### The Nemrud Dağ Project

### University of Amsterdam / University of Nijmegen

### International Nemrud Foundation



Proposal for the 2004 campaign

Amsterdam, December 2003

His Excellency The Ambassador of Turkey Mr. Tacan Ildem The Embassy of Turkey Jan Evertstraat 15 2514 BS 's-Gravenhage Nieuwe Prinsengracht 130 1018 VZ Amsterdam The Netherlands

Amsterdam, 14 December 2003 Your reference: Our reference: Enclosure(s): attachments 1-7 Regarding: *Nemrud Dağ Project*  AAC Contact: Tel.: +31 (0)20-525 2564 Fax: + 31 (0)20-525 2544 E-mail: hbrijder@hum.uva.nl

#### Your Excellency,

Herewith I have the honour to present you the application for the license to carry out the fourth campaign (2004) of our Nemrud Dağ project for the restoration, excavation and protection in accordance with:

The decision of the Minister's Council no. 2001/2898 / Prime Ministry of the Turkish Republic as stated in the letter of the General Directorate for Laws and Decisions no. B 02.0.K. KG / 153-9 / 4074.

During the 2004 campaign we intend to continue the restoration and conservation program for the sandstone reliefs and other objects from East and West Terraces and for the colossal limestone statues on the East Terrace.

The Project managers are Prof. Dr. Herman A.G. Brijder (University of Amsterdam) and Prof. Dr. Eric M. Moormann (University of Amsterdam/University of Nijmegen).

#### Enclosed are:

- A general description of the objectives of the Nemrud Dağ Project (attachment 1).
- A detailed plan for the 2004 campaign (attachment 2)
- The C.V. and a list of publications of Prof. Dr. Herman A.G. Brijder including scholarly experience and specialisation (attachment 3).
- The C.V. and a list of publications of Prof. Dr. Eric M. Moormann including scholarly experience and specialisation (attachment 3).
- The team list and the C.V. of each member (attachment 4).
- Structural Consolidation of Nemrud Sculptures, Mission Report 2003 by Dr.P.Gavrilovic (attachment 5).
- Repair Mortar for Tuffite by Dr.E.Wendler (attachment 6).
- Repair Mortar for Fissure in Limestone by Dr.E.Wendler (attachment 7).

We would like to draw your attention especially to the General Planning 2001-2010 in Attachment 1, asking your permission for the different steps as stated.

We would like to start the project on the  $15^{th}$  of June until the  $15^{th}$  of August 2004.

During the 2004 campaign, Prof. Dr. Herman Brijder will be the project manager from the 15<sup>th</sup> of June till the 15<sup>th</sup> of July and Prof. Dr. Eric Moormann from 15<sup>th</sup> of July till the 15<sup>th</sup> of August.

From Monday the 3rd till Friday the 28<sup>th</sup> of May 2004, Drs. Tesse D. Stek and Drs. Ellen Thiermann, both archaeologists of the University of Amsterdam, wish to work on the documentation of the fragments of the sandstone reliefs kept in boxes in the storeroom of the Adiyaman Museum.

We hope you find this information satisfactory. In case you might have any questions or remarks, please contact us.

Yours sincerely,

Prof. Dr. Herman A.G. Brijder (project manager / chair Classical Archaeology, Amsterdam)

Prof. Dr. Eric M. Moormann (project manager / chair Classical Archaeology, Nijmegen)

#### ATTACHMENT 1 The Nemrud Dağ Project: MASTERPLAN

The Masterplan of our project is shortly described below. Included are:

- 1.0 Infrastructure required to execute the different steps of the Masterplan.
- 2.0 Site management.
- 3.0 Documentation, Site Information System, and prospecting.
- 4.0 Restoration and conservation:
- 4.1.1 Restoration and conservation of colossal limestone statues on East Terrace; publication.
- 4.1.2 Restoration and conservation of colossal limestone statues on West Terrace; publication.
- 4.2.1 Restoration and conservation of sandstone reliefs and other objects on West Terrace; publication.
- 4.2.2 Restoration and conservation of sandstone reliefs and other objects on East Terrace; publication.
- 4.2.3 Restoration and conservation of sandstone reliefs and other objects on North Terrace.
- 5.0 Excavation of tomb of Antiochos I; publication.
- 4.3 Restoration and conservation of Tumulus and platforms.

#### **Objectives:**

#### Protection and documentation of the site

As stressed in different scientific publications and as clearly shown by our own scientific documentation during the 2001, 2002 and 2003 campaigns the monument on Nemrud Dağ is in need of protection, conservation and restoration. In accordance with the European Code for Restoration the first step is a systematic documentation and survey of the present situation of the monument.

#### Conservation and restoration of the site

Now that documentation is available for the most part, the UvA, INF and WMF (World Monuments Fund) have organised two round table conferences dedicated to the conservation and restoration of the monument: in Kahta, (Adiyaman) July 2001, and in Amsterdam, November 2001. Participants were the archaeologists of the University of Amsterdam involved, representatives of the Ministry of Culture, members of the INF, and international conservation specialists. On the basis of these meetings a proposal for the conservation and restoration of the monument was formulated.

Learned from the experiences of the 2002 and 2003 campaigns, and taking into account the suggestions and advices given by members of the METU University (Ankara) and the Adana commission for conservation and restoration given to us during the 2002 campaign, this proposal was evaluated and re-formulated during a meeting held at the University of Amsterdam on 10 and 11 November 2002. Prof. Dr. Orhan Bingöl (University of Ankara) was one of the participants and advisors. In close co-operation with the different parties involved a long-term restoration and conservation plan has been defined (see attachments 1 and 2).

The 2003 campaign also served as a pilot project to study the practice of restoring the colossal limestone statues. As appeared, we were able to hoist the blocks of the Antiochos statue on the East Terrace, to restore them and to stabilize the rock

underneath and finally to rebuild the whole figure (except for the head). The methods chosen (crane for hoisting, repairing blocks and replacement with crane) proved to work fast and accurately.

#### **Excavation of the tomb of Antiochos I**

This item has not our primary interest, as the priority of the project are the above mentioned objectives. In 2006 additional geophysical research is required to locate the exact position of the tomb. In 2007 the excavation has been planned.

Gene	eral Planning 2001 – 2010								<u>۱</u>	version	: 2003
Item	Description	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
1	Infrastructure										
1.1	Site-office										
1.2	Container storage										
1.3	Restoration house										
1.4	Temporary access roads										
1.5	Site Museum										
2	Site Management										
2.1	Routing and fence erection										
2.2	Information signs and posts										
3	Documentation & Prospecting										
3.1	Geodesv										
3.2	Epigraphy										
3.3	S.I.S.										
3.4	Photo&Film documentation										
4	Restoration										
4.1	Limestone statues										
4.1.1	East-Terrace										
4.1.2	West-Terrace										
4.2	Sandstone Reliefs and Statues										
4.2.1	West-Terrace										
4.2.2	East-Terrace										
4.2.3	North-Terrace										
5	Excavation Tomb										
5.1	Geophysic research										
5.2	Support dam										
5.3	Excavation										
5.4	Conservation										
4	Restoration										
4.3	Tumulus										
4.3.1	Platforms repair										
4.3.2	Filling										

# **GENERAL PLAN for conservation and restoration of the SANDSTONE ELEMENTS on the Nemrud Dağ**

#### **INTRODUCTION:** general outlines of the program

All tuffit elements are in very bad condition and in need of protection, conservation and restoration. During the 2003 campaign the dexiosis stelae and the lion horoscope of the West Terrace were brought to the on-site restoration house. They will be conserved and restored in 2004 and the following campaigns. After that they should be exhibited in the (future) site museum while on their original position copies should be placed.

The very bad condition of the reliefs becomes most clear, of course, from the Lion Horoscope relief and the *dexiosis* stelae on the West Terrace. However, on this terrace and on both terraces (East and North Terraces) there are more sculptured tuffit elements now deteriorating: ancestor and/or other reliefs and guardian animals.



Herakles-dexiosis relief as preserved in 2001

During the 2003 campaign the four *dexiosis* reliefs and Lion Horoscope were protected by bringing them to the restoration house. It is our intention to restore and conservate them, where possible, during the next campaigns. There are many fragments of the *dexiosis* reliefs and ancestor stelae very well preserved in the storerooms of the Museum of Adıyaman. During the 2002 and 2003 campaigns an inventory and documentation was made of this material (see below). This dbase has to completed during the 2004 campaign. Then, there will thus be a dbase showing which fragments there are for the restoration of the reliefs.

