V THE TU MUNICH RESEARCH PROJECT ON FRAGMENTS OF THE GIANT BUDDHAS OF BAMIYAN (2007–2009)

Introduction

Although the Buddha statues of Bāmiyān have frequently been admired and discussed, their manufacturing techniques and their original appearance were never investigated in detail. Art historical observations only concerned their shape and style. Visitors with archaeological interest mentioned peculiar details, but even when a comprehensive restoration was executed by the Indo-Afghan co-operation in 1969–78, no systematic technical examination was carried out.

Between 2004 and 2008 about 10'000 fragments were recovered from the rubble at the feet of the statues. The fragments are the only clue to find out how the two statues were made, which materials were used and how their appearance changed over time. Therefore scientific analyses in-depth were carried out on the fragments.

From the large number of fragments, tiny pieces were selected by conservator Edmund Melzl for analytical purposes. Between autumn 2005 and autumn 2007, several hundreds of samples were brought to Munich allowing investigations on a large scale. A research team, financed by ICOMOS and the UNESCO, was established at the Technische Universität München (TUM), Lehrstuhl für Restaurierung, Kunsttechnologie und Konservierungswissenschaft (chair of restoration, art technology and conservation science).

The project team at the Technische Universität München and in Bāmiyān

The study group in Munich consisted of the conservators:
Erwin Emmerling – head of the project
Stephanie Pfeffer – supervision of examination, project organisation; examination of paint layers
Maruchi Yoshida – set up of a data base
Catharina Blänsdorf – examination of paint layers, identification of pigments; organisation
Additionally six students have contributed to the work with term papers concerning special questions:
Laura Thiemann and Eva Höfle – investigation on clay layers
Monica Reiserer and Nicole Wagner – investigation on paint layers
Maximilian Knidlberger – identification of pigments
Anna Rommel – translation of Russian texts on Central Asian painting techniques
The studies were supported by observations during the conservation work on-site. From the persons involved there, most important for the research project were:
Edmund Melzl – collecting of findings; fragment catalogue and photographic documentation
Bert Praxenthaler – observations on the Eastern Buddha in 2008, collecting of fragments
Between June 2007 and January 2009, examinations in various fields could be done. Besides the team at the TUM, external experts have been involved for special analyses.

Table 1 Overview of samples from the Giant Buddha statues

Material	Number of fragments from Eastern Buddha	Number of fragments from Western Buddha
clay with paint layers	102	173
clay without paint	2	2
pebbles from undercoat		1 box
chaff and hair from clay layers	46 samples	24 samples
wood from anchoring system	1 splinter	320 splinters 7 complete pegs
piece of rope		14
textile fragment		1
leather rags		2
leather pouch, small		1
stone fragment		1 (from junction of arm, blackened and partly molten by explosion)
white filling from Indian restoration		1

Table 2 Reference samples from Bāmiyān

Material	Origin	Amount
stone material	Buddha cliff face	2 boxes
clay layers	Kakrak Buddha	1 box
clay layers from the niches behind the Buddha statues	Eastern Buddha Western Buddha	3 samples 3 samples
loam from surrounding area	Keule kotschak Regischad Surch-kul Khami-Kalak	1 box 1 box 1 box 1 box
wooden pegs	niche I behind Western Buddha maybe from niche behind Western Buddha	3 pegs 1 wooden piece
wood samples (leaves, twigs)	Bāmiyān and surrounding	4 tree species
piece of rope	Bāmiyān bazaar	1 piece
hair of sheep, goats, donkey	Bāmiyān Valley	about 30 strands of hair

Table 3 Numbering system for fragments and samples

Numbering system by E. Melzl	GB – Western Buddha KB – Eastern Buddha	L – clay layers Ha – hair Hä – chaff F – rock
Numbering system TUM	ID	101 - 199 – PLM 201 - 299 – cross section 301 - 399 – XRD 401 - 499 – EDX 501 - 599 – quantitative XRD 601 - 699 – analysis of binders 701 - 799 – microscopic wood identification 801 - 899 – identification of hair 901 - 999 – ^{14}C radio carbon dating 1001 - 1099 – particle size measurements

Sample material

The samples brought to Munich are tiny pieces of the clay layers of the Buddha statues, comprising clay plasters with paint; plant parts, chaff, hair and pebbles from the undercoat and finish coat; splinters of wood and pieces of rope from the anchoring system of the clay layers on the Western Buddha. Stone samples were not collected. An overview is given in table 1.

