounted by torus, fillet and cyma reversa" (Olivieri, 2018, p. 36). Samples AKD 13C and 14C were collected from the S (back) side of Shrine 60 (Fig. 9).

Structural and decorative phases
The Main Stupa originally (Period I) had a gray bluish schist decoration, whose fragments were found largely re-used or abandoned (Fig. 10a-b). Most of the decoration found *in situ* is made of *kanjur* and is coeval or posterior to Period II. In Period II the 1st stairway was heavily damaged, perhaps during one of the two earthquakes that hit Barikot in the 3rd century CE. Instead of rebuilding it, the monks simply built a new flight of steps on top of the damaged one, reusing the same material. Consequently, the staircase became higher, therefore longer and with a different inclination. To the same Period II belongs the stucco decoration of the Main Stupa, as well as of Shrine 60 and the other minor monuments (see Figs. 11-13).
All the samples analysed in the three reference studies (Bonaduce et al., this issue; Rosa et al., this issue; Festa, Pannuzi, this issue) therefore belong to a phase coeval or posterior to Period II.

Gumbat and its chronology (Festa and Pannuzi, this issue; Rosa et al., this issue) (Fig. 14)
The Buddhist sanctuary of Gumbat with its two terraces and monastery, has been recently reassessed (Brancaccio, Olivieri, 2019), and does not need to be here presented anew. The Great Shrine of Gumbat, the only surviving example of double-domed cupola in Gandhara, is located in the centre of the northermost terrace. The building was studied and restored in 2011-2012, while a portion roughly corresponding to 1/4 of the terrace was excavated in 2011 (Olivieri et al., 2014).
The chronology of the monument is based on the radiocarbon dates of the surviving wooden elements of the architecture (Olivieri et al. 2014: 302; Di Giulio et al., 2018).

Fig. 8
Sampling area of samples AKD 4-5: stairway, side W (photo by E. Loliva; courtesy ISMEO).

> Based on the available data, it appears that the Great Shrine had two building phases [...]. The Great Shrine and Buildings [3] and [13] (= Period III) were erected in the early-2nd century CE as suggested by conventional 14C analysis of the wooden lintel of the upper south clerestory window of the Great Shrine (1840 +/-30 BP = 110 CE). A second phase (= Period V) should have included the reconstruction of the Great Shrine double dome took place in the mid part of the 3rd century CE.
> (Brancaccio, Olivieri, 2019, p. 127)

Information on the sampling area of GBK 17 are missing. However, on the basis of the fieldwork notebook, it seems that it was sampled from the upper dome of the Main Shrine (Fig. 14), or from one of the Period V minor monuments. In any case, the sample GBK 17A (but also GBK 17B; Rosa et al., this issue; Festa, Pannuzi, this issue) is coeval or posterior to Period V of the site.

Barikot, Unit K, Shrine 1023 (Bonaduce et al., this issue; Festa, Pannuzi, this issue; Zaminga et al., this issue) (Figs. 15, 17)

Barikot, the ancient urban site of Bazira, is a key site for the reconstruction of the cultural and historical framework of ancient Swat (see ref. in Olivieri, Filigenzi, 2018). The samples analizyed in Bonaduce et al. and Festa, Pannuzi (this issue) were taken from the stucco decoration of a small Buddhist shrine (1023) in Court 107 of the ancient city (BKG Periods VIII and Period VII = Macrophases 5a and 5b = c. 3rd century CE). Shrine 1023 is located at the N side of Court 107 opposite to a small dystile temple (Temple K) (Fig. 16) (Olivieri et al., 2014).

Shrine 1023 (Fig. 19)

The structure in Court 107 is a detached Buddhist chapel (Shrine) (Olivieri, 2011 [2015]). It is rectangular in plan, facing S. It has a high podium with flat base and a moulded cornice supported by plain brackets; on the top front of the chapel there was a wooden architrave supported by a row of plain brackets. The cella was closed by two folding wooden leaves hinged to a wooden frame (the iron parts of which have been almost completely recovered).

At least the moulded parts and the brackets were plastered. At the end of the first phase of the Shrine's life (Period VII) an earthquake damaged the building; in front of the monument, where fragments of giliding were found (Zaminga et al., this issue), an entire portion of the roof with a portion of the original stucco decoration and plastering was recovered (and sampled, see Bonaduce et al., this issue). The collapse occurred in two phases: first the roof collapsed, then the rest of the structure (Fig. 18). In the second phase of the Shrine's existence (Period VIII), while the lower part of the podium was covered by debris (leveled but not removed), the cella was modified. A final collapse, caused by another earthquake, resulted in the abandonment of the Shrine (Fig. 19).

Inside the cella in Period VII a votive stupa was housed, the remains of which were partly recovered during the excavations. In Period VIII the cella housed one Buddhist stele.

Fig. 9
Sampling area of samples AKD 13C and 14C, and of AKD 2 (view from SSE of Stupa 61) (photo by L. M. Olivieri; courtesy ISMEO).

Fig. 10a, 10b
Fragments of the Period I schist decoration of the Main Stupa (AKD 24, 61) (photos by E. Loliva; courtesy ISMEO).

Chronology of abandonment phase of Barikot (Period IX = Macrophase 6)
Table 2 shows the new calibration made by CIRCE, which confirms the chronology proposed earlier by CEDAD – Università del Salento, Lecce (Olivieri, 2011 [2015]; Cupitò, Olivieri, 2013). "The main chronological range falls within the 3rd century CE. This evidence not only confirms the historical unity of the re-use and re-functionalization phenomenon and its relative short duration, but also indicates how this event significantly took place at the same time as the great expansion of the Sasanian dynasty which, in the mid-3rd century CE, conquered Gandhara, turning it into the Kushanshahr province [more precisely during BKG Period VIII]" (Olivieri et al., 2014, pp. 88).
With the support of the archaeological materials (including coins) we have hypothesized a 3rd century chronology for BKG Periods VII and VIII, and a late-3rd to early-4th century chronology fro BKG Period IX.

Fig. 11a, 11b
Example of stucco decoration from Period II: fragment of statue of Buddha: AKD 100; note the holes for the back assemblage) (photos by E. Loliva; courtesy ISMEO).

Concluding notes on some technical issues

Orientation (Fig. 20)

The orientation of the Main Stupa at Amluk-dara shows a slight difference of about 35° with astronomical N. The orientation can be explained if the planning of the stupa was performed at a time of the year after the Autumn Equinoce, when the sunrise, at this latitude, is less than 40° to the ESE (Olivieri, 2018, p. 2).

Building process (Fig. 20)

On the basis of the available data, the dome of the Main Stupa at Amluk-dara was surmounted by a chattravali with at least 7 chattras. The biggest fragment was >7.50 m (diam.) and 0.34 m (thickness)., the second

Fig. 12a, 12b
Example of stucco and stucco/kanjur decoration from Period II: fragment of a spacer of chattravali?: AKD 166; part of the spacer of chattravali of a minor stupa: AKD 177a-b (photos by Aurangzeib Khan; courtesy ISMEO).

biggest – corresponding to a 1/8 sector - was 7.20 m (diam.) and 0.26 m (thickn.). Assuming a possible average specific weight of 25 g/dm3, these disks, once assembled, were extremely heavy (the biggest complete chattra (the second last one) (d 4.00 t 0.30) might have had a total weight of 9.5 tons). "Although the calculation is not precise, these figures can give some idea of the real order of magnitude. Even today lifting a large 9 tons piece of stone to a height of more than 30 m would be a challenging operation [...]. It is therefore hard to imagine that these almost impossible operations were performed from the bottom up. We do not have any kind of evidence, either direct or indirect, regarding the existence or the use of engineering machinery *yantra* or *machinae* in Gandhara" (Olivieri, 2018, pp. 13-14).
The presence of rocky walls near Buddhist sacred areas (e.g. besides Am-

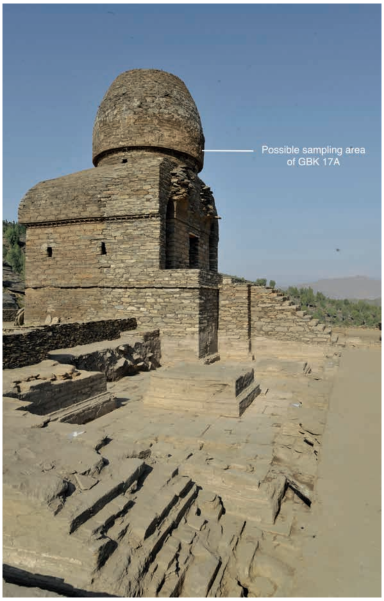
Fig. 13
Examples of architectural parts in kanjur (stuccoed): spacers, cornices, cyma-reversa false brackets, metopes (photo by L. M. Olivieri; courtesy ISMEO).

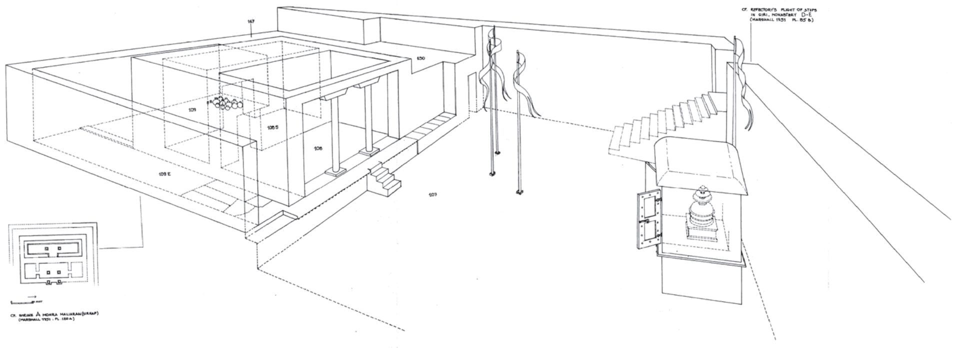
Fig. 14
Possible sampling area of sample GBK 17A: Great Shrine (view from SSE) (photo by E. Loliva; courtesy ISMEO).

luk-dara, at Tokar-dara and Saidu Sharif I) might have been utilized for the erection of sloping ramps in order to reach the top of the stupa. The chattras could have been more easily dragged up there with a rope-winch. During the construction the rocky walls were quarried to obtain construction material, and the resulting space was used to house new constructions (as it was documented at Saidu Sharif I and Amluk-dara) (Olivieri, 2016).

The role of kanjur (Figs. 12, 13)
Schist is *the rock* of Swat, its petrographic and artistic signature. It was the main stone material quarried and used for architectural decoration and sculptures in Swat especially in 1st-3rd century CE (see references in Pannuzi ed. 2015). On the other hand, *kanjur*, a limestone, is not a local stone. Therefore, we may guess that the shift to *kanjur* which is extensively documented after 3rd century CE at Amluk-dara and in other sites of Swat, implied a major change in the local economy. The appearance of *kanjur* might support the hypothesis that the local schist quarry areas of Swat were working "at an unusually very low pace for their standard, maybe just for the only surviving contemporary production", i.e. the portable stelae that are a typical 3rd century production in Swat (Olivieri, Filigenzi 2018, pp. 85).

Kanjur and stucco appear together in Swat. The shift to *kanjur*, for its rough and porous structure, implies a massive use of stucco modelling and finishing. Petrographic analyses of samples of both kanjur and stucco from Amluk-dara (Rosa et al., this issue) have proved that the two materials are chemically compatible, thus supporting the hypothesis that the stucco was largely obtained as a by-product of *kanjur* stone workmanship.