As it is clear that an in situ display of the vulnerable tuffit reliefs and other sculpted elements is very bad for their condition, we propose that, after their protection, conservation and restoration, they will be displayed in the (future) site museum. Replica's will be placed in situ.

The restoration and conservation project will be undertaken in close co-operation with Professor Dr. Orhan Bingöl (University of Ankara and D.T.C.F.), with Dr. Selçuk Şener (also of the University of Ankara and D.T.C.F.), Christoph Kronewirth (Trier), who has gained great experience at several archaeological sites in Turkey, and Dr. Eberhard Wendler (Munich).

It is the intention that the conservation and restoration project will be a joint Dutch-German-Turkish enterprise that will also function as a training program for Turkish and international students in the discipline.

#### Sandstone elements at Nemrud Dağ: what needs to be done:

This section describes and illustrates what kind of sandstone elements have been preserved, where they are located and how they have been preserved. Based on this inventory a proposal for tasks urgently to be undertaken in the 2004 campaign will be presented in **attachment 2**.

#### **East Terrace**

On and in front of the lower platform (in front of the statues) there are many sandstone blocks and slabs. Most of them belong to the revetment of the platform. There are, however, also some (fragments of) reliefs.

On the south side, behind the altars for the Greek ancestors, are still lying some of the corresponding ancestor reliefs. Also (fragments of) reliefs of the smaller base are still in situ.

On or next to the structure that is known as 'the fire altar' originally guardian animals were placed. Remains of these are still lying or standing next to the structure or on the slope behind it: eagle (south side); lion and eagle (north side).

On the north side, behind the altars for the Persian ancestors, are still lying some of the corresponding ancestor reliefs. Also (fragments of) reliefs of the smaller base are still in situ.

#### **North Terrace**

In front of the terrace there was originally a platform from large, sandstone blocks on which a guardian eagle was placed. Remains of this eagle are still lying on the slope and have to be collected and preserved. None of the slabs lying on this terrace show sculpted elements.

#### West Terrace

On the north side of the terrace the remains of reliefs belonging a smaller base are have to be protected. On the slope of this side of the terrace originally a three headed guardian lion was standing; remains are still lying on the slope. They have to be collected for restoration and conservation.

On the south side of the terrace, behind the altars for the Persian ancestors, are still lying some of the corresponding ancestor reliefs.

Detailed proposals for work to be done during the 2004 campaign are presented in **Attachment 2.** 

#### **Introduction: general outlines**

Structural consolidation, repair, strengthening and reconstruction are done with due respect for international conservation standards. 'Minimum intervention – maximal protection' can be seen as our main rule. This implies that nothing will be altered in the existing situation if such an intervention is not absolutely necessary for the protection of the statues. It is our intention to protect the monument by conservation and restoration; not to rebuild all statues. Nemrud Dağ must stay a fascinating archaeological site, but a documented, restorated and protected one.

#### Seismic safety criteria (see also Attachment 5)

Seismic structural stability of the monuments should be taken into account according to the maximum expected ground acceleration in the region and defined criteria of stability and safety. Experimental investigation and testing will be highly appreciated, but they are not "conditionally necessary". Analytical modelling, as well as appropriate calculation and design, however, provide enough safety.

Basically, it can be concluded that the original structure of the statues, although constructed of massive large stones and dry masonry, possesses extensive lateral seismic resistance.

Nemrud is situated at a distance of over 200 km from the North Anatolian Fault, but it is in the immediate vicinity of the East Anatolian Fault (at a distance of 5-10 km). According to the seismic zoning map, an official document and a constituent part of the regulations, the entire territory of Turkey is divided into four seismic zones. According to this map, Nemrud is located in the 1st zone of the greatest possible earthquake effects with expected intensity of IX degrees MCS or effective ground acceleration of I = 0.40 g (g - earthquake acceleration).

These data point to the fact that the mentioned location is a seismically active area, which should be taken into account in the reconstruction of the statues. The Codes for Protection against Earthquakes have been effective since 1996 as an official document of the Ministry of Public Works - Turkish Government. The Codes define the expected seismic effect according to the Seismic Zoning Map and provide elements for analysis and providing safety of structures. According to these regulations, the effective ground acceleration is:

Zone 1:	Ao = 0.40 g;
Zone 2:	Ao = 0.30 g;
Zone 3:	Ao = 0.20 g;
Zone 4:	Ao = 0.40 g

The above values refer to earthquakes with a return period of 500 years. The Codes do not specify any particular conditions for historic monuments and structures of this kind. Considering the fact that all the regulations for seismic protection are basically established for new structures, it is necessary to define special conditions and criteria for seismic stability of structures belonging to a specific category as are the historic

monuments and other structures, taking into account the expected seismicity, the importance of the monuments, the structural systems and the materials used.

Taking into account the seismicity of the region and the site and the type of monuments and structures, the following safety criteria are proposed:

- For the expected effect of earthquakes with a return period of 500 years and effective ground acceleration of Ao = 0.40 g, the monuments behave suffering no damage to the integral structure or individual parts. This means that the integral structural system behaves in the linear range. This level should be considered designed level of safety.
- For the expected effect of earthquakes with a return period of 1000 years and effective ground acceleration of Ao = 0.50 0.60 g, damages to the structures should be allowed, but the structure should be repairable and the general stability of the structure thoroughly preserved. This means that nonlinear behaviour and partial damage can be allowed under such effects, but the structure should remain stable as a whole. This earthquake level should be treated as a controlling one, i.e., it should serve for verification of the stability of the structures against failure and severe damage.

#### Crane

The use of cranes in conserving historic monuments is increasing throughout the world. At Nemrud Dağ the crane shall be used for "transport" and hoisting. To make the access roads for the crane, the principle of "temporary works" should be used instead of monolithic "cast in situ" concrete, or other invasive methods. The weight of the crane, amounting to 90 tons, and the micro tremors produced cannot affect the stability of the statues considering that they represent massive, heavy and rigid structures. It must be stressed that during the 2002 and 2003 seasons the crane did not induce any damage nor it created conditions for any consequences in the process of its transport and operation; quite the contrary. The telescope crane with a capacity of 90 tons has extraordinarily good technical characteristics providing the possibility of precise handling, controlled lifting and transportation of the stone heads and blocks. The computerized control structure of the crane enables preciseness in motion in all the directions measured in millimeters as well as desired speed of motion. The additional crane equipment consisting of a system of plastic ties for binding of objects and their transportation is of a particular quality and has a soft contact surface so that no damage can be induced upon contact with stone surfaces.

This section presents a general plan for the conservation and restoration of the statues on the East Terrace. The following definitions are used:

Documentation = taking photographs and making drawings to be included in the SIS
 Stabilization of bedrock/base = inserting hydraulic mortar or cement (if necessary) and adding stones

- Insertion new stones = (if required/necessary) missing elements or blocks will be made by stone cutter from similar but distinguishable material from the area, i.e. the quarry at the north side of the mountain.

#### East Terrace, Statue A (lion):

• Situation: remains of the statue are lying beside the original location towards the south side on the steep slope. The blocks are only partly visible due to gravel that has fallen down from the tumulus.



Blocks of statues A and B (lion and eagle)

Eight blocks have been identified as (probably) belonging to the statue: layer 2 is preserved in total (A2a, A2b and A2c); from layer 3 three blocks are still present (out of four) (A3a, A3b, A3c); from layer 4 one block (A4a) is present (out of two), as from layer 5 (A5a); the head has so far not been identified.



Remains of statue A (lion)



Block 5: A2a (lion)

• Proposed intervention:

- Removal of all blocks on the south slope and temporarily storage on East Terrace.

- Removal of gravel.
- Subsequent documentation and identification of single blocks.
- Stabilization of bedrock; restoration and reconstruction of base.

- According to outcome of research done on state of preservation and identification: reconstruction of statue in subsequent year. It is likely that new

pieces are to be added; it is, however, impossible to say which pieces are missing as the blocks are largely buried under the gravel and identification/inspection will only be possible when they can be lifted.

- Restoration: repair and strengthening of broken blocks. Some blocks clearly show damages.

#### Proposed intervention to be executed in the 2004 campaign, see attachment 2

#### East Terrace, Statue B (eagle):

• Situation: remains of statue are lying in front of original location and on steep slope to south-east side. Nine blocks have been identified as belonging to statue. In all probability identified: all elements apart from block B4b.