Additionally, material from Bāmiyān and the surrounding area was collected by E. Melzl as reference samples. The samples are listed in table 2.

Investigations

The aim of the examination of the fragments was to identify the materials, to investigate the technique of manufacture and, as far as possible, to date the materials and to detect historical changes. The investigations comprised the following aspects:

- examination of the clay materials;
- identification of fibres from the ropes;
- identification of wood species on the wooden pegs;
- identification of corn species on the organic additives in the clay layers;
- identification of hair from the clay layers;
- AMS ^{14}C dating of organic materials;
- examination of paint layer sequence;
- identification of pigments;
- identification of binders.

Edmund Melzl has catalogued about 10.000 fragments of the Buddha statues found since 2004, using a numbering system (altogether 4757 entries until end of 2008). In this numbering system the first two letters indicate the statue, the following the type of material (see table 3).

Most of the fragments sent to Munich for examination are tiny pieces additionally retrieved from the rubble and not included in Melzl's catalogue. Thus a new numbering system was established in Munich using sample ID numbers and additional number codes to indicate the type of investigation carried out.

Analyses performed by external experts

Clay layers: Layer sequence and identification of materials
Two different methods have been used to characterise the clay materials of the clay layers: Quantitave XRD (x-ray diffraction) was performed by Albert Gilg, TUM, Chair of Engineering Technology, together with Eva Höfle. Laser scattering spectrometry was done by Laura Thiemann with support of Steffen Krause and Christina Schwarz at the University of the Federal Armed Forces, Institut für Wasserwesen, Munich. First measurements were carried out with the support of Retsch Technology GmbH, 42781 Haan, Germany.

Identification of wood species
The identification of wood species on the fragments was done by means of microscopic wood properties. First analyses were made by Dietger Grosser, Ludwig-Maximilians Universität München, in 2002. In 2008, twenty samples were analysed by Hans Georg Richter, Zentrum Holzwirtschaft at the University of Hamburg.

Reference material from Bāmiyān was identified using macroscopic phenomena (leaves, bark, wood) by Hans-Jürgen Tillich and D. Podlech, Ludwig-Maximilians Universität München, Faculty of Biology.

Identification of fibres and organic additives in the clay layers
The material of the ropes and the organic additives of the straw mud layer (plant parts, residues of threshing, grass) were analysed by Hans-Jürgen Tillich, Ludwig-Maximilians-Universität, Munich, Faculty of Biology, with the help of reference material from Bāmiyān (different corn species, *Dom-i-shutur* plant, modern ropes).

Identification of hair in the clay layers
The wisps of hair contained in abundance in the clay layers were analysed by Jan Grunwald, Landeskriminalamt, Munich, using reference samples from different animals (goat, sheep and donkey) in Bāmiyān, collected by Edmund Melzl.

AMS ^{14}C dating of organic materials
^{14}C AMS radio carbon dating was done in three parts. Georges Bonani from the ETH (Eidgenössische Technische Hochschule) Zurich, Institute for Particle Physics, analysed two samples in May 2004 and seven samples in January 2009. Pieter Grootes, Matthias Huels and Marie-Josée Nadeau from the Leibniz Laboratory for Radiometric Dating and Isotope Research, Christian Albrecht University Kiel analysed 13 samples in December 2004.

Pigments and binders
The layer sequences were analysed at the TUM. For pigment determination mainly polarised light microscopy (PLM) was used. For additional questions external experts were involved. Inorganic materials were analysed by Klaus Rapp, Munich (XRD, ESEM) and Vojislav Tucic, Bayerisches Landesamt für Denkmalpflege, Munich (XRD, XRF); Sonngard Hartmann, Susanne Greiff, Roman Germanic Central Museum Mainz (Micro XRF).

Ilaria Bonaduce and Maria Perla Colombini, University of Pisa, Dipartimento di Chimica e Chimica Industriale identified the binders in the different layers of 10 fragments.

Yoko Taniguchi, University of Tsukuba, worked on the investigation and conservation of the murals in the caves of Bāmiyān. She provided numerous historical photographs, many of them privately taken during a trip to India, and a lot of very valuable background information.

Catharina Blänsdorf