Vegetal and protein-based substances

The analysis presented in this Volume (Bonaduce et al., this issue) have shown that vegetal and protein-based resources were used to produce substances utilized as binder. One of these was collagen (animal glue). It was extracted from animal bones in late autumn (when weather is dry and cold, and it is more favorable for gelatinization). In late spring, after the end of the rainy season, when the weather is mild and dry, stucco was prepared. Various binders were then used to make the stucco and color layers more stable and weather resistant. The presence of egg (but not tragacanth gum, Astragalus sp., which grows also in Swat; see e.g. Humayun et al., 2005; Chaudhary et al., 2008) in the final layer of the stucco, suggests the hypothesis that the stucco surface was dry and smooth when color was applied. In this condition pigments needed to be mixed with a strong binder to adhere to the substratum.

Fig. 15
Axonometry of Temple K and Court 107 (seen from NNE; drawings by F. Martore; courtesy ISMEO).

Fig. 16
Court 107 and Shrine 1023 seen from ESE, from Temple K (photo by L. M. Olivieri; courtesy ISMEO).

Fig. 17
Elevation and plan of Shrine1023 (drawings by F. Martore; courtesy ISMEO).

Fig. 18
Shrine 1023: first collapse (Period VII) (photo by L. M. Olivieri; courtesy ISMEO).

Fig. 19
Shrine 1023 in Court 107: final collapse phase (Period VIII) (photo by L.M. Olivieri; courtesy ISMEO).

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Fig. 20
The building phases of the Main Stupa of AKD I (drawings by F. Martore; courtesy ISMEO).

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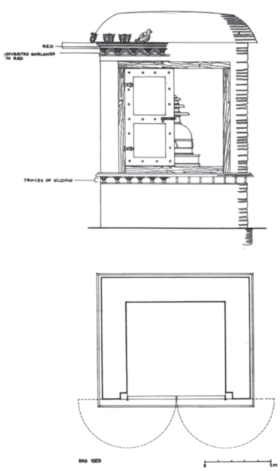

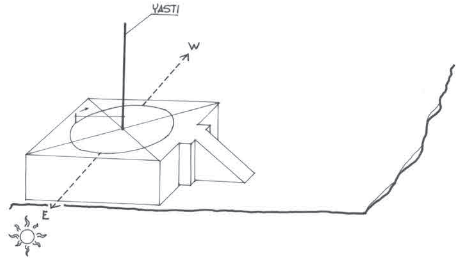

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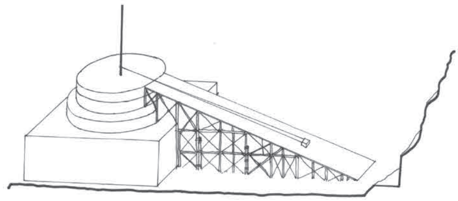

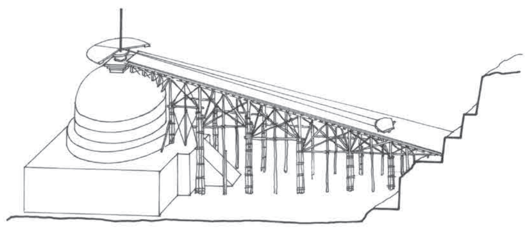

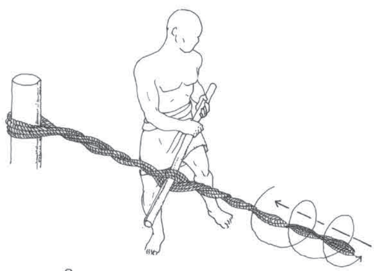

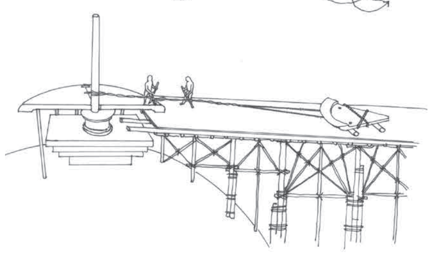

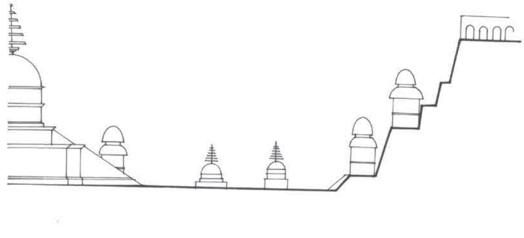

Clays and colours: Tracking technologies and theories of vision in the ancient Buddhist art of Afghanistan

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opposite page
Fig. 1
Tepe Narenj (Zone 14): Buddha images showing traces of restoration with red clay.

Abstract

New, targeted and comparative studies are under way on clay sculptures recovered in Afghanistan, thanks to a collaborative project between the Italian Archaeological Mission in Afghanistan and the Archaeology Institute of Afghanistan. The specific target of the preliminary analyses are the sculptures from the Buddhist site of Tapa Sardar, which have been excavated between the 1960's and the 1970's by the Italian mission in the Ghazni area, and those, only partially published, that have been brought to light at Tepe Narenj, a site in the Kabul area under excavation since 2004 under the aegis of the Archaeology Institute of Afghanistan. Our aim is to analyse their physical, technical, stylistic and iconographic features, in order to identify patterns that might be associated to a coherent aesthetic system. This would be of fundamental importance to the understanding of the ideological frames of reference that shaped the art-making process in a period of great artistic vitality and innovations, which roughly spans the second half of the first millennium A.C.

Introduction

The use of pliable materials such as clay, stucco and, only in rare cases yet to be ascertained, of terracotta was central to the history of art of Afghanistan, and, broadly speaking, of Central Asian regions[1].

Around the 4^{th}-5^{th} century the use of clay, very often combined with stucco (a term used here in a conventional manner), predominated over stone (in particular schist and limestone), which apparently had long been the main medium of a refined Buddhist art known as art of Gandhara[2].

In particular, in the history of excavations, Afghanistan has yielded numerous clay artifacts, which, although sharing the same formal principles and the basic clay-sculpting skills, attest to a strong local character and a great experimentation of techniques and materials.

However, despite the considerable evidence, we still know very little about their material, technical, technological, iconographic and iconological aspects, as well as the aesthetic values of reference of this vast figurative repertoire.

[1] Sculptures reported as terracotta have turned out very often, in the light of archaeological and stratigraphic data, to be accidentally baked clay. However, the question whether a genuine terracotta sculpture ever existed, and how to unquestionably identify it as such, deserves the utmost attention, also in the light of the sculptures described as terracotta from the recent excavations of the sites of Mes Aynak (A.A.V.V., 2016, p. 127) and Taxila (Samad et al., 2017; Hameed et al., 2018).

[2] It is commonly understood that Gandhara art refers to a vast phenomenon of Buddhist art and architecture, which, although with important regional variations, comprises a far larger area than the homonymous historic region, embracing the territories included between present-day northwest Pakistan and eastern Afghanistan. Although conventionally linked to the Kushan period (1st-3rd cent. A.C.), its beginnings had already taken shape around the beginning of the 1st cent. A.C., during the Saka-Parthian period, while its last traces date at least from the 4th/5th cent. A.C.

RA 1 | 2019, pagg. 128 | 139
ISSN 1724-9686 (print) | ISSN 2465-2377 (online)

Fig. 2
A bodhisattva image of Late Period from Tapa Sardar (TS 1500).

The study of utilized materials and procedures is an essential key to understanding the known productions in relation not only to production contexts but also to original archaeological contexts. This makes it possible not only to simply identify the nature of the materials, but to investigate formal and ideological aspects of an aesthetic, iconographic and iconological nature, fundamental for reconstructing and interpreting unified figurative programmes.

The extensive documentation on the clay sculptures from Tapa Sardar[3], which provide a high stratigraphic reliability (Taddei, 1968; Taddei and Verardi, 1978; Verardi and Parapatti, 2005), and the availability of accurate documentation on the sculptures found at the Tepe Narenj site (Paiman and Alram, 2013), in combination with preliminary studies already under way, have made it possible to reveal and analyse, in a scientific and comparative perspective, significant elements of the use of different clays and their original polychromy, of which they retain numerous though often minimal and scarcely considered traces.

Tapa Sardar and Tepe Narenj: observations on clays

At both the Tapa Sardar and Tepe Narenj sites, the use of different types of brown, yellow or red clay is attested, the red one being used above all for the more superficial layers of the modeling, especially during a relatively late phase of the life of the two sites, dating from around the end of the 7th century to the beginning of the 8th century.

Tapa Sardar's Late Period production is so far one of the most remarkable and well known. Made of red clay, it is datable from the end of the 7th century, based on archaeological data and stylistic comparisons with the sculptures of Fondukistan, a site excavated by DAFA in the 1930's, dated to post 689 A.C. on the basis of numismatic findings (Hackin et al., 1959, pp. 49-58).

At Tepe Narenj, in addition to two types of production, distinguishable according to the colour of the clay (yellow or red), evident restorations done in antiquity with red clay of works originally made with yellow clay coated with one or more layers of stucco, underline the succession of two artistic phases and a stylistic change, in concomitance of which the use of red clay seems to become predominant (Fig. 1).

We do not yet know what motivated this phenomenon, already observed previously at Tapa Sardar, but the idea that aesthetic needs determined this change appears for the moment the most plausible. Both types of clay are widely available, for example, in the Kabul area, but it is clear that, from a certain point on, red clay became the preferred material at many sites in different regions.

At the same time there was a general renewal of artistic manifestations, expressed stylistically in a greater standardization of forms. It suffices to examine Tapa Sardar's Late Period sculptures (Fig. 2, 3; Filigenzi, 2009, fig. 3) and the Fondukistan figures, especially the bodhisattvas (Hackin et al., 1959, fig. 174, 175), in addition now to those from Tepe Narenj (Fig. 4; Paiman, 2013, pl. XXIII, b), to ascertain their notable formal affinity.

[3] The corpus of the clay sculptures from the Tapa Sardar site has been entirely published on the portal *Buddhist and Islamic Archeological Data from Ghazni, Afghanistan. A Multidisciplinary Digital Archive for the Managing and Preservation of an Endangered Cultural Heritage*, <http://ghazni.bradypus.net> (03/19), to which I refer the reader for details on the materials not included in the illustrative section of this work.

Fig. 3
A bodhisattva image of Late Period from Tapa Sardar (TS 1561).

There is a typical lengthening and thinning of the forms, visible even more in the shape of the torso, hands and feet, this last characterized by the second toe being longer than the others, a new or at any rate less pronounced element in the previous phase (Fig 5). Among their salient features are also a strong decorativism and geometric abstraction, which can be found especially in the faces and drapery, far from the almost naturalistic vision of the previous productions.
Recent experiments with the clays at Tepe Narenj, for restoration purposes, have been of great interest. They have revealed the reduced plastic and cohesive capacity of red clay, which proved to be more difficult to work with. This data was confirmed by the comparative chemical-physical analyses, which, by extending an already planned program for the activities of the Italian Archaeological Mission in Afghanistan, were carried out on some clay samples from both Tapa Sardar and Tepe Narenj.
The preliminary results of the analyses revealed, in addition to the presence of plant and mineral elements (data already familiar from other sites, see Fondukistan), generally employed to augment the compactness of the mixture, the use of vegetable glues in the red clay mixtures. The initial idea, now confirmed, is that the vegetable glue could increase not only the adhesiveness of the mixture itself, but also that of the coating layers, such as gilding or colour rendering.