Blocks and head of statue B (eagle)

- Proposed intervention
- Removal of all blocks and temporarily storage on East Terrace.
- Removal of gravel.
- Subsequent documentation and identification of single blocks.
- Stabilization of bedrock; restoration and reconstruction of base.
- Reconstruction of statue. There are some uncertainties as to our identification of

individual blocks as remains are partly buried under gravel and identification will only be possible when they will be lifted. If it turns out that block B4b has not been preserved under the gravel, it has to be newly made and added.
Restoration: block B2a = block no. 12 (right paw) has to be restored: insertion of (newly made) stone. Block B5a (right breast) has to be restored (pasting).
Proposed intervention to be executed in the 2004 campaign, see attachment 2



Block 12: B2a (eagle)



Block 23: B5a (eagle)

#### East Terrace, Statue C (Antiochos):

• Situation: this statue has been dismantled and the bedrock has been stabilized according to the proposal of the 2003 application. The head of the statue stands on the terrace in front of the statue.

#### East Terrace, Statue D (Kommagene):

- Situation: statue is largely intact up till layer 4: these parts are well preserved. Breast piece (originally two pieces (D6a and D6b), now three because one has been broken), head and *kalathos* are on East Terrace. Blocks from layer 5 have been transported to terrace in front. Structure and base have to be stabilized as some of the blocks are twisted from their original position.
- Proposed intervention:
- Stabilization of base.
- In situ stabilization of the statue.
- Repiecing the broken elements.
- Head, deteriorated by algae, has to be treated/restored.



Statue D (Kommagene) as preserved in 2001 (present state differs; breast piece is now on the terrace)



Head of statue D (Kommagene) (block no. 19) as preserved in 2001

The *kalathos* has to be restored by pasting and the use of small pins.



Kalathos of Kommagene (block no. 26) as preserved in 2001

#### East Terrace, Statue E (Zeus):

• Situation: statue is largely intact and standing upright; only head and *tiara* are on terrace. A stone in body part is visibly dislocated and vertically separated. This points to initial "general instability" that has resulted also in crushing of stone blocks in lower rows.



Statue E (Zeus) as preserved in 2001

- Proposed intervention :
- In-situ stabilisation.
- Subsequent documentation.
- Stabilization of base.

- Restoration:

Block E3a (front) damaged at front side.

Block E3b (front) damaged at left lower side.

Block E3d (back) damaged at left lower side.

Block E4b (front) damaged at lower left side: a newly made piece of stone will be made and fixed.



Statue E (Zeus): layers 3, 4 and 5



Head of statue E (Zeus) (block no. 25) as preserved in 2001

The tiara has to be restored (pasting newly made pieces) on two sides and has to be fixed onto head.



Part of tiara of statue E (Zeus) (block no. 20) as preserved in 2001

#### East Terrace, Statue F (Apollo):

• Situation: statue is largely intact and standing upright; shoulder piece and head are standing on terrace. Instabilization of base has resulted in many vertical separation cracks; the statue is structural instable. Urgent measures for consolidation are necessary to avoid collapse.



Statue F (Apollo) as preserved in 2001

• Proposed intervention:

- Removal of all blocks and temporarily storage on East Terrace (if absolutely necessary) or (preferably) in-situ stabilisation.

- Subsequent documentation.
- Stabilisation of base.

- Restoration:

Block F2a shows an inserted element (antique restoration?); this block has to be fixed by pasting.



Block F2a (Apollo)

#### East Terrace Statue G (Herakles) :

• Situation: statue is largely intact and standing upright apart from head; this stands on terrace. Three types of characteristic damage to statue have been observed: damages to principal structural system manifested by displacement of stone blocks from their original position leading to formation of gaps between blocks; damages to stones themselves particularly pronounced on front side and manifested by local failure or cracks and erosion; and

deterioration of bedrock/soil foundation, particularly expressed on front side. It is urgently necessary to intervene as stability of soil, i.e., bedrock, has suffered from considerable deterioration and erosion in course of time. Such an intervention is imposed by the need to prevent further erosion and make contact between principal structure and soil. The cavity caused on front side might induce failure of stone blocks leading to progressive failure of entire structure.

The temporary stabilization done during 2002 campaign involved cleaning of base, removal of tiny stones and failures and incorporation of stone blocks in form of walls and cramps. The new stone blocks basically transfer load from structure to base and prevent occurrence of cracks in lower stones and failure of statue. Stabilization of soil was not done. Dry stone masonry was used with the intention that this intervention be temporary and used material reversible.



Statue G (Herakles) as preserved in 2001

• Proposed intervention:

- Removal of all blocks and temporarily storage on East Terrace (if absolutely necessary) or (preferably) in-situ stabilisation.

- Subsequent documentation.

- Stabilisation of base. It is recommended to perform permanent stabilization with improvement of existing soil by injection of rock mass and incorporation of new, stable and regularly shaped blocks below the existing blocks of statue. The contact between new blocks and existing ones (belonging to statue) should be dry, if possible, or should be made by use of hydraulic mortar or lead.



Statue G (Herakles), base before temporarily stabilisation

- Restoration:

Block G4a (lap) should be glued and pinned.

Block G5a and G5b are damaged at front side on left and right sides: newly made piece of stone has to be inserted here.



Proposed intervention to be executed in the 2004 campaign, see attachment 2

Statue G (Herakles), layers 4 and 5

#### **East Terrace Statue H (Eagle):**

• Situation: basis restored and statue partly rebuilt in 2003: layers 1-3 plus block H4b.

All remaining blocks are identified and situated on terrace (which are: head (H6 = block no. 35), two chest pieces (H5a = block no. 30 and 5b = block no. 31), belly (H4a = block. no. 29).

Proposed intervention to be executed in the 2004 campaign, see attachment 2



H6 = block no. 35 (eagle)



H5a+b = block nos. 30 and 31 (eagle)



H4a= block no. 29 (eagle)



Detail crack block no. 35 (eagle)

#### **East Terrace Statue I (Lion):**

• Situation: base has been restored. The elements of statue have been systemized on terrace.

#### Proposed intervention to be executed in the 2004 campaign, see attachment 2



Statue I (lion), head (block no. 44)

#### ATTACHMENT 2 Program 2004

The 2004 campaign of the Nemrud Dağ Project will have FOUR MAIN POINTS OF INTEREST:

- 1. Conservation and restoration of the four dexiosis reliefs and the Lion Horoscope (from the West Terrace) and replacements of fragments in storeroom of Adiyaman Museum: in the restoration laboratory on Nemrud Dağ.
- 2. Conservation and restoration of the statues on north side of East Terrace: G (Herakles), H (eagle) and I (lion). Complete reconstruction of eagle with head and reconstruction of lion without head.
- 3. Preparation of reconstruction of statues on south side of East Terrace: A and B (lion and eagle) by transporting blocks to East Terrace and displaying them on East Terrace; consolidation and reconstruction of basis.
- 4. Conservation and surface restoration of limestone statues on East and West Terraces.

#### **1 INFRASTRUCTURE**

#### 1.1 Site Office

A temporary site office has been constructed below the East Terrace and will be needed during all campaigns.

#### **1.2** Storage Containers

Container storage facilities of two 20 feet containers have been installed next to the Thor container; they will be needed during all campaigns.

#### **1.3** Restoration House

The restoration house will serve during the conservation and restoration work of the tuffit reliefs. Tourism: since the monument of Nemrud Dağ is a site of highly touristic value, it is planned that the visitors may have the possibility to see the work in the restoration laboratory.

#### 2 SITE MANAGEMENT

2.0 Routing and fences. Work should be executed during the 2004 campaign.

#### 2.1 Information signs. Should be prepared during 2004 campaign.

#### **3** DOCUMENTATION, SIS, AND PROSPECTING

#### 3.1 Epigraphy (prepared by Prof. Dr. O. van Nijf)

The main aim of the epigraphic research is to provide full documentation of all the inscribed surfaces. The secondary aim is to publish any unpublished inscriptions.

During the 2001 campaign work was started on the West Terrace where all texts were photographed. We have made squeezes, drawings and descriptions of the "palimpsest"' inscriptions at the back of the stelae, and of two small inscriptions that were found on fragments on the West Terrace. In the winter of 2001-2002 we have

started to collect documentation of all published texts. We have studied the squeezes and the photographs of the "palimpsest" inscriptions. The surfaces are very hard to read due to erasure in Antiquity and to the influences of weather and climate. We have not been able to make significant progress with the decipherment.

The documentation will be entered into a database that will be integrated into the SIS. We have made a preliminary presentation of a small text that was recently found on the West Terrace. During the campaign of 2002 we have completed our photographic documentation of the nomos inscription on the East Terrace and of a smaller fragment that was found on the West Terrace. We still have to photograph the northern parodos inscription (currently lying upside down near the north parodos) and fragments that are reported to be in the care of the site-attendant.