Fig. 4
Tepe Narenj (Zone 14): bodhisattva image in pensive position (to the right).

opposite page
Fig. 5
Tepe Narenj (Zone 14): bodhisattva image, detail
Fig. 6
Head with traces of red paint on the face from Tapa Sardar (TS 1831).
Fig. 7
Head with traces of red paint and gold leaf on the hair and on the face from Tapa Sardar (TS 1870)

This also reinforces the hypothesis that their qualities, and therefore the need to satisfy certain aesthetic features, took precedence over the plastic qualities of the material used.

Polychromy and the non-naturalistic use of colour

Polychromy is one of the main aspects of visual language, especially of Buddhist art, in which colour does not have a simple decorative value but contributes to creating distinct iconographic types that reflect the intrinsic qualities of the characters represented and participate in transmitting specific 'philosophical,' moral and intellectual messages, which we are not always able to decode.

Moreover, the application of colour was the culmination of a true process of vivifying the image, realized according to detailed prescriptions, where nothing was left to chance. Hence there was an undeniably strong magical, symbolic value of images created according to established codes.

However, we still know very little about the use of colour, both because the evidence is fragmentary and because the traces are not always visible to the naked eye or systematically documented. The question becomes even more delicate when we come upon a non-naturalistic use of colour, in which we can also classify the very common practice of gilding.

The non-naturalistic use of colour, especially red, has already been reported several times in the history of studies on the art of Afghanistan, for example at Tapa Sardar, where the red appears to have been used on the face (TS 1831, Fig. 6; other examples are: TS 1869, TS 1872), on the hair (TS 1870, Fig. 7, see also TS 1868) or to outline the eyebrows (Verardi, 1983, p. 489) of Buddha or divinity figures, or at Bamiyan, for the hair (Hackin, 1933, 51 no. 30, fig. 77). In these instances, however, with the exception of the eyebrows, it could be the bolus, a very liquid red clay mixture, with adhesive capacity, which was spread on the body of the figure to enable to adhere and to enhance the gilding.

At Tapa Sardar this became a dominant feature starting from Early Period 2, at the turn of the 5th century, as attested by the Niche 76 sculptures, which still retain traces of gilding (Fig. 8; Verardi and Parapatti, 2005, pp. 415-416), and by numerous ancient restoration interventions that adapted part of the original iconographic programmes to the new concept of the sanctuary. Many sculptures of the ancient phase (Early Period 1), usually made of yellow clay and covered with a white surface layer (defined as lime milk, but whose composition needs to be ascertained; see Verardi, 1983, p. 490), in fact preserve the visible traces of a second white coating, covered in turn by a red layer (Fig. 9; Verardi, 1983, fig. 30).

Even at Tepe Narenj some heads retain traces of red colour on their faces (Fig. 10, 11), in all likelihood also in this instance the bolus. More explicit gilding remnants were found on the drapery of a Buddha or bodhisattva

Fig. 8
Tapa Sardar: Niche 76, © Italian Archaeological Mission in Afghanistan.

opposite page

Fig. 9
Head with traces of ancient restoration from Tapa Sardar (TS 1869).

Fig. 10
Head with traces of red paint on the face from Tepe Narenj.

Fig. 11
Head with traces of red paint on the face from Tepe Narenj.

Fig. 12
Head with traces of red paint on the face and blue paint on the hair from Tepe Narenj.

Fig. 13
Head with traces of blue paint on the hair and on the eye outline from Tepe Narenj.

figure, part of a set of figures that surrounded the inner perimeter of a hall or porticoed courtyard (Paiman, 2013, 71 no. 12).

Another example from Tepe Narenj shows traces of red colour on the face in conjunction with the traces of blue on the hair (Fig. 12).

The non-naturalistic use of blue is particularly documented at the Tepe Narenj site, both for the hair and to outline the eyes, above all of the Buddha figures in yellow clay coated with one or more layers of stucco (Fig. 13, 14), dating from the end of 484 A.C., based on numismatic findings; the presence of the same elements on a donor figure remains to be verified.

We do not yet have chemical-physical analyses that confirm whether the blue is the original colour or a degraded black, but, as emerges from a preliminary comparison with other productions, the seemingly incongruous use of blue appears to be very common in clay sculptures, as well as in other media.

It is hard to say whether even in the Gandharan stone tradition we can speak of a non-naturalistic use of blue, due to the fragmentary nature of the evidence. What is certain is that this feature, never highlighted or analysed in its symbolic meaning by previous studies and only recently brought to our attention (Filigenzi, in collaboration with Paiman and Alram, in press), seems to mark a powerful innovation, already introduced with the first clay experiments.

An example is the bodhisattva from Tepe Maranjan, found in the 1930's and now housed in the Kabul National Museum, assigned by recent studies to the 4th century *ca.* (Kuwayama, 1991; Filigenzi, 2010). Despite the damage suffered and modern restorations, the figure still retains traces of its blue colour, already reported by the excavators, to highlight the eye outline (Fig. 15; Hackin et al., 1959, 10, fig. 7-9).

In the Hadda production too, especially on the lower eyelid line of a bodhisattva head, now kept in the Musée Guimet storerooms (Inv. MG 26837), traces of blue are preserved, recently identified thanks to an inspection by the director of the Italian Archaeological Mission in Afghanistan, Anna Filigenzi, and the generous collaboration of Pierre Cambon, chief conservator of the Musée Guimet.

Clear traces of never reported blue are preserved on the hair of the figures found at the Fondukistan site, some of them now kept at the Musée Guimet, especially a Buddha *paré* figure, a seated Buddha and two *nāga* princes, found in the Niche D (Hackin, 1940, fig. 16-18; Hackin et al., 1959, fig. 171, 172, 174).

At Tapa Sardar, even if there are no conspicuous traces, this particular use of blue cannot be excluded. Some of the statues, because of possible contact with the fire, which may have altered the original colours, need to be verified; among these we can list some heads, namely from Vihāra 17 (TS 574, TS 867, TS 1029), which housed the figure of a colossal Maitreya Buddha against the wall opposite the entrance, flanked by bodhisattva figures and other characters, and by rows of Buddhas under arches with attending deities on the side walls, from Vihāra 37 (TS 1272, TS 1500), from Vihāra 23 (TS 1145?), and a head of which we only have excavation photos (Fig. 16). In addition to these mention can be made of fragments of wall paintings found in Room 52, where we see a Buddha in three quarter view, with likely traces of blue on the eye outline (Silvi Antonini, Taddei, 1981, fig. 5) or bodhisattva figures with what seems blue hair (Fig. 17; Silvi Antonini, Taddei, 1981, fig. 2, 3).

The site that yielded the most representative specimens is Mes Aynak, where the extraordinary preservation of polychromy confirms that the blue was used here in a very marked way both to outline the Buddhas' eyes and those of the faithful who looked on him, and to highlight their hair (Engel, 2011, pp. 37, 46-47; AAVV, 2013, p. 132; AAVV, 2016, p. 184). The surviving evidence shows that the non-naturalistic use of blue is also combined with gilding.

Fig. 14
Head with traces of blue paint on the eye outline from Tepe Narenj.

The recurrence of this iconographic feature (with its iconological meaning) is therefore attested starting from the most ancient phases of clay sculpture, up to the most recent productions, such as that of Fondukistan. This fact is important because it suggests that the non-naturalistic use of blue becomes, at a certain point, a true *topos*, not only in sculpture but also in painting, and over a vast area.

The use of blue colour to outline eyes is also sporadically reported in the literature about Bamiyan, but not documented by specific photos (Hackin, 1933, 50 no. 20; Klimburg-Salter, 1989, pp. 192, 195, pl XLI, fig. 48), while clear evidence can be found also in the pictorial productions of Xinjiang, in particular in Qizil (examples in Herbert, Yaldiz, 1982, pp. 82-97).

These data forcefully suggest the association of blue with notions of peace and purity as constitutive features of the Buddha's appearance, but also with the transfiguring power of divinity and its contemplation, which is reflected in the eyes of the faithful. This is explained in the context of Buddhist speculation on the symbolism of light and on the *darśan* (vi-

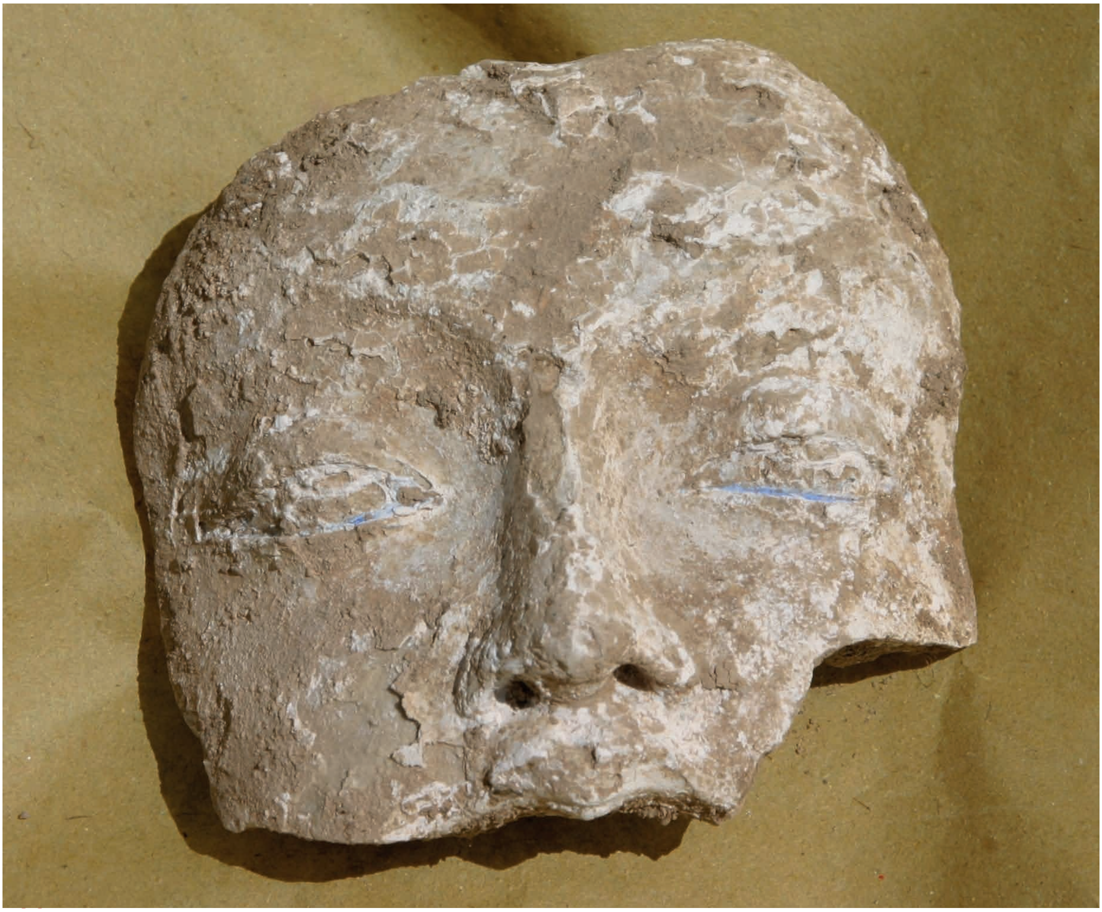

Fig. 15
The bodhisattva from Tepe Maranjan: detail of the traces of blue paint on the eye outline.

sion, contemplation), where attention to the eyes and the concept of colour have fundamental value (Filigenzi, in collaboration with Paiman and Alram, in press).
We therefore begin to see a continuous enrichment of the iconographic repertoire, which, in addition to incorporating traditional models, uses new contributions from local tradition and a vigorous experimentation of techniques and materials, which led to the creation of new artistic codes, inherent to specific philosophical and religious concepts.
With clay sculpture and the possibilities offered by plastic materials, some themes and aspects seem to be more prominent, for example gigantism, gilding, and the luminous, transcendent aspect of Buddha's nature.
It is therefore essential to probe this topic through programmed, comparative studies, with the aid of chemical-physical analyses aimed at solving open issues and lacunae, starting from the vast scientific documentation available, to shed light on problems that also concern less documented sites, from an archaeological point of view, such as Mes Aynak.

Acknowledgments
Special thanks go to Anna Filigenzi, director of the Italian Archaeological Mission in Afghanistan and to Zafar Paiman, director of the Tepe Narenj excavation, who made this work possible. Also, on behalf of the Italian Archaeological Mission in Afghanistan, I would like to thank Pierre Cambon, chief conservator of the Musée Guimet for his collaborative support to our enquiry into colours. Photos nos. 1, 4-5, 10-15: copyright Zafar Paiman, in particular photo
n. 15 taken at the Kabul Museum. Photos nos. 2-3, 6-9, 16-17: copyright Italian Archaeological Mission in Afghanistan. The remaining photos are copyrighted by the Italian Archaeological Mission in Afghanistan.

Fig. 16
Head with traces of blue paint on the hair from Tapa Sardar.

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Collections gandhariennes et afghanes à Paris, Musée national des arts asiatiques-Guimet

Pierre Cambon
Conservateur en chef, Musée national des arts asiatiques-Guimet

opposite page
Fig. 1 Maitreya debout, Schiste, Art du Gandhara, actuel Pakistan, 1er – 3ème s., Mission Alfred Foucher, 1896-1897, Musée National des Arts asiatiques-Guimet, AO 2908, photo Thierry Ollivier.

Abstract
Les collections de Paris occupent une position singulière en Europe parce qu'elles font le lien entre les collections anglaises, ou bien encore allemandes, largement gandhariennes, au sens de Peshawar (Londres, British Museum; Berlin, Museum für Asiatische Kunst), et les collections italiennes, qui, elles, renvoient généralement au Swat (Rome, Museo Nazionale d'Arte Orientale «Giuseppe Tucci», maintenant fusionné dans le Museo delle Civiltà).

Gandhara (Cambon 2010)
Le fonds premier des collections de Paris renvoie à la mission d'Alfred Foucher sur la frontière indo-afghane, en 1896-1897, quand il étudie l'art indien, dans le sous-continent, sous mandat britannique, au temps de l'*Archaeological Survey of India.* L'intérêt de cette mission est de rapporter à Paris une centaine de fragments avec quelques statues, dont l'origine est très souvent donnée. Ceux-ci sont d'abord attribués au Louvre, où ils sont présentés au Département des Antiquités Orientales, ce qui est symptomatique de la vision de l'époque – le Gandhara comme prolongement à l'Est de l'art gréco-romain (Foucher 1900, Migeon 1929).
Ce sont ces reliefs et ces quelques sculptures qui illustrent la thèse d'Alfred Foucher sur l'art gréco-bouddhique du Gandhara, dont le 1er volume parait en 1905, avec les collections du musée de Lahore (Foucher 1905-1951). Ils y sont donnés comme collection du Louvre. Ce fonds ne sera versé au musée Guimet qu'après 1945, dans le cadre de la redéfinition du déploiement des collections entre les deux institutions. Il renvoie essentiellement à la région de Peshawar, avec la fouille de Shahbaz-garhi dont provient le bodhisattva aux allures de maharaja ou bien de prince indien, mais dont l'auréole est rehaussée par des rubans qui flottent dans le vent, à la manière du diadèmes des Grecs, et dont la bouffette de turban s'orne d'une transcription à l'indienne du rapt de Ganymède par Zeus, traduit ici par l'enlèvement d'une *nagini* par l'oiseau Garuda. Au collier brahmanique, répond le torque et les bijoux de bras incrustés de pierres semi-précieuses, le collier

RA 1 | 2019, pagg. 140 | 153
ISSN 1724-9686 (print) | ISSN 2465-2377 (online)

Fig. 2
Bas-relief avec scènes de la vie du Buddha, sommeil des femmes et grand départ, Schiste, Art du Gandhara, actuel Pakistan, 1er – 3ème s., Buner, Mission Alfred Foucher, 1896-1897, Musée National des Arts asiatiques-Guimet, AO 2956, photo Thierry Ollivier.

où sont représentés deux *putti* affrontés, que l'on retrouve aussi à la base du turban, les pendentifs en forme de léogriphes, voire des sandales à la grecque avec masque de lion. Bref, une sculpture de tout premier plan, où l'éclectisme des références correspond parfaitement à l'approche de Foucher, pour qui le Gandhara est l'art de la rencontre entre Inde et méditerranée, sur fond d'apport des steppes, voire aussi comme l'avait dit Emile Sénart, et ce bien avant lui, de l'Orient hellénisé.
A côté existent des morceaux de reliefs provenant de Ranigat ou bien de Charsadda, mais également du Buner et du Swat, où Alfred Foucher fait une brève incursion en franchissant la passe de Malakand. Tout ce fond majoritairement de schiste, quelques plâtres mis à part provenant de Shahbaz-garhi, apparait parfaitement homogène sur le plan de la structure des pierres, comme l'analyse l'a montré - les reliefs du Swat mis à part, dont la composition témoigne d'une histoire géologique complètement différente, même si sur le plan formel, tous les reliefs relèvent du style du Gandhara dans sa facture la plus classique, l'école de Peshawar. Renvoyant à ce fond Foucher, mérite aussi d'être citée une statue de Maitreya debout, au charme adolescent et portant l'auréole, le vase à eau à la main, même si sa provenance n'apparait pas donnée. De taille plus petite que le bodhisattva de Shahbaz-garhi, elle est l'un des très rares exemples de statues gandhariennes en ronde-bosse, puisque le revers est sculpté et les

Fig. 3
Eléphant, Schiste, Art du Gandhara, actuel Pakistan, 1er – 3ème s., Don de M. et Mme Georges Frémont, 1996, Musée National des Arts asiatiques-Guimet, MA 6295, photo Thierry Ollivier.

plis du drapé parfaitement suggérés, même en l'absence de tout relief ou bien de tout volume. Se dressant sur un piédestal, orné d'un motif harmonieux de lotus à quatre pétales, dessinés avec élégance, que l'on retrouve sur d'autres sculptures du musée de Lahore, elle renvoie peut-être aux premiers développements de l'art du Gandhara, encore influencé par un modèle de type hellénisant (Figg. 1, 2, 3).

Kapisa

En 1921, Alfred Foucher qui poursuit alors ses recherches en Inde, aux temps de l'*Archaeological Survey of India*, avec Sir John Marshall, est contacté par Philippe Berthelot, secrétaire général au Ministère français des Affaires étrangères, pour être envoyé en mission à Kabul. Une fois sur place, il pose les bases de l'accord de coopération, entre les deux pays, signé en 1922, qui fonde la DAFA (Délégation Archéologique Française en Afghanistan) et accorde à la France le monopole des fouilles en Afghanistan pendant une période de trente ans (clause qui sera levée en 1945), tout en lui concédant un partage des trouvailles, les pièces exceptionnelles mises à pat (clause qui va durer jusqu'à la suspension des accords en 1982)[1]. Alfred Foucher pendant son séjour en Afghanistan explore les environs de Kabul, fait les premiers sondages sur le site de Hadda, visite le Kapisa et la ville de Begram, et plus tard la vallée de Bamiyan, posant les jalons du programme de recherche que va développer la DAFA dans les années 1930, - cela avant d'aller lui-même fouiller à Balkh, où Joseph Hackin le rejoint, le temps d'une campagne, avant de devenir plus tard le directeur sur le terrain de la DAFA *de facto,* parallèlement à son poste de directeur au Musée Guimet à Paris.

[1] Auboyer 1968; Allchin, Hammond 1987; Cambon 2012, Cambon (ed.) 2002.

Fig. 4
Le grand miracle de Sravasti, schiste, site de Païtava, école du Kapisa, Afghanistan, 3ème - 4ème s., Mission Joseph Hackin, 1924, Musée National des Arts asiatiques-Guimet, MG 17478, photo Thierry Ollivier.

opposite page
Fig. 5
La légende de Dipankaa, l'offrande de l'étudiant Megha, schiste, site de Shotorak, école du Kapisa, Afghanistan, 3ème - 4ème s., fouilles de Jacques Meunié, 1937, Musée National des Arts asiatiques-Guimet, MG 21148, photo Thierry Ollivier.

C'est au cours de cette première mission en Afghanistan que Joseph Hackin, en revenant de Balkh, reprend le site de Païtava en 1924 (Hackin 1925-1926 ; Cambon 1986, Id. 1996), où avait été découverte dix ans auparavant, une stèle au grand miracle, en schiste, par les équipes afghanes du musée de Kabul. Celle-ci est aujourd'hui à Berlin, la pièce ayant été donnée en cadeau officiel par le roi d'Afghanistan, Amanullah, lors de son voyage en Europe, en 1929. Le site de Païtava, sur la route de Begram, renvoie au Kapisa et montre la diffusion en territoire afghan de l'art du Gandhara, à une époque relativement tardive (3ème – 4ème siècle). Le style est différent de celui de Peshawar, plus hiératique et raide; les thèmes également, qui témoignent d'une influence visible des confins iraniens, avec ce motif de

[2] La 1ère stèle en schiste, de style gandharien, à être publiée dans le *Journal of Asiatic Society of Bengale*, en 1834 (Calcutta, Vol. III, pl. XXVI), provient de fouilles effectuées à Kabul et montre un Buddha assis et méditant sur un fond d'auréole, des flammes sortant de ses épaules.

[3] "Vendredi 12 décembre// Samedi 13 décembre. Visite à Paîtâvâ avec Gholam Mohammed Khan et Gholam Moyeddine Khan, visite du teppeh où G.M. a trouvé des bas-reliefs gréco-bouddhiques. Fouilles faciles avec main-d'œuvre abondante. Jusqu'au bout, cependant, c'est l'incertitude, car le propriétaire du champ a gros appétit// Dimanche 14 décembre// Lundi 15 décembre. Préparatifs de départ pour Pâitâvâ// Mardi 16 décembre. Faux départ// Mercredi 17 décembre. Départ pour Pâitâvâ, sous la neige, arrivée et interminable discussion de 3 h. à 8 heures avec le propriétaire du teppeh où nous devons fouiller; quelle singulière mentalité; on rédige des projets de contrat qui déclinent les amendements les plus abracadabrants et on conclut enfin sur la base proposée au début: 600 roupies kaboulies; nous pourrons donc commencer demain. Remarquer que les discussions sont coupées par

flammes sortant des épaules du Buddha[2]; le matériau enfin se distingue pareillement de celui utilisé dans l'art du Gandhara, le schiste étant plus vert, d'une extrême dureté, très différent dans sa morphologie de l'aspect lisse des schiste de Peshawar, dont le coloris gris est parfois très légèrement bleuté et qui semble plus friable (Cambon [avec Leclaire] 1999). Il est très éloigné aussi des schistes de la vallée du Swat, à la structure interne beaucoup plus chaotique. La fouille de la fondation bouddhique de Païtava, témoin d'un ancien monastère, se fait en plein hiver, à 2.000 mètres d'altitude. Le carnet de Joseph Hackin relate la découverte majeure de cet exercice, soit une deuxième stèle au grand miracle, sur le modèle de la stèle précédente[3].