We have also experimented with a Minolta High resolution 3D Scanner. We have scanned the backside of two stelae on the West Terrace (the so-called palimpsests). The first results were promising. However, due to illness and subsequent death of the main operator of the scanner we have not as yet been able to analyze the results. We hope to resume the scanning of all the inscribed surfaces in the course of the next few campaigns.

We expect to complete the documentation of the published texts before the end of 2004. We aim to present the results in the form of an electronic repertory on the internet. In subsequent years we would like to extend our project to the region of Kommagene as a whole and include, for instance, other *hierotheseia* like Arsameia and Direk Kale.

# **3.2** Inventory and dbase documentation of sandstone fragments and other objects

No comprehensive inventory of the artefacts from Nemrud Dağ exists. They are scattered over the mountain itself, the villages around and the museums in Gaziantep, Adıyaman, Ankara, Berlin, etc.

During the 2002 campaign the work on inventory of all archaeological objects from Nemrud Dağ started, studying the material in the storerooms of the Adıyaman Museum and making this accessible by means of a database.

The inventory will consist of digital photographs, a description and an interpretation of every piece. These data will be entered into a database that enables us, for example, to assign easily all the fragments that belong to the same relief. This dbase is of crucial importance for the restoration work that will be undertaken. The work will be published in the future.

The storerooms of the Adiyaman Museum preserve ca. 55 wooden cases with fragments of sandstone reliefs and statues, and of limestone reliefs from Nemrud Dağ. In short visits during the 2002 and 2003 campaigns the contents of seven of these cases have been studied. In 2004 the fragments from the other 48 boxes will be documented. We wish to have completed this work before the start of the 2004 campaign on the mountain in order to be able to present the results the the restoration experts.

Therefore, Drs. Tesse D. Stek en Drs. Ellen Thiermann (both PhD-students, University of Amsterdam) intend to work on the inventory and dbase documentation of the sandstone and limestone fragments in the storerooms of the Adiyaman Museum: from the 3rd to the 28th of May 2004.

#### 3.3 Site Information System

One of the main goals of the first two campaigns was the compilation of a Site Information System (SIS). The SIS has different levels, ranging from a general overview to a specific detail.

The most general level (1) is formed by the topographical map. Many thousands of GPS points have been combined and show the tumulus with its remains and some of the characteristic features directly around it. This level is now finished.

Level 2 provides detailed maps of the East- and West Terraces with the position of the statues, the falling down blocks and most other elements. Level 2 maps consist of a combination of GPS points from the topographical map (level 1) with handmade drawings. This work is almost finished: some small details still have to be added and the plans will be checked one last time before the situation on the terraces will be changed by the movement of reliefs and blocks (see infra).

Level 3 presents overview photographs of the terraces. Now the terraces' maps can be visualised from different angles while the placing of the statues and the location of the different groups of blocks becomes clearer. Work is almost finished: only some details are to be added.

On level 4, one encounters the colossal limestone statues themselves. Here are drawings that show the statues' structures in different blocks and also indicate which blocks are still in situ. This work, a *conditio sine qua non* for the start of the protection/restoration/conservation program, has been finished.

On level 5, the statues' fallen-down blocks can be studied. It provides photos of groups of blocks and, after that, of individual blocks. It is combined with a database that shows, amongst other things, our assignment of the blocks. This work, a *conditio sine qua non* for the start of the protection/restoration/conservation program, has been finished. It is, however, possible that our assignment will have to be re-adjusted when blocks are cleared from gravel.

On level 6, most of the individual blocks can also be found. Here are scale drawings of blocks with sculpted details, from different perspectives, thus giving more detailed and precise information than the photographs. Also during the 2004 campaign to work on these drawings will be continued.

#### 4.0 CONSERVATION AND RESTORATION

#### 4.1 Conservation and restoration of the COLOSSAL LIME STONE STATUES ON EAST TERRACE: proposal for the 2004 campaign

As to the conservation and restoration of the colossal limestone statues on the East Terrace we intend to do the following during the 2004 campaign:

- 1. Restoration of the eagle and lion at the north side (statues H and I).
- 2. Undertaking emergency measures on Herakles (statue G).
- **3.** Only preparation of the restoration of the lion and eagle at the south side (statues A and B) by bringing the blocks on the terrace and clear the spot from gravel.
- 4. Only reparation of the restoration of Kommagene (statue D) by gluing the quickly deteriorating shoulder/breast pieces.

# Ad 4.1.1-2 Restoration of the eagle and lion at the north side (statues H and I) and emergency measurements of the Herakles statue (G):

See for details the report "Structural Consolidation of Nemrud Sculptures" by Prof. Dr. Predrag Gavrilovic (Attachment 5).

# Ad 4.1.3 Preparation of the restoration of the lion and eagle at the south side (statues A and B):

Given the present condition of the colossal statues on this part of the terrace it is impossible to prepare the restoration of statues A and B, since many blocks are buried under gravel that has come from the tumulus.

We therefore intend to dismantle the rubble of blocks at the south side of the East Terrace, hoist the blocks and to display them temporarily on the terrace. There they will be documented and studied for possible reconstruction during the 2005 campaign. During that campaign it will then be possible to stabilize the underground and base of the lion and eagle statue and to restore them.



Present condition of the colossal limestone statues on the south side of the East Terrace

#### Ad 4.1.4 Preparation of the restoration of Kommagene (statue D)

We intend to glue the quickly deteriorating shoulder and breast pieces of statue D (Kommagene) to prevent further deterioration.

#### -- Surface conservation and restoration of the limestone statues on East and West Terraces. Deterioration and Conservation of the Limestone Surface (Dr. E. Wendler)

#### **Damage Mechanisms**

Fissures running randomly through the structure of the limestone are of diagenetic origin. Since the boarderlines are lined with clay minerals, these zones are subject of heavy weathering. The final weathering products are small pieces free of fissures having some 3 to 6 cm in diameter. These homogeneous areas of the limestone are very stable over centuries, showing water absorption coefficients of less than 0.1 kg/m<sup>2</sup> h<sup>0.5</sup>.

Water entering the fissures by capillary forces is rapidly moved foreward leading to fast hydric swelling with high loads to the structure (and shrinking during the subsequent drying process). Since drying takes place slowly, water can freeze inside leading to additional stress to the structure by ice crystallization. Especially in late winter (Feb., March) the physical loads to the structure are at maximum, since water from melting snow is absorbed for several days, while in the nights water freezes inside and melts during the day (freeze-thaw-changes). Additionally, the thermal stress is greatest on the east terrace in late winter morning when direct sun immission on a frozen surface occurs.

In contrast, honeycomb weathering is thought to be a stable weathering form. The "bridges" are stabilized due to crystallization of calcite mobilized in the "valleys" before.

#### **Conservation Procedure**

Leaving the statues in situ it is absolutely necessary to close the fissures by a mortar with mechanical and hydric properties well adapted to the stone. The strength and the modulus of elasticity must not exceed the values of the stone, as is valid for the capillary absorption. Lime should be the favourite binder, but it should be modified with small amounts of e.g. acrylate to reduce capillarity and enhance the binding force to the surface. In advance, lichen should be removed and a cleaning of the fissures with water should be carried out immediately before application.

In situ tests have been carried out in July with five different compositions and exposed for one year. Additionally, the mechanical properties of the compositions are tested in the laboratory. If necessary, there will be a modification to adapt the mechanical and hydric parameters to those of the stone 11.07.03 23:59

Dr. Eberhard Wendler Diplomchemiker Fachlabor für Konservierungsfragen in der Denkmalpflege Obere Mühlstraße 50 81247 München Fax: 49-89-89129441 Tel: 49-89-89129440 Mail: e.wendler@t-online.de

### TELEFAX

Prof. Dr. E.M.Moormann Prof. Dr. Predrag Gavrilovic KERVANSARAY HOTEL Fax +90-416-7372085

12.07.2003

#### Grout Harci YKS Emaco S 55

Sample	Adhesive Stength [MPa]*	Failure
1.1.2	0.24	100% cohesion
1.1.3	0.17	100% cohesion
2.2.2	0.34	100% cohesion

Table: Adhesive Strength between Limestone (fresh) and Grout. \*: after 2 days. It can be assumed that the values increase ca. 50% during 28 days.

#### **Result:**

The grout can be used for the enclosure of intact limestone. However, for the first step of refilling fissures, the larger aggregates > 1 mm should be removed in advance.