Ce thème du grand miracle de Sravasti, où le Buddha s'élève dans les airs pour convaincre les maitres hérétiques, l'eau s'échappant de ses pieds, les flammes de ses épaules, parait très en faveur au Kapisa, quand il n'est que très peu évoqué dans l'art du Gandhara, sans jamais prendre les dimensions monumentales que celui-ci va prendre dans la région de Begram, avec notamment la statue de Sarai Khwaja. Une stèle quasiment de même type et de même facture que celles trouvées à Païtava, et d'une taille identique, sera mise à jour plus tard lors des fouilles du monastère de Shotorak, en 1937, même si celle-ci n'est pas illustrée dans la publication. Elle est pourtant au musée de Kabul, suggérant peut-être la présence d'un atelier local, tant les trois stèles apparaissent similaires[4]. Des exemples à la taille beaucoup plus imposante et de date sans doute plus tardive, existent également au musée de Kabul, montrant par l'influence indienne de style post - gupta très nettement visible, la popularité du thème sur une longue période, dans cette région frontière aux confins de l'Iran (Figg. 4, 5).

Hadda

Mais, la grande affaire des années 1920 sera le site de Hadda où Jules Barthoux dès 1926 prit le relais d'Alfred Foucher (Foucher 1929 ; Barthoux 1930, Id. 1933 ; Cambon 2004, Id. 2016). Le site est éloigné du pouvoir central et rongé par le fondamentalisme local. Les premières statues mises au jour sont détruites par le village voisin. Mais Jules Barthoux n'en continue pas moins sous la protection de l'armée les fouilles du monastère de Tapa-kalan en 1927, enchaînant par la suite avec les monastères de Bagh Gaï, de Chakhil-i-ghoundi, de Tapa-i-kafariha, sans oublier Gar-nao, Prates ou Deh-ghoundi, et cela en l'espace de deux ans, 1926-1928. Le site est en effet d'une extrême richesse comme en avaient témoigné les pèlerins chinois, et notamment Xuanzang qui situe là la rencontre du futur Buddha Sakyamuni et de Dipankara, l'un des Buddha du passé. Dès le début du 19ème siècle, un aventurier comme Charles Masson avait reconnu les lieux, effectuant les tous premiers sondages des stupas, qu'il prenait pour des tombes (Mason 1841). L'illustre aussi plus tard la reprise des fouilles, dans les années 1960, par l'Institut archéologique afghan, avec le monastère de Tapa Shotor (fouilles de S. Mustamindi, poursuivies par la suite par Zémaryalaï Tarzi).

des diversions sans liens logiques avec la préoccupation dominante, puis on revient au sujet. Quels ergoteurs// Jeudi 18 décembre. Nous commençons à 8 h 45, tracé rapide et les hommes au nombre de cinquante se mettent au travail; bons travailleurs; nous découvrons immédiatement des jarres énormes: 2 m 70 de tour, 1 m 20 de hauteur, rien d'autre. Gholam Moyeddine fonde les plus beaux espoirs sur Pâitâvâ – teppeh. Je suis moins enthousiaste// Vendredi 19 décembre. Trouvailles insignifiantes. G.M. témoigne d'une juvénile ardeur ; nous trouvons de nouvelles jarres// Samedi 20 décembre. La matinée est signalée par la première trouvaille, un petit génie, sans doute l'un des enfants de l'ogresse Hâritî ; la face poupine apparaît tout d'abord encastrée dans la terre compacte (couche terreuse compacte). Puis apparaissent les détails du corps. Un peu plus tard, on découvre une tête de Buddha et enfin, à 3 h et demie, la pièce de résistance, un Buddha au grand miracle. Il apparaît neuf et tout doré ; la face tout d'abord dégagée étincelle face au soleil à son déclin. C'est la belle lumière d'or dont la légende embellit l'image du Bienheureux. Mais le prestige s'évanouit, car, très rapidement, les feuilles d'or disparaissent, s'écaillent. Rush autour de nous ; le mollah s'empresse et nous aide// Dimanche 22 [*sic*] décembre. Découverte de soubassement// Lundi 23 [*sic*] décembre. Retour à Kâboul. " (Joseph Hackin, *journal, mission 1924*, Archives musée Guimet).

[4] Meunié 1942 : 49, N° 93, H. 85 ; Larg. 31 cm.

Fig. 6
Escalier de la plateforme du stupa C 1, calcaire, monastère de Chakhil-i-ghoundi, Site de Hadda, Afghanistan, 1er – 3ème s., fouilles de Jules Barthoux, 1928, Musée National des Arts asiatiques-Guimet, MG 17191*, photo Thierry Ollivier.

opposite page
Fig. 7
Base du stupa K 20, calcaire, monastère de Tapa-i-kafariha, Site de Hadda, Afghanistan, 1er – 3ème s., fouilles de Jules Barthoux, 1928, Musée National des Arts asiatiques-Guimet, MG 17217*, photo Thierry Ollivier.

Le site de Hadda fut la révélation d'un art du stuc gréco-afghan, un art du modelage qui apparait bien plus hellénisant que les reliefs de schiste de l'art du Gandhara, même s'il semble plus tardif et dater de la dernière phase de la période Kouchane (1er – 4ème s.), voire de l'époque des Chionites-Hephtalites (5ème - 6ème s.). L'occupation est en effet très longue, du 1er jusqu'au 7ème s., offrant un panorama général de la diffusion de l'art du Gandhara venu de Peshawar et des différents aspects qu'elle prend successivement, dans le courant des siècles. A côté du stuc, ou bien de la terre crue – massivement représenté à Tapa-kalan dans un cas et dans l'autre à Tapa-i-kafariha -, existent également des schistes, strictement de même style et de même facture, de même composition aussi, que les exemples du Gandhara, ressemblance qui n'est pas simplement formelle, mais aussi structurelle, puisque la pierre à l'analyse s'avère être la même. Existe aussi le calcaire représenté notamment à Tapa-i-kafariha, à côté du stuc, de la terre et du schiste, mais qu'on trouve aussi à Chakhil-i-ghoundi sur un mode différent et peut - être plus ancien, un calcaire qu'illustre avec élégance la tête de *Salabhanjika* provenant de Tapa-i-kafariha, dont la polychromie est restée dans tout son éclat et dans toute sa fraicheur – soit une extraordinaire diversité de matériaux dont la palette semble bien plus large qu'au Gandhara lui-même et qui témoigne visiblement d'une évolution dans le temps.

L'intérêt des collections de Paris est enfin que ces collections de Hadda sont restées bien souvent dans l'état d'origine, celui du terrain de la fouille – mis à part les pièces prélevées en réserve par Joseph Hackin, alors conservateur, pour ouvrir la première galerie afghane, inaugurée au musée au tout début de 1929. Si celles-ci parfois ont été 'nettoyées' un peu abusivement, selon les critères d'aujourd'hui, certaines toutefois ont su garder leurs couleurs initiales, comme la base de stupa en calcaire du monastère de Tapa-i-kafariha - une base ponctuée d'éléphants en saillie, le cornac sur le dos,

opposite page
Fig. 8
Tête féminine, Salabhanjika, calcaire, monastère de Tapa-i-kafariha, Site de Hadda, Afghanistan, 1er – 3ème s., fouilles de Jules Barthoux, 1928, Musée National des Arts asiatiques - Guimet, MG 17203, photo Thierry Ollivier.

entre des panneaux à décor d'atlantes classicisants et de pilastres à chapiteaux néo-corinthiens sur le mode asiatique – soit tout un programme décoratif qui semble la transcription exacte de ce qu'on trouve en schiste en terre de Gandhara, à Shahri-bahlol par exemple. On mentionnera d'ailleurs la présence de peintures à Bagh-gai, parfaitement conservées, qui au vu des analyses s'avèrent être peintes à la fresque, le rouge utilisé correspondant à une ocre rouge, le bleu à du lapis-lazuli, le noir à un pigment à base de noir de charbon (Figg. 6, 7, 8).

Fondukistan

La fin de l'art bouddhique en territoire afghan est illustrée par la fouille du petit monastère de Fondukistan, sur la route de Bamiyan (dont les dimensions ne sont pas données dans la publication, sans doute par suite d'un oubli), et dont les collections ont été partagées scrupuleusement entre le musée de Kabul et celui de Paris (Hackin 1940 ; Hackin et al. 1959)[5]. La fouille menée par Jean Carl, en 1937, parallèle à celle du site de Begram, qui révèle la même année la première chambre du 'trésor', dégage au cœur du monastère une cour carrée qu'occupe le stupa principal. Sur celle-ci s'ouvrent des niches sur les quatre côtés, avec tout un décor de terre, modelé dans les trois dimensions, ou plus exactement allant du bas au haut-relief, voire à la quasi ronde-bosse, à la manière d'un décor de théâtre [6]. Entre, des restes de peinture, dont Jean Carl a fait quelques copies (Maitreya, les dieux lunaire et solaire). Le programme voit ainsi dans la niche C un buddha trônant, flanqué de chaque côté, par un Buddha à la pose très souple, évoqué de trois – quart, tout en faisant le geste de l'*abhayamudra*; dans la niche D, un Buddha, portant sur les épaules le camail à trois pointes, assis sur un lotus qui sort d'un bassin, où paraissent deux nagas à mi-corps ; dans la niche E, un couple de donateurs, représentés dans la pose du délassement royal, la princesse dénudée à l'indienne, le prince vêtu à la sogdienne.

Témoin d'une sophistication croissante qui annonce les bronzes du Swat et plus tard du Cachemire, Fondukistan témoigne d'une esthétique nouvelle, une esthétique au canon allongé, à la tête très petite, aux silhouettes longilignes, à la ligne fluide, non sans préciosité, aux gestes affectés, quasiment maniéristes, qui joue la grâce ou bien la séduction, et dont l'écho se retrouve sur les peintures murales dans la vallée de Bamiyan. Les statues ici ont gardé toute leur polychromie dont les teintes jouent du bleu, du rouge ou bien du noir. L'approche est différente de celle qui se voit dans les fondations de Hadda, où la couleur n'est là que pour mieux souligner le modelé, de façon incidente. Fondukistan souligne ainsi le chemin parcouru depuis le Gandhara et la vallée du Swat, où les reliefs sont massivement en schiste, un schiste qu'on retrouve au Kapisa, mais décliné un peu différemment et qui peut-être était parfois doré, quand il n'était pas peint (exemple de Mes Aynak), le chemin parcouru du schiste à la terre crue, annonçant la manière du Xinjiang, où la polychromie touche l'image dans sa globalité, avec ses couleurs crues, à la gamme très vive, dénuée de toute réalité (oasis de Turfan).