With best regards and greetings to all collegues

1 and 6

Eberhard Wendler

**P**01

4.2 Conservation and restoration of the SAND STONE RELIEFS AND OTHER OBJECTS: proposal for the 2004 campaign

As to the conservation and restoration of the sandstone elements we intend to do the following during the 2004 campaign:

- **1.** Restoration and conservation of the Lion Horoscope and the four *dexiosis* reliefs, West Terrace.
- 2. Transport of the remaining fragments of the sandstone reliefs and other objects from the Adyiaman Museum to the restoration house on the Nemrud Dağ.
- **3.** Transport of the sandstone remains of guardian animals and ancestor reliefs lying scattered on and around the mountain to the restoration house.
- 4. Placing of a copy of the Lion Horoscope in situ on the West Terrace.



Lion Horoscope as preserved in 2001

### Ad 4.2.1. Restoration and conservation of the Lion Horoscope and the four *dexiosis* reliefs

#### **Deterioration and Conservation of the Tuffite Reliefs : Damage Mechanisms and Stone Properties (by Dr. E. Wendler)**

Water uptake by capillary forces leads to hydric swelling due to the high content of clay minerals. The extent of swelling in a sedimentary rock is larger in the direction perpendicular to the stratification layers. Therefore, scaling as well as exfoliation is observed on the reliefs themselves showing the stratification layers more or less in vertical direction. In contrast, on the soccle the stratification is horizontal, consequently horizontal fissures between the layer occur as a damage form. Fissures without any orientation to the anisotropy of the stone structure may have come from mechanical impacts like earthquakes.Thermal stress and freeze-thaw-cycles seem to play another important role and support the effect of hydric dilatation, leading to a weakening of the structure always perpendicular to the stratification layers. Damage patterns see below.

Laboratory tests of the stone properties showed that the characteristics of the tuffite are a rather low capillary water uptake (0.5 - 0.7 kg/m<sup>2</sup>h<sup>0.5</sup>), a surprisingly moderate extent of hydric swelling (with large deviations from 100 to 250  $\mu$ m/m) and a low evaporation rate ( $\mu$  = 100). The biaxal flexural strength is rather high (8-10 Mpa), the corresponding Youngs modulus indicates a rigid material (14000 - 22000 MPa).

#### **Conservation Procedure**

Since the reliefs have to be moved and transported to restoration and finally to the museum, fragile surface parts will not survive even very careful procedures. Preliminary tests with Paraloid B72 and Primal fixation with the help of Japan paper and cotton seem to give enough stabilization. However, for the subsequent steps in restoration like strengthening, refilling of scales, application of stone repair mortars etc. the products have to be removed by a very time-consuming repeated application of several solvent poultices. Moreover, one cannot be sure that the products have been removed completely. An alternative would be the application of Cyclododecane = CDD (as a melt of some  $40^{\circ}$ C or in proper solvent solution). This product is absorbed by the surface and gives sufficient strength to the structure after solidification. The product sublimizes completely after a period of some 4 to 12 weeks depending on the pore structure and the temperature.

After complete removal of CDD the reliefs can be strengthened partially by ethyl silicate.

Refilling of scales should be carried out with the same binder (no waiting time, compatibility) in different subsequent steps: first, a diluted ethyl silicate should be injected behind the scales in order to prestrengthen the brittle material and bind it to the outer and inner boarders. Then, after 10 to 20 minutes of waiting, more concentrated solutions should be applied the same way, followed by concentrated ethyl silicate with admixed fumed silica. As a final step, an ethyl silicate bound injection grout containing aggregates < 50  $\mu$ m should be applied to close the really hollow gaps (> 300  $\mu$ m).

Repair mortars are going to be adapted to the stone by a proper sieve line with aggregates of different size, for reasons of compatibility ethyl silicate should be used as binder: Stone repair and refilling of scales often have to be carried out simultaneously by the restorer.

Repair mortars have been developed in the laboratory and will be tested in situ in 2004.

### Plan for Restoration and Conservation of the Tuffit Stelae during the 2004 campaign (by Dr. Y.S. Sener)

During the 2004 campaign we intend to execute restoration and conservation activities to the tuffit dexiosis stelae and Lion Horoscope brought to the restoration house on the Nemrud Dağ according to the following list:

- examination of the temporary and provisional consolidations made during the 2003 campaign;

- completion of the graphic documentation of the condition of conservation;

- completion of cleaning and removal of earlier, non adequate treatments (remains of mortar and resin that one finds on the surface of the stelae);

- removal of the tape from the sections that have been consolidated because of the transport during the 2003 campaign;

- consolidation of the crumbling sections with resin and mortar that is pre-mixed with silicate ethyl;

- consolidation in the depth of coming loose sections of the layers of the tuffit stone with resin and mortar that is pre-mixed with silicate ethyl;

- levelling of the sides and the gaps of minor dimensions;

- research and determination of the tuffit pieces that can be attached and glued again on the stelae in the storeroom of the Adiyaman Museum;

- glueing and/or impregnation of the fragmentary pieces;

- graphic documentation of the executed intervention.

The above listed restoation activities will be executed under the direction of Prof. Dr. Herman Brijder in colaboration with Dr. Y. Selcuk Sener of the Restoration School of the University of Ankara.

# Ad 4.2.2. Transport of fragments of the reliefs from the storeroom of the Adiyan Museum to the restoration house on the Nemrud Dağ.

Permission should be given to transport the fragments from the Adyian Museum to the restoration house on the Mountain.

# Ad 4.2.3. Transport of the sandstone remains of guardian animals and ancestor reliefs lying scattered on and around the mountain to the restoration house.

Many of the sandstone remains of guardian animals and ancestor reliefs are now in danger of falling down the slopes or vanish otherwise. We intend to bring them to the restoration house for thorough documentation and conservation and to study the possibility of restoration during our 2004 campaign.

#### Ad 4.2.4. Placing of a plaster copy of the Lion Horoscope in situ

The *Gipsformerei* in Berlin has been ordered to cast a copy of the Lion Horoscope. The copy will be transported to the Nemrud Dağ and placed in situ.

The plaster copy is vulnerable and has to be protected from the tons of snow and ice running down from the tumulus at the end of the winter by a support frame. Therefore a sheet pile wall of prefabricated concrete slabs is foreseen. It has to absorb the pressure (see drawing) and is prefabricated in two pieces.

The vertical slab is erected first on a layer of felt or lead. Than the horizontal slab is placed with a shear key to be cut in the bedrock. Next the connection between vertical and horizontal slab is poured with concrete. Finally the plaster copy is fixed to the vertical concrete slab. The concrete slabs are to be painted in matching colours.

Note that the horizontal slab will not touch the pedestal of the Lion Horoscope. See for details and approximately measurements the drawing.

If this solution proves to be durable, the same can be applied for copies of the *Dexiosis* reliefs to be made in the future.



For the 2004 campaign a documentation of the site and the ongoing protection and restoration activities by means of film/video is planned.

It is likely that parts of both the terraces will temporarily have to be closed for the public during the protection and restoration activities.

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#### ATTACHMENT 3 CV and lists of publications by Brijder and Moormann

#### Curriculum vitae of Prof. Dr. HERMAN A.G. BRIJDER

Born: on 21-1-1945 in Amsterdam.

Study: Master's degree (*cum laude*) in Classical Archaeology and History of Ancient Art, University of Amsterdam, on 3-9-1973.

PhD Classical Archaeology (*cum laude*): *Siana Cups* I and *Komast Cups*, University of Amsterdam, 14-12-1982.

Professor of Classical Archaeology and History of Ancient Art, since 1-9-1986.

- Head of the Department of Classical Archaeology and History of Ancient Art, University of Amsterdam, since 1-9-1986.

- Director of the Allard Pierson Museum, The Archaeological Museum of the University of Amsterdam, from 1986 to 2001. Scholarly director from 2003 onwards.

- Editor-in-chief / publisher of the Allard Pierson Series, since 1979.

13 volumes in the Allard Pierson Series, 5 in the Scripta Minora, 1 in Collections of the Allard Pierson Museum, and 1 CVA.

#### Main publications:

- Siana Cups I and Komast Cups, Amsterdam 1983.

- Siana Cups II: The Heidelberg Painter, Amsterdam 1991.

- Corpus Vasorum Antiquorum, Allard Pierson Museum, Amsterdam, fasc. 2, Amsterdam 1996.

- Siana Cups III: The Red-black Painter and Griffin-bird Painter and Siana Cups resembling Lip-cups, Amsterdam 2000.

#### Fieldwork:

- Excavations of the Casa del Protiro in Ostia, Italy: campaigns in 1973, 1974, 1975.
- Director of the excavations at Satricum, Italy: since 1990.
- Director of the international Nemrud Dağ project: since 2001

- President of the Organizing Committee of the Symposion on Ancient Greek and Related Pottery, Amsterdam, 11-15 April, 1984; editor of the proceedings.

- President of the International Congress of Classical Archaeology, Amsterdam, 12-17 July, 1998.

- Korrespondierendes Mitglied des Deutschen Archäologischen Instituts, since 1992.
- Secretary of the Allard Pierson Stichting
- Member of the Senaat of the Universiteit van Amsterdam, 1999-2002
- Head of the Committee of Classical Antiquity of the Dutch Institute at Rome.
- Member of the CVA Committee of Royal Dutch Academy of Sciences.
- Scientific senior advisor Allard Pierson Museum, sinds 2001
- Member of the board Stichting Nederlands Studiecentrum voor Latium
- Member of the board Vereniging van Vrienden van het Allard Pierson Museum
- Editor Satricum-Serie
- Editor Mededelingenblad Vereniging van Vrienden Allard Pierson Museum

#### List of Publications since 2000:

#### 2000

- Siana Cups III, The Red-black Painter, Griffin-bird Painter and Siana Cups resembling Lip-cups, Allard Pierson Series, Amsterdam, Vol. 13. Text: 241 pp. Plates: 103 pp.

- 'Placca di Schnabelkanne con haruspice', in *Gli Etruschi, Catalogo della mostra, Palazzo Grassi, Venezia* (Venice), 592.
- 'Hydria ceretana del Pittore dell'Aquila, in *ibid.*, 594.
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- 'Kantharos', in *ibid.*, 610.
- 'Een Etruskische prachtschaal', Mededelingenblad Amsterdam 79, 7-9.
- 'Een veelkleurig eierschaaltje uit Apulië', Mededelingenblad Amsterdam 79, 16-17.
- 'Een Etrusco-Romeins tempelmodel', Mededelingenblad Amsterdam 79, 18-21.

#### 2002

- 'Greece' in, A Guide to the Collections of the Allard Pierson Museum Amsterdam (Amsterdam), 102-139.

- 'Southern Italy and Sicily' in *ibid.*, 142-53.

- Editor, with G. Jurriaans-Helle, A Guide to the Collections of the Allard Pierson Museum Amsterdam (Amsterdam) 223 pp.

- 'The Study of Attic Black-figure Vases over the Past Thirty Years', in *Proceedings of the International Vase Symposion, Griechische Keramik im kulturellen Kontext, Kiel* 24–28 September 2001 (Kiel), 1-9. **2003** 

- 'Oude Wijn', Mededelingenblad Amsterdam 85-86 (2003) 12-14.

- 'Een symposion in Athene: wijn, zang en liefjes', Mededelingenblad 85-86 (2003) 18-24.

#### Curriculum Vitae of Prof. Dr. Eric M. MOORMANN

Born 9 January 1955 in Boxmeer, The Netherlands

MA Classics, Classical Archaeology and Italian Literature, Nijmegen University, 21-5-1980 PhD Classical Archaeology, Nijmegen University, 26-9-1986

- University Docent Classical Archaeology, University of Amsterdam, as of 1-5-1987
- Archaeologist and interim director Dutch Institute in Rome 1-9-1992 1-2-1997
- Visiting Professor University of Bologna, Italy1-1-1997 1-7-1997
- Interim Director Dutch Institute in Athens 15-4-2000 15-10-2001

Professor of Classical Archaeology at the University of Nijmegen, as of 1-3-2002 Since 1997 Korrespondierendes Mitglied des Deutschen Archäologischen Instituts Excavation and fieldwork practice:

Excavations at Agrigento (Sicily) 1978; Dutch excavations at Nijmegen, Alphen, Zwammerdam 1974-1978; Fieldwork in Pompeii, Herculaneum and Rome from 1979 onwards in various projects.

Main fields of research:

Greek and Roman sculpture; urbanistics of Pompeii and Rome, Roman wall painting; Fortune of Antiquity in western European culture

#### List of Publications since 2000:

2000

- Ancient Sculpture in the Allard Pierson Museum Amsterdam, Amsterdam 2000.

- Tussen Olympus en Merwede. Griekse goden en helden in de culturele erfenis van de Nederlanden in de late Middeleeuwen en de Renaissance, in: *Griekse goden en helden in de tijd van Rubens en Rembrandt*, tent. cat. Athene-Dordrecht 2000-2001, Dordrecht 2000, 15-33 (ook in Griekse en Engelse versie).

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- La bellezza dell'immondezza. Raffigurazioni di rifiuti nell'arte ellenistica e romana, in: X. Dupré Raventos/J.A. Remolà (edd.), *Sordes Urbis. La eliminación de residuos en la ciudad romana. Actas de la reunión de Roma (15-16 de noviembre de 1996)*, Roma 2000, 75-94.

- Offerte aan Marcus Agrippa Minor, Hermeneus 72 (2000) 4-7.

- De mens als maat van alle Griekse beelden, in: J. Lips Besselink, *Maar de reizen namen geen einde*, Maastricht 2000, 13-15 (ook in Duits, pp. 29-31, en Engels, pp. 45-47).

- R.F. Docter/E.M. Moormann (eds.), *Proceedings of the XVth International Congress of Classical Archaeology*, Amsterdam 1999.

- P.S. Lulof/E.M. Moormann, Man or sphinx? An early Archaic bronze head in the Allard Pierson Museum, in: From the parts to the whole, I, Portsmouth 2000 (= JRA Suppl. 39),59-64. **2001** 

- Op weg naar de zevende hemel, Dordrechts Museum Bulletin 26.1, 2001, 9-13.

Una città mummificata: qualche aspetto della fortuna di Pompei nella letteratura europea ed americana, in: P.G. Guzzo (ed.), *Pompei scienza e società.* 250<sup>0</sup> Anniversario degli Scavi di Pompei. Convegno internazionale, Napoli 25-27 novembre 1998, Milano 2001, 9-18.
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- Carandini's Royal Houses at the Foot of the Palatine: Fact or Fiction?, BABesch 76 (2001) 209-212.

- Romeinse wereld/Roman World, in: H.A.G. Brijder/G. Jurriaans-Helle (red.), *A Guide to the Collections of the Allard Pierson Museum*, Amsterdam 2002, 177-205.

- Pompeii's proprietors and tenants under one roof. Review article on J.A. Dickmann, Domus Frequentata, and F. Pirson, Mietwohnungen in Pompeji, *JRA* 15 (2002) 429-436. **2003** 

- *Een goddelijk interieur. Geschilderde decoraties in heiligdommen in de Romeinse wereld*, oratie KUN, Amsterdam 2003.

- Een marmeren tuinattribuut, Mededelingenblad Amsterdam 83 (2002) 14-16.

- Evocazioni letterarie dell'antica Pompei, in: P.G. Guzzo (ed.), *Storie da un'eruzione. Pompei Ercolano Oplontis*, Milano 2003, 15-33.

- Portitor ille Charon: de onverbiddelijke veerman van de onderwereld, Hermeneus 75 (2003) 136-147.

- Mooie zang uit monsterlijke kelenen ander verraderlijk schoon. Fabeldieren in de Grieks-Romeinse wereld, in: J. de Hond (ed.), *Monsters & fabeldieren. 2500 jaar geschiedenis van randgevallen*, Amsterdam/'s-Hertogenbosch 2003, 9-33.

- H.A.G. Brijder/E.M. Moormann, In memoriam Jos de Waele, Gnomon 75 (2003) 94-95.

- P.G.P. Meyboom/E.M. Moormann, L'interpretazione delle scene figurative nelle decorazioni dipinte della *Domus Aurea*, in: J.-M. Coisille/Y. Perrin (edd.), *Neroniana* VI. *Rome à l'époque néronienne*, Bruxelles 2003, 46-53.

- S.T.A.M. Mols/E.M. Moormann, Romeinse schilderkunst in Italië en maatschappelijk vertoon, *Leidschrift* 17.3 (2002) 15-35.

- E.M. Moormann/M.J. Versluys, The Nemrud Dağ Project: First Interim Report, *BABesch* 77 (2002) 73-111.

E.M. Moormann/M.J. Versluys, The Nemrud Dağ Project: new research on the mountain of the gods by Amsterdam University (2001), in: 20. Araştırma sonuçları toplantısı, Ankara 2003, 1, 249-256.