[5] L'article de Joseph Hackin (Le monastère bouddhique de Fondukistan (fouilles de J. Carl, 1937), in Hackin et al. 1959 : 49-58) reprend en fait un papier qu'il publie en anglais (Hackin 1940). Il est agrémenté ici d'un plan, d'après un dessin schématique de Jean Carl, sans toutefois comporter d'orientation, ou bien de dimensions. D'après le croquis de Carl, dans son journal de fouille (Archives, Musée Guimet), les niches C, D, E qui occupent le mur Est mesurent respectivement en largeur 1 m 15, 1 m 15, 1 m 20 ; les niches K, L, J, qui, elles, agrémentent le mur sud, 0 m 75, 0 m 70, 0 m 85, avec en plus, sur cette paroi, la présence d'une porte d'entrée qui donne sur la cour, d'1 m 30 de large – soit en tenant compte de l'aération entre les différentes niches, une cour au stupa de plan carré, d'environ 4 m 50 sur 4 m 50.

[6] "Chaque cellule individuelle était une combinaison de peinture et de sculpture, le fond peint étant un prolongement et un décor pour les groupes de statues, en une sorte de tableau vivant bouddhique ou de trompe-l'œil stéréoscopique des régions célestes." (Rowland 1974 : 108).

Fig. 9
Buddha assis en délassement royal, terre, Monastère de Fondukistan, niche C, Afghanistan, 6ème – 7ème s., fouilles de Jean Carl, 1937, Musée National des Arts asiatiques-Guimet, MG 18970, photo Thierry Ollivier.

Fondukistan, tout comme Tapa Sardar, témoigne d'un art de la terre crue qui semble faire suite aux modelages en stuc et dater largement de l'époque Hephtalite (6ème – 7ème s.). Les connexions avec Bamiyan ne portent pas seulement sur l'iconographie, mais aussi sur la palette des couleurs retenues, aux harmonies très vives, à base de tons primaires, posées largement en à-plat - et l'atmosphère qu'elle suggère visuellement. Certains coloris sont privilégiés à Fondukistan, sur la chevelure des figures ou le manteau monastique, les mêmes que l'on retrouve en arrière–plan, dans l'évocation du fameux 'roi chasseur' du site de Kakrak, qui porte la couronne, ornée des trois croissants [7]. Le réalisme des Buddha de Hadda aux yeux d'un bleu très sombre, à la chevelure noire, bordé d'un très fin liseré rouge, avec délicatesse, laisse place dès lors à un monde merveilleux, quasiment irréel, où le sauveur bouddhique prend des allures de prince, au charme très aristocratique, et aux boucles bleutées (Fig. 9).

Conclusion

Les analyses réalisées en 2016 confirment le rapport de fouille de 1924. Les reliefs du Kapisa étaient dorés, que ce soit à Païtava, ou bien à Shotorak, quand ils n'étaient pas peints, comme c'est le cas à Mes Aynak. La période semble la même et le style identique. Ils témoignent d'une phase kouchane tardive de l'art du Gandhara, aux frontières de l'Iran, une phase koushano-sassanide ou même post-kouchane, qui annonce déjà celle des Hephtalites, sous couvert des Turcs Occidentaux. Fondukistan illustre le chapitre suivant qui ouvre sur l'Asie Centrale, le Swat et l'art himalayen, les derniers feux de l'art bouddhique en territoire afghan. Bamiyan, alors, se retrouve au carrefour de ces multiples routes, et prend une importance croissante, entre le monde indien et celui du Xinjiang, et là aussi, au dire des pèlerins chinois, et notamment Xuanzang, les icones monumentales, sculptées dans la falaise, paraissent avoir été dorées. Reste le problème du Gandhara et celui de Hadda, puisqu'il s'agit de la période d'avant le Kapisa, même si Hadda déborde très largement la phase classique du style de Peshawar, faisant le lien entre le Kapisa et certains sites, comme Shahri Bahlol, dans les reliefs ou les stèles en calcaire du monastère de Tapa-i-kafariha, mais évoquant aussi les peintures de Bamiyan, dans certains stucs venant du même complexe.

Qu'en est-il exactement du rapport entre schiste et peinture dans l'ancien Gandhara? A Hadda, la polychromie des stucs reste naturaliste, à Bagh Gaï notamment; elle est aussi de type minimaliste, rehaussant simplement le modelé à la marge, pour lui donner un aspect au plus près du réel. Si la chevelure est peinte en noir, ou le vêtement en rouge, pour ce qui est des Buddha, les yeux, dont l'iris est marqué, sont soulignés de manière très légère par le trait des sourcils et la bouche indiquée par la couleur des lèvres, de façon naturelle. La différence est grande avec Fondukistan où la polychromie joue sur un monde hors du temps, où les couleurs bien souvent arbitraires confèrent à l'image un statut différent. La question se pose donc de l'approche retenue à Peshawar, en fonction des époques, pour ce qui est du schiste. Est-ce la même que celle du Kapisa, qui préfigure Bamiyan ou bien Fondukistan ? A la manière de l'interprétation actuelle des frises du Parthénon, à la période classique. Ou s'en distingue-t-elle par une gamme de couleur différente, une démarche réaliste, sur le mode de Hadda, et des couleurs moins vives. Y a- t-il évolution chronologique, au sens stylistique ? Différence régionale ? Ou simple '*distinguo*' entre les matériaux, dès lors qu'il s'agit de la pierre ou du stuc ?

[7] Hackin 1933 : 62-63, pl. LXIV.

A relire Xuanzang, en tout cas, la peinture n'est pas étrangère à la pierre puisqu'il mentionne très explicitement une image peinte du Buddha sur le stupa de l'empereur Kanishka, à Po-lu-sha-pu-lo:

> *On the northern side of the stone steps of the great stupa, there is a painted figure of Buddha about sixteen feet high. [...] The painter having received thus a gold piece from each, procured some excellent colours (blue and vermilion) and painted a picture.*

Sa description du monument lui-même est d'ailleurs ambigüe et suggère un décor coloré, même s'il le donne comme des jeux de lumière, à la cause plus ou moins merveilleuse:

> *On the northern side of the steps, on the eastern face of the great stupa, [...] there are two full-sized figures of Buddha, one four feet, the other six feet in height. [...] When the full rays of the sun shine on them they appear of a brilliant gold colour, and as the light decreases the hues of the stone seem to assume a reddish-blue colour*[8].

Reste que la polychromie évolue à Hadda, pour ce qui est des stucs, du réalisme de l'image à la polychromie partielle, pour les figures dont l'esthétique est proche de celles du Gandhara, Shahri-Bahlol notamment, aux à-plats de l'icône, dont la silhouette parait entièrement peinte, voie même éventuellement dorée, pour les images dont le style annonce déjà l'Asie centrale, ou Fayaz tepe par exemple, et là aussi la gamme des couleurs apparait différente, sur le plan chromatique ou celui des pigments[9].

[8] Beal [1968]: 101-102.
[9] Descamps–Lequime (éd.) 2007, Varma 1987.

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The Gandharan Collection of the Civic Archaeological Museum of Milan

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opposite page
Fig. 1
Milan, Civic Archaeological Museum, Bodhisattva statue, inv. A 0.9.2921.

Abstract

The Civic Archaeological Museum of Milan holds a small but remarkable collection of Gandharan Art, acquired by the former Director Ermanno Arslan, between the 70s and the 90s of the 20th century. Archaeological method, that is to say contextualization, must apply also to objects without provenance. Cultural diversity is the starting point to understand/detect relations, connections, mutual interferences between cultures. Through museum exhibitions, we can transmit the notion that archaeological objects, more than being works of art to be admired for their beauty, are a cluster of various information regarding the ancient culture to which they belong.

The Civic Archaeological Museum of Milan holds a small but remarkable collection of Gandharan Art, acquired by the former Director Ermanno Arslan, between the 70s and the 90s of the 20th century.
The collection, which is composed of less than 40 pieces from the antiquarian market, were selected in order to give an insight into this artistic production, mostly unknown to the museum's general public.
At the time of acquisition, Milan was an important market for Oriental art and the purpose was to assign to public view objects which were about to enter private collections. The latter prevailed due to the ancient and ongoing pillage of Gandharan art (on this topic see Ali, Coningham 1998).
Though questionable, the acquisition of this collection offers the museum the possibility to let visitors discover such an important artistic production, as well as to stress the importance of context, both in the strict and in a broader sense, in order to understand these ancient works.
These issues – the importance of context and how the loss of it undermines the identity of artifacts without provenance – are among the most relevant issues that an archaeological museum must address.
Furthermore, Gandharan art has long suffered from being perceived as Buddhist art dressed in Hellenistic forms[1]. This allure has determined its success in Europe but has also undermined its comprehension. Formal qualities, being a straightforward means for museum visitors to interpret

[1] Filigenzi 2012b, and in press.

RA 2 | 2019, pagg. 154 | 161
ISSN 1724-9686 (print) | ISSN 2465-2377 (online)

Fig. 2a, 2b
Milan, Civic Archaeological Museum, Pilaster Capital, inv. A 990.05.01.

objects, can be misleading if not correctly explained. The museum must function as a mediator, fostering curiosity but also providing insights that underline the importance of scientific knowledge for the interpretation of is collections.

Exhibition guidelines

The museum exhibition[2] is accompanied by panels with illustrations on the geographical, historical, religious and social contexts of Gandharan art. Graphical reconstructions help contextualize the scattered pieces, while texts give visitors insights into Buddhism, long distance trade routes and the discovery of Gandharan art.
Once properly framed in its historical and religious context Gandharan art appears less a mere branch of Hellenized East and more a phenomenon in its own right, that cannot be read and understood out of its local context. Gandharan art follows its own specialized codes that vary in time and space. Though archaeological contexts are still very few in regard to the collections around the world, recent research has prompted new approaches and provides some significant viewpoints. Reconnected to its own cultural universe Gandhara offers a significant and illuminating example of how a cultural entity develops through interactions with other cultures.
Art is a conventionalized system of communication that depends on context and we must rethink our way of looking at objects. Archaeological method, that is to say contextualization, must apply also to objects without provenance. Cultural diversity is the starting point to understand/detect relations, connections, mutual interferences.
Through museum exhibitions, we can transmit the notion that archaeological objects, more than being works of art to be admired for their beauty,

[2] Due to lack of display space, some objects are in the store-rooms.

Fig. 3
Milan, Civic Archaeological Museum, Relief, inv. A 0.9.18499.

are a cluster of various information regarding the ancient culture to which they belong; they bear information about religion, society, economy, because of their being, in antiquity, the most powerful media of communication.

The Gandharan Collection of Milan ranges from statues to reliefs and architectural elements (a *nāgadanta* – *stūpa* peg –, a small capital from an engaged pilaster, a dividing element with an engaged pilaster). It also includes five reliquaries and an inscribed terracotta jar. Stucco and clay production is represented by the head of a Buddha and other figures belonging to reliefs and scenes once applied to walls.

Some items have been cited in papers and books[3]; none of them have ownership history – as far as I can infer from archival documents – except the name of the last dealer/owner. Some fragments are allegedly said to come from Swāt (Provenzali 2005, nn. 4, 19) or from Hadda/Nagarahara (Provenzali 2005, nn. 30-31)[4]; in some cases the type of schist (green schist) points to Swat as the place of provenance[5] (Provenzali 2005, nn. 22 - Fig. 2a-b, 23). This provenance can also be tentatively hypothesized for other items that display similarities in material or iconography with items from Swāt (Provenzali 2005, n. 12 - Fig. 3).

[3] Besides the bibliography cited in Verardi 1991, Provenzali 2000 and 2005 see Taddei 1991, p. 317, n. 5 (Civic Archaeological Museum, Inv. N. A 0.9.18496; Filigenzi 2012a, fig.13 (Civic Archaeological Museum, Inv N. A 0.9.18497).

[4] Reported in the acquisitions register.