#### ATTACHMENT 4 Team List 2004

Prof. Dr. Herman A.G. **Brijder : Projectmanager** see attachment 3

Prof. Dr. Eric M. **Moormann : Projectmanager** see attachment 3

#### Ir Maurice L.A. Crijns : Project Coordinator

1966-1972	HBS/Gymnasium
1972-1977	Technical University of Eindhoven / architecture
1977-1987	Senior Architect ZON
1987-1990	Comm.Director Rolscreen Company Inc.
1990-1996	Research & Development Director Alumax Inc.
from 1996 onwards	Managing Director Ems-NL BV

#### Prof. Dr. Predrag Gavrilovic : Civil Engineer

1963: MA Institute of Earthquake Engineering and Engineering Seismology, Skopje, Republic of Macedonia, M. Sc. in Earthquake Engineering PhD Civil Engineering Faculty, University of Belgrade, Doctor of Technical Sciences in Structural engeneering

Assistant Professor, Faculty of Civil Engineering University Ciril and Metodius, Skopje 1974-1982 Associate Professor, IZIIS, Skopje

1982- 1991 Professor and Head of Structural Department at the Institute, IZIIS, Skopje 1991- now:

Professor, Principal Investigator and Research Advisor, JZIIS, Skopje; Professor on Post Graduate study and International School on following subjects: Seismic Design of Building Structures. Reinforced Concrete Structures. Repair and Strengthening of Structures; Principal Investigator of a number of National and International Projects; Visiting Professor and lecturer of different Universities (Belgrade, Italy-Bologna, Algeria CGS, Podgorica, Phnom Penh and other); Director of International Council of Seismic Design of Structures; UNESCO and UNDP expert and consultant in different projects; The Getty Conservation Institute (GCI) and World Monument Fund (WMF) New York consultant.

#### Christoph Kronewirth : Conservator/Restorator

Christoph Kronewirth (Trier) was trained as a restorator and stone expert on many sites around the Mediterranean. He worked for 20 years with the German Archaeological Institute in sites like, for instance, Pergamon on the reconstruction of the temple of Trajan. In Didyma he works as a collaborator to Prof. Dr. O. Bingöl.

#### Marlies Schipperheijn : Epigraphist

1990-1996	Highschool, G.S.G.D. Doetinchem
1996-1997	Propaedeutics Dutch language and Literature, RUG Groningen
1997-2001	Greek and Latin, RUG Groningen, Major Ancient History.
Drs. Tesse D. Stek :	Classical Archaeologist
1990-1996	Gymnasium Amsterdam
1996-2001	Classical Archaeology, University of Amsterdam
2001-2005	PhD research at the University of Amsterdam
Drs. Ellen Thiermann :	Classical Archaeologist
1982-1995	Gymnasium Berlin
1996-2000	Prehistory and Classical Archaeology, University of Freiburg and
	Berlin
1998-1999	Student stipend, University of Rome
2000-2002	Masters, University of Amsterdam
2003-2008	PhD research at the University of Amsterdam
Prof. Dr. Onno M. Van I	Nijf : Epigraphist
June 2000-to dat	Professor of Ancient History University of Groningen
July 1998-June 2000	Royal Dutch Academy Postdoctoral Research Fellow. Research
project: The festive cultu	re of the Greek City in the Hellenistic Roman Periods. University of
Amsterdam/Faculty of C	lassics Cambridge.
Sept.1997-July 1998	Leverhulme Research Fellow in Greek epigraphy Faculty of
1 5	Classics, Cambridge.
Oct.1995 – Sept.1997	Teaching fellow in Ancient History. Dept. of Classics and
L L	Ancient History, University of Bristol.
1991-1995	Junior Research Fellow in Ancient History. Faculty of Arts,
	University of Amsterdam.
March 1996	PhD. (with distinction).

Dissertation: The Civic World of Professional Associations in

the Greek Cities of the Roman Empire. Univ. of Amsterdam1987-1990Postgraduate study Ancient History Faculty of Classics,CambridgeStudy Classics University of LeidenBooks published:Study Classics University of Leiden

- Trade, Transport and Society in the Ancient World. A sourcebook. (with F.Meijer) London, 1992. (Routledge).

- The civic world of private associations in the Greek East. Amsterdam, 1997. (J.C.Gieben).

#### Dr. Eberhard Wendler : Stone Scientist

Dr. Wendler studied Chemistry at the University of Munich, Germany, where he obtained his PhD in Solid State Chemistry (development of artificial bone for implantation materials). He was Scientific Researcher at the Bavarian State Conservation Office and Chairman of the Stone Conservation Working Group at Geological Institute of the University of Munich. Since 1992 he has established a private Conservation Laboratory, continuing research in the field of stone conservation while serving as consultant in both national and international projects on Stone and Brick Conservation (Brazil, Norway, Finland, France, Eastern Europe, India, Thailand, Cambodia, Easter Island/Chile). He has published extensively in the field.

Anne Ten Brink :	Pre-Historian
1980-1988	Highschool docent
1982-1986	Pre-history Assen
1988-1993	Interim-Management
as of 1993	Director Coa
Ir Jaap Groot :	Civil engineer
1956-1962	Gymnasium HBS Hilversum
1962-1966	HTS Utrecht
1966-1974	Consultant South Africa
1974-1980	Technical University Eindhoven
as of 1980	Consultant worldwide

Drs. Jan M.F. Diederen : Cineast

MA History
Research, production, and direction of many documentaries for
Dutch television, thereby mainly focussing on science and scientific projects
Cineast
Hogeschool Sittard: Photography (graduation 1990; cum
laude)
Filmacademy Amsterdam (NFTVA) Direction: Camera (graduation
1994)
Preparation, direction and shooting of many documentary
camera- and directing projects
Cineast
Assistant to the Project Coordinator
<b>Operator High Resolution Scanner</b>

Participating student-assistents from the Universities of Amsterdam and Nijmegen: Drs. Jurriaan **Venneman** (UvA) Drs. Louis **van den Hengel** (KUN)

#### **ATTACHMENT 5**

International Nemrud Foundation Nemrud DAG Conservation Project Adiyaman, Turkey



# STRUCTURAL CONSOLIDATION OF NEMRUD SCULPTURES

**Mission Report, 2003** 

Dr. Predrag Gavrilovic Consultant Engineer

June - December 2003

International Nemrud Foundation Nemrud DAG Conservation Project Adiyaman, Turkey

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  - 2.1. Structural Consolidation and Stabilization of Antiochos Statue on East Terrace
    - Present Condition and Diagnosis
    - Structural Consolidation and Stabilization of
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#### APPENDIX A : STRUCTURAL ANALYSIS AND SEISMIC STABILITY OF HERAKLES STATUE

#### PREFACE

The main objective of this report is presentation of activities taken for structural consolidation during the mission of the consultant and the 2003 campaign as well as proposals for structural consolidation to be carried out in the 2004 field campaign along with elements for their realization.

#### ACKNOWLEDGEMENT

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.1. INTRODUCTION -GENERAL PRINCIPLES, CRITERIA AND METHODS FOR CONSERVATION AND STRUCTURAL RESTORATION OF NEMRUD MONUMENTS

Based on a project proposal, structural consolidation and stabilization of the Antiochos statue on the East Terrace were carried out during the 2003 campaign.

As to the pilot project on structural restoration of the North Platform with the Eagle and Lion statues on the East Terrace, a detailed project was elaborated within the project proposal. However, this was not accomplished due to local and other conditions. What has been done is: dismantling of the Eagle statue, complete stabilization of ground below the platform and identification of stone blocks from the platform and the statues. Reconstruction based on a detailed project proposal for structural reconstruction is anticipated to start immediately within the 2004 campaign.

In accordance with the general plan and project proposal for the 2004 campaign, structural consolidation and stabilization of the Herakles statue is planned. This statue is in a critical condition from the aspect of its integral stability wherefore temporary intervention for consolidation of its foundation was carried out during the 2002 campaign. Now there is a need for a complete intervention. In compliance with the general principles and criteria, there have been elaborated two alternatives for consolidation and stabilization and an alternative for reconstruction by placement of the Herakles head on the statue.

The general principles, stability criteria and methods of structural reconstruction are given in the Mission Reports of this consultant and are incorporated in the reports from the Amsterdam meeting 2001, 2002 as well as in the Proposal for the 2003 Campaign and the Proposal for the 2004 Campaign.

#### **General Principles**

Structural consolidation, repair, strengthening and reconstruction are done with due respect for international conservation standards. "Minimum intervention - maximal protection" can be seen as the main rule. This implies that nothing will be altered in the existing situation if such an intervention is not absolutely necessary for the protection of the statue. The intention is to protect the monument by conservation and restoration modern principals. Nemrud Dag must stay a fascinating archaeological site, restored and protected one.