[5] A gandharan-corinthian capital and the dividing element (the latter in talcose schist).

opposite page
Fig. 4
Milan, Civic Archaeological Museum, Bodhisattva Head with inscription, inv. A 0.9.18496.

Lacking their archaeological context and all related data, the items must be scrutinized from various perspectives in order to gather as much information as possible.
Morphological analysis, material, masons tool marks, combined with iconographic and stylistic analysis can give us useful data to link the items in the collection to others whose provenance is known, and to eventually detect fakes.
When dealing with out-of-context items, careful scrutiny is the only feasible approach. It can be very discouraging as it raises more doubts than it provides certainties; often it clashes with the singularity of an object. We can only commit ourselves to observe every item from different points of view, without forgetting that any assumption must be thoroughly examined.
Diagnostic analysis such as that conducted by Pannuzi, Talarico, Guida, Rosa (in this issue) is a useful means to gain information about objects, that we hope will also be useful to contextualize them.
In this brief contribution we can only outline some issues regarding the Milan collection.

Detecting recent modifications

Coming from the antiquarian market, reliefs and statues are liable to have been modified in order to meet the taste of the collector[6].
The Bodhisattva head with inscription on the halo (Fig. 4, schist, H.30 cm, Lenght.24, Provenzali 2005, n.4) is puzzling if one observes the treatment of the eye. The surface of the concave halo has not been polished notwithstanding the inscription, while the face of the bodhisattva is in very good condition. It could be a fake, but the inscription is deemed to be authentic.
Some stucco figures bear traces of restoration aimed at hiding fractures and junctions (see for example Provenzali 2005, nn. 30-31). I devoted an article to the biggest reliquary of the collection, a "pastiche" composed from different fragments.
A Bodhisattva statue (Inv. N. A 0.9.2921, Provenzali 2005, n.5) shows holes, made in recent times, to fix to it other pieces (Fig. 1).

Research perspectives

The advancement of Gandharan studies linked to the publication of archaeological reports and to archaeological investigations is bringing new perspectives to the study of the collection[7].
Stucco and clay statues need to be studied for their materials and moulding/modeling technique and their relation to the archaeological records (see for example Filigenzi 2010).
A morphological analysis that takes into account mortises, tenons, masons and tool marks can give us clues regarding the possible original location of objects.

[6] See for example Provenzali 2005, nn.30-31.Heads seems to have been rejoined (or simply attached) to another part/to the body.

[7] See Faccenna 1980-1981;1993 and 1995, Olivieri- Filigenzi 2018.

We hope that, being studied and exhibited in a public museum, these items which are stuck in show-cases so far from home, will regain as much as possible of their identity.
Surely they have much to teach us about the way we should perceive cross-cultural relationships in the ancient as in the contemporary world.

Fig. 5a, 5b
Milan, Civic Archaeological Museum, Relief, inv.A 0.9.18498.

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

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opposite page
Fig. 3
Butkara I (Swāt Valley, Mingora, Pakistan). General plan with stūpa n. 17 highlighted in blue. Published in Faccenna, 1980, part 5.2. Courtesy IsMEO Italian Archaeological Mission in Pakistan.

Abstract

Taking into account the reports on archaeological excavation and the resulting successive publications, the present article wants to define the exact place of origin and an accurate dating for a schist bracket showing traces of gilding, currently preserved in the MAO Museo d'Arte Orientale in Turin (Inv. n. IAp/151). The bracket has been unearthed during excavations carried out between 1956 and 1962 by the Missione Archeologica Italiana at the site of Butkara I (Pakistan). In 2016, the conspicuous gilding still present and the bole underneath it have been scientifically analyzed by the ISCR, Istituto Superiore per la Conservazione e il Restauro based in Rome. At present, the ISCR is carrying out important studies at international level on the polychromy and the gilding of stone and stucco elements pertaining to the Buddhist artistic production of the ancient region of Gandhara, an area at present situated between the two nation-states of Pakistan and Afghanistan.

The gilded bracket at the MAO Museo d'Arte Orientale

The collection of Gandharan art at the MAO Museo d'Arte Orientale in Turin preserves a considerable number of archaeological finds from the Buddhist Sacred Area of Butkara I. Between 1956 and 1962 the excavations carried out in the Swāt Valley by an Italian Archaeological Mission — led by the IsMEO from Rome and Centro Scavi e Ricerche in Asia from Turin, under the direction of Domenico Faccenna — uncovered Butkara I, one of the most important Buddhist Sacred Areas of Gandhara, located in the Swāt Valley near the village of Mingora (Khyber Pakhtunkhwa, formerly North West Frontier Province), Pakistan. The importance and complexity of the site, together with the scientific rigour of the excavations, which for the first time in the ancient Gandhara region were conducted with particular attention to stratigraphic analysis, have provided important chronological information about the evolution of architectural styles and figurative Buddhist arts of that area. The archaeological site includes a Buddhist Sacred Precinct connected to a large Inhabited Area. The central nucleus of the site is a Great Stūpa (GSt.), the earliest construction of which (GSt. 1)

RA 2 | 2019, pagg. 162 | 171
ISSN 1724-9686 (print) | ISSN 2465-2377 (online)

dates back to the 3rd century B.C. (Faccenna, 1980, part I, p. 32), the period of the first great spread of Buddhism in Asia from its place of origin in Northern India. Over the centuries the site, an irregular square of 75 × 80 metres, has undergone many architectural transformations and additions, reaching a total of 227 buildings that include many minor *stūpas*, columns, monasteries and shrines containing Buddha and Bodhisattva images. Currently their remains are in close proximity to one another. The Great Stūpa underwent reconstruction several times, each of them encapsulates the previous one: the remains of Great Stūpa are the result of four successive modifications (GSt. 2-3-4-5) of the ancient structure (Gst. 1), a large dome in blocks of dark phyllite resting on a cylindrical foundation, both coated with plaster. The five architectural periods of the Great Stūpa correspond to a variety of building techniques and decorative motifs; they also coincide with several periods in which the Sacred Precinct and the monuments it encloses were developed (for a detailed description of the five periods of the Great Stūpa of Butkara I, see Faccenna, 1980, part 1, pp. 21-127). The height of the splendour of the Sacred Precinct of Butkara I probably occurred with the third period of the Great Stūpa, GSt. 3, dated between the 1st and the 3rd century A.D. The first period of the following stage (GSt. 4, 4th-7th century A.D.) attests to great expressive maturity. Thereafter, a slow decline prevailed during the last period (GSt. 5, 8th-10th century A.D.), when the Great Stūpa was rebuilt following its destruction in the 7th century A.D. During subsequent reconstructions stucco was increasingly used to replace lacunae in the schist decorations and also to add new sculptural elements (Filigenzi, 2007, pp. 239-244; Olivieri and Filigenzi, 2017, pp. 85 – 90; Behrendt, 2017, pp. 159-161).

Among the sculptural and architectural elements uncovered during the Butkara I excavations, a few stucco and stone (schist) finds show traces of polychromy or gilding; the use of coloured plaster is equally evident on the surface of monuments. Notably, as far as the stone finds are concerned, traces of gilding can be found on statues and narrative reliefs, as well as on the cornices that framed the latter. In some cases, the gilding of the cornices also extended to the architectural elements and walls of the monuments (Faccenna, 1980, part 3, pp. 703-722). Since 2012, a research group headed by the ISCR, Istituto Superiore per la Conservazione ed il Restauro, based in Rome, in collaboration with the former Museo Nazionale d'Arte Orientale "Giuseppe Tucci" in Rome (at present MuCiv, Museo delle Civiltà – Museo d'arte orientale "Giuseppe Tucci") and with the Missione Archeologica Italiana in Swāt, directed by Luca Maria Olivieri, has begun to investigate some technological and productive aspects of Gandharan art. In particular, preliminary studies have evidenced the need to investigate through adequate diagnostic instruments an element which until now has not received due attention, i.e. the polychromatic or gilded coating of sculptures and Buddhist monuments in the ancient region of Gandhara (Pannuzi, 2015, pp. 9-15). In the following years, the ISCR has continued its research in this direction analyzing samples taken from different sculp-

Fig.1
Gilded bracket.
Butkara I (Swāt Valley, Mingora, Pakistan), 1st – 2nd century A.D.
Schist with traces of gilding, 11,7 × 19,8 cm.
MAO, Inv. n. IAp/151.
Courtesy Fondazione Torino Musei.

tural elements, which have produced important results published in the present volume. The artworks analyzed include a small bracket measuring 11,7 × 19,8 cm, found during excavations by the Missione Archeologica Italiana in the Swāt Valley (1956 – 1962) and presently preserved at the MAO Museo d'Arte Orientale in Turin.

In his excavation report, among the gilded architectural elements, Faccenna (1980, part 3, p. 721, note 1) mentions two findings in particular: a crossbar, Inv. no. 3941 and a bracket, Inv. no. 4581. The latter has been consigned at the time Museo Civico of Turin in the 1963 (fig. 1). The bracket, which is currently catalogued at the MAO Museo d'Arte Orientale of Turin under Inv. n. IAp/151, is a double volute type with vertical groove (Faccenna and Filigenzi, 2007, p. 96); the part of the body has triangular profile with two volutes at the upper and lower corners, while the tenon portion is missing. The upper part has two fillets, lower one is recessed below the upper one, followed by a row of dentils and bars of smaller height and width. This type of bracket is frequently found in the Swāt region (Zwalf, 1996, vol. I, p. 61). The bracket Inv. n. Iap/151 presents calcareous concretions that partly cover the gilding (gold leaf?). Indeed, the bracket still preserves ample areas of the original gilding that probably covered the whole object: despite lacunae, the most extensive areas of gilding can be found on the central part of the bracket and on the upper volute, however, there are also visible traces of gilding on the lower volute and on the second dentil from the left. High-resolution imaging shows further fragments of gilding on the fourth dentil from the left, on the recessed bar next to the second dentil, and on the terminal part to the right of the upper bar. Slight traces of red pigment are also visible, especially on the terminal part of the upper bar (fig. 2). In the catalogue of the *Sculture Buddiste dello Swat* exhibition, these remains are described as a red bole used as under layer for the gilding. Indeed, the caption about the golden bracket contains the following text:

> *Frammento di mensola con doppia voluta semplice. Restano tracce abbondanti della doratura che doveva coprire tutta la superficie a vista. Tracce del colore rosso di preparazione.*
> (*Sculture buddiste dello Swat*, 1963, p. 18, fig. 105)

The catalogue does not mention the name of the author of the texts, however, from correspondence between Vittorio Viale, the then Director of the Museo Civico of Turin, where the exhibition was held, and Domenico Faccenna, one may deduce that the caption had been written directly by Faccenna's colleagues (Archivio Museo Civico, CAA 1150, segnatura, 1963 – Scavi archeologici in Asia).

The gilded bracket was unearthed during the excavation of a minor *stūpa* (n. 17) that overlooks the circular ambulatory passage intended for ritual circumambulation (*pradakṣiṇapatha*) of the Great Stūpa (fig. 3). The *stūpa* lies on the Western side of the Northern entrance of the *pradakṣiṇapatha* and is considered to be one of the most noteworthy *stūpa*, within the variety of this class of monuments (Faccenna, 1962, vol. 1, pp. 39-40). The *stūpa* n. 17 has a quadrangular base and green schist decorations. The *stūpa* n. 17 (fig. 4) is worthy of note not only because the first level of its base is preserved, but part of the second as well, reaching a total height of 1.23 metres, while no remains of the hemispherical dome (*aṇḍa*) have been found. Both levels are square in shape; the second is more recessed compared with the first. The 1st storey consists of a base composed of a plinth, torus and cavetto, walls built with four rows of soap-stone blocks and an architraved cornice. Each wall is decorated with four columns and two angle pilasters in green schist. The 2nd storey is noticeably set back and consists of a base composed of a plinth, torus and cavetto, walls built with a row of soapstone blocks and a badly damaged frame. The walls are decorated with six quadriglyphs on each side, including the angular ones, fixed by means of tenons to base and cornice. Visible traces of different layers of plaster are visible on the *stūpa,* although it is not possible to establish exactly whether the layers date back to the period during which the *stūpa* was erected. In some areas of the plaster layers, in the panels placed between the columns and the quadriglyphs, pictorial decorations depicting a single subject have surfaced: an open lotus flower, alternately blue and red, against a white background. The pictorial decorations were probably surrounded by gilded architectural elements, which framed them. This *stūpa*, like other monuments of the same period, was later repeatedly damaged and subsequently restored (Faccenna, 1980, part 2, pp. 250-255). The gilded bracket that is the subject of this article, together with the Corinthian capital of a pillar (Inv. n. 595) "come from the core of a restoration carried out against the upper part of [the *stūpa*] no. 17, on the N side, in correspondence with the 6th and the 7th quadriglyphs". (Faccenna, 1980, part 3, p. 721, note 1; for a detailed description of the quadriglyphs and the dentil and bar motif of the *stūpa* n. 17 see Faccenna, 2007, pp. 175-179).

Faccenna (2007, p. 168) points out the importance of the evolution of the Sacred Area during the GSt.3 Period, when the architectonical structure of the site underwent significant changes. During that period, the Great Stūpa though maintaining its traditional circular plant, presents several levels which divide its cylindrical basis. The last, highest level, which can be accessed through a series of steps, is protected by a railing. Along a South-North axis, the circular Great Stūpa acts as a counterpoint to the coeval quadrangular-based monastery (Great Vihāra n. 57), which at the time of the excavations had been referred to as the Great Building (GB.). In between these two principal buildings there is a quadrangular-shaped space

Fig. 2
Gilded bracket: detail of the red bole. Butkara I (Swāt Valley, Mingora, Pakistan), 1st – 2nd century A.D. Schist with traces of gilding, 11,7 × 19,8 cm. MAO, Inv. n. Iap/151. Courtesy Fondazione Torino Musei.

flanked on its two shorter sides by stairways which in the past granted access on one side to the Great Stūpa (Gst.3) and on the other to the Great Vihāra n. 57. Near GSt.3 – along a line which touches on it along a west-east running parallel to the facade of the Great Vihāra n. 57 – are found a series of buildings going back to the same period (*stūpas* n. 27, 17, 14, column n. 33 and pedestal n. 135). As stated by Faccenna and Salomon (2007, pp. 113), the *stūpas* n. 17 and n. 27, separated by column n. 33, the *stūpa* n. 14 and the pillar on the pedestal n. 135, together with the Great Vihāra n. 57, are built using precious materials such as talc schist and chlorite schist, presenting moreover rich decorations making use of colours and gilding. The importance of *stūpa* n. 17, already noted by Giuseppe Tucci (1978, pp. 60, 63-66), is described by Faccenna in his earliest publications about the Butkara I excavations, in which he stresses the importance of the gilding found in these types of buildings:

> Stūpas 14 and 17 are the best preserved, and from them we can have an idea of the quality of their decoration, since this is still *in situ*, and since the green schist of which it is made is as good as new in those areas sealed up by the walls of buildings that were made later to lean up against it. The sides were parted by fluted Corinthian half-columns with pilasters at the corners. The upper cornice was made up of fillets, ovoli and kymation, and was decorated with lion protomes or alternately with full curly manes in glory, stylised lilies, eagles, cupidis on lotus-flowers. On stūpa 17 a square upper storey is also preserved, slightly smaller, decorated with quadriglyphs between the lower and upper cornices. In the spaces between the half-columns and the quadriglyphs, the side of the wall was painted with large open lotus flowers, alternately red and blue: these are preserved on the south wall. All the architectural features, made of schist, together with the dome, likewise built of schist blocks, were gilt. We can now only surmise the rich splendour of these monuments in a lavish yet refined taste.
> (Faccenna, 1964, p. 44)

As to dating the bracket, a comparison between the successive transformations of the Great Stūpa and the monuments inside the Sacred Area, with their respective floor levels and stratigraphic sequence, together with the studies of the numismatic finds that had been unearthed, attribute the construction of the *stūpa* n. 17 to Period 3, corresponding to the third stage of the Great Stūpa (GSt. 3) and to floor level F4 (fig. 5). In the reports about the campaign at Butkara I, Faccenna (1980, part I, p. 173) attributes Period 3, F4/F3 to the 1st-3rd century A.D. In particular, he attributes to floor level F4 the period between the end of the 1st century B.C./beginning of the 1st century A.D. and the beginning of the 2nd century A.D. Later studies by the same scholar, in which he compares some decorative elements from the site at Saidu Sharif I, Paṇr I (Swāt Valley) and Dharmarājika (Taxila) with the stylistic and architectonical evolution witnessed at Butkara I, date *stūpa* n. 17 of Butkara I, together with *stūpas* n. 14 and n. 27, to the first quarter of the first century A.D., that is during the pre-Kuṣāṇa, i.e. the Indo-Parthian period. In particular, in his study on two fragments of a bracket from the site of

Dharmarājika (Taxila), Faccenna identifies close affinities – both in relation to the kind of material (chlorite schist) and to the processing technique used – with the artworks of Swāt Valley, which during the period was probably the principal centre of artistic production. Moreover, the two brackets present decorative elements very similar to those present on *stūpas* n. 14 and n. 17 of Butkara I, dated about 20 A.D. (Faccenna, 2001, pp. 141-145, 166; 2005, pp. 94-95). As far as the dating of the numismatic findings and their relation with the GSt.3 is concerned, floor level F4, Faccenna (2007, pp. 168-170) pays particular attention on some coins found in different parts of the sacred area, including an excellently preserved Azes II tetradrachm (n. 5229) discovered in one of the two relic-caskets inside the plinth of column n. 135, which in precedent studies had been defined by the same scholar "a guide to chronology" (1980, part 1, p. 57). As reported by Fabrègues (1987, pp. 34-35), on the basis of the stratigraphic layout of the site it is possible to determine that the *stūpas* n. 14 and n. 17 are coeval with or immediately successive of column n. 135, built during the GSt.3 Period. Although it is difficult to date the Indo-Scythian reign of Azes II with precision, on the bases of some inscriptions it is possible to put the end of Azes II's reign before 20 A.D., the year in which it was replaced by the Indo-Parthian dynasty.

The gilded bracket, together with the other sculptural Gandharan finds unearthed by the Butkara I excavations and intended for the city of Turin, became part of the holdings of the then Museo Civico in 1963, following the *Sculture buddiste dello Swat* exhibition that was held that same year at the Galleria d'Arte Moderna. In 1989 the Gandharan finds were allocated to the new Museo di Numismatica, Etnografia e Arti Orientali. When the Mu-

Fig. 4
Stūpa n. 17: Northeast side, 1st and 2nd storey.
Butkara I (Swāt Valley, Mingora, Pakistan).
Published in Faccenna D., 1980, *Butkara I (Swat, Pakistan) 1956-1962*, IsMEO Reports and Memories, Roma, part 5.1, pl. 145.a.
Courtesy IsMEO Italian Archaeological Mission in Pakistan.

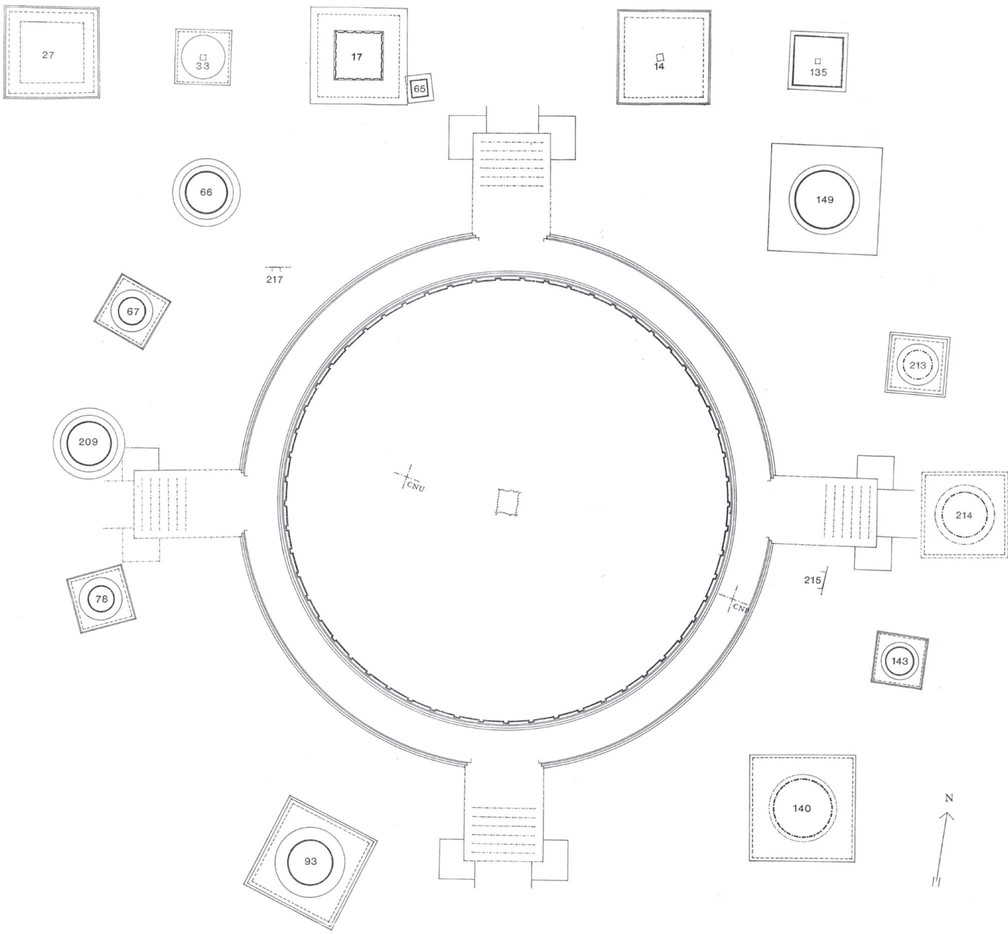

Fig. 5
Reconstruction sketch of GST. 3, F4, with *stūpa* n. 17 and surrounding monuments. Butkara I (Swāt Valley, Mingora, Pakistan). Published in Faccenna, 1980, part 3, pl. VIII. Courtesy IsMEO Italian Archaeological Mission in Pakistan.

seum was closed down in 2001, the finds were allocated to the collections of the Museo Civico d'Arte Antica, Palazzo Madama. More recently, since the opening of the MAO Museo d'Arte Orientale in December 2008, the bracket has been on display in the Gandhāran Art Room as part of the permanent exhibition of South Asian and Southeast Asian Collections. The finds have a long history of museum exhibition and have been held by several institutions, however no written records exist about its past conservation and restoration interventions. The MAO Museo d'Arte Orientale has simply cleaned its surface with soft brushes, without intervening on the calcareous concretions.

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