#### Seismic Safety Criteria

Taking into account the seismicity of the region and the site and the type of monuments and structures, the following safety criteria are proposed:

- For the expected effect of earthquakes with a return period of 500 years and effective ground acceleration of  $a_0 = 0.40$  g, the monuments behave suffering no damage to the integral structure or individual parts. This means that the integral structural system behaves in the linear range. This level should be considered designed level of safety.
- For the expected effect of earthquakes with a return period of 1000 years and effective ground acceleration of  $a_0 = 0.50 0.60$  g, damages to the structures should be allowed but the structure should be repairable and the general stability of the structure thoroughly preserved. This means that nonlinear behaviour and partial damage can be allowed under such effects, but the structure should remain stable as a whole. This earthquake level should be treated as a controlling one, i.e., it should serve for verification of the stability of the structures against failure and severe damage.

The use of modern equipment as are cranes with appropriate characteristics and ability to execute a number of operations has proved to be extraordinarily efficient, without causing any additional effects upon the statues and the environment. It is recommended to use of a telescopic crane with electronic equipment and trained staff as that in the 2002 and 2003 campaign, with the equipment and the team from the "ENKA" company from Istanbul.

#### Methods and Techniques

The methods and techniques of reconstruction are the subject of detailed studies but a simplified method that enables preservation of authenticity and avoiding of damages to stone blocks, particularly those bearing inscriptions, decorations etc. has been proposed and presented in the mission reports and project proposals 2003, 2004.

Care should be taken to respect, to the maximum extent, the original mode of building and arrangement of the stone blocks, without mortar, concrete or similar materials and each individual stone should undergo a stone conservation treatment. New techniques and materials that are easy to be performed in situ (wedges, connections, stainless steel, carbon with epoxies and alike) should be used for repair of the broken stone blocks and their connection, if justified from structural aspects.

#### 2. STRUCTURAL CONSOLIDATION OF NEMRUD SCULPTURES - FIELD CAMPAIGN 2003

#### 2.1. Structural Consolidation and Stabilization of Antiochos Statue on East Terrace

Antiochos statue can be evaluated as critical because of the large displacements of stone blocks, particularly manifested through the vertical separation - the gap on the south side (Photo 1).

Analyzing the stability of both lower parts of the statue (the head of the statue has fallen off the statue), it can be said that these are in the state of being structurally unstable and with disturbed structure of dry masonry. The analysis of stability of the structure by detailed inspection has proved that the main reason for the occurred damage is degradation of bearing ground - rock, which therefore needs to be stabilized.

Possible minimal motions caused by natural phenomena or activities of Man may lead to abrupt progressive failure of the entire statue. Certain contacts, i.e., supports of stone blocks from the inner side are so weak and in critical condition that they require urgent intervention involving structural stabilization.

Urgent - temporary structural stabilization was done in July 2002 involving supporting of the inner side by timber blocks and steel tie connections on the lateral - the external side. The performed stabilization that basically consists of supporting the statue by timber struts with timber cramps is not only temporary, but insufficient as well (Photo 2)

#### Structural Consolidation and Stabilization of the Statue Undertaken in 2003

The works on structural stabilization began after detailed analysis and numbering of the stone blocks.

Considering the existing condition of the structure, i.e., its deformation and degradation with large deformations on the southeast corner, the upper three rows of the statue on the southeast corner close to the ground were dismantled. Such an intervention was necessary because of the need for consolidation of the ground and repair of the stone blocks. The dismantling was done fast, efficiently and without inflicting any additional damage, by means of a telescopic crane and corresponding equipment. The stone blocks were placed on the platform and after the treatment (repair) of the cracks by the team of stone conservators, they were returned back to their original position. Consolidation of ground was done by partial injection of the cracks in the rock by grouting after which the holes from rock deterioration were filled by rebuilding with stone masonry as far as the lower surface of support of the stone blocks of the statue (Photo 3).

After the performed stabilization of ground, the blocks from the lower three rows were moved, the expansion joints cleaned and the blocks returned to their original place by bringing them close again (Photo 4).

The placement of the dismantled stone blocks in their original position was done fast and efficiently without any damage.

The Antiochos statue was thoroughly reconstructed and structurally stabilized in the position in which it was found. The head has not been placed on the structure. Conservation works on stone blocks can be done in-situ, without dismantling (Photo 5).

It can be concluded that the process of dismantling of the stone blocks has been efficient, fast and without inflicting damage. The process of mounting of the blocks is also fast and efficiently done by workers who operate the crane and have already acquired the necessary skills as well as local workers.

#### 2.2. Structural Restoration of North Platform with Eagle and Lion Statue on East Terrace

The project proposal for 2003 contains the complete report of this consultant referring to the restoration of the north platform with the Eagle and Lion statues on the east terrace along with all the elements of soil consolidation and reconstruction. The report provides a detailed insight into all the elements of the existing condition, the need for interventions, diagnosis, reconstruction with structural interventions and conservation as well as conservation methods and techniques. Given in the Appendix is structural and seismic analysis in accordance with the seismic safety criteria and the seismicity of the site. The detailed report was meant to serve as the basis for the pilot project (see Project Proposal 2003, 2004).

#### **Consolidation Works Undertaken in Campaign 2003**

The first phase "stabilization of ground and preparation of the platform base" was particularly emphasized in the project considering the high level of degradation and erosion of the surface part of the ground.

With the starting of the works on the north part of the platform and elimination of the eroded and unstable soil to reach a sound base, it was shown that the eroded and unstable layer was considerably deeper than it was assumed (Photo6.). After removal of unstable stone structures, the cracks were injected by grouting after their previous treatment (cleaning) by means of a water jet. After the injection of the entire platform, the hole in the north part was filled with masonry (stone masonry in cement lime mortar). In this way, there were created conditions for starting with reconstruction and conservation of the stone blocks from the platform and then the statues. The stone blocks of the Eagle statue have been dismantled, the stones below the statue have been cleared out (inside the platform) and the placement of the stone blocks on the south part of the terrace (below the eagle). Identification of the remaining stone blocks below the Lion statue and preparations for shaping of missing blocks or missing parts of blocks have to be done.

Rebuilding of the platform, below the Eagle statue has been done (Photo 7,photo 8). Rebuilding below the Lion statue is qyet to be finished. The stone blocks of the Eagle statue have already been placed in their original position. There remains the head to be placed and fixed during the 2004 campaign.

#### 3. STRUCTURAL CONSOLIDATION OF NEMRUD SCULPTURES - PLAN AND PROPOSAL FOR FIELD CAMPAIGN 2004

### 3.1. Continuation of Works on Structures Restoration of North Platform with Eagle and Lion Statues - East Terrace

After completion of the platform on the north side and finalization by a final layer, reconstruction of the Eagle and Lion statues should start.

#### Statue of Eagle (Figs. 1-2)

The Eagle's head should be fixed with stainless steel SS bars anchored into the lower blocks with 6  $\phi$  12 bars with a length of 2 x 20 cm, placed at an equal distance and drawn inside for 10 - 12 cm from the inner side. /Layer 5/, Fig. 1, Fig 2. All stainless steel bars should be poured with epoxy resin.

Horizontal clamps should be placed to connect the blocks of layer 3. It will be necessary to embed the clamps of SS in melted lead for connecting two blocks of layer 3 (see Fig2).The clamps are made according to the directions of the restorator.

It is necessary to point out the importance of providing a good resting place for the blocks to avoid concentration of stresses and penetration of water into the connections. Flattening of the contact surfaces for achieving a good resting place should be done by incorporation of layers of lead and/or hydraulic lime mortar.

#### Statue of Lion (Fig. 3)

The Lion's statue is completely ruined but the stone blocks have been identified. During the previous research and analyses, a large number of stone blocks were missing and a solution was logically imposed not to begin with rebuilding until an insight into the actual situation is obtained. With the investigations done in 2003, there was additional identification of stone blocks (Fig. 3) which considerably changed the situation.

In this situation, it is quite justified to perform reconstruction by rebuilding now that only a small number of stones are missing.

The blocks that are missing or partially broken should be replaced by new hewn ones and marked as new (a sign INF-2004 should be engraved). The blocks are taken from the (ancient) quarry at the Malatya (north)side. It should be pointed out that these are necessary for static and seismic stability.

The reconstruction of the Lion statue should be done in the same way, by returning of the stone blocks into their original position after their treatment from structural aspect - repair and possibly strengthening and conservation.

In this phase, it is proposed that the Lion statue be finished up to its head during the 2004 campaign. Considering the state in which the head is and the great extent of damage

and degradation, ways should be found to halt the process (by some fixation) while the realization of the activities required for the head should be left for the 2005 campaign.

#### 3.2. Structural Consolidation and Stabilization of Herakles Statue

#### **Present Condition and Diagnosis**

The statue is largely intact and standing upright apart from the head; this stands on the terrace. Three types of characteristic damage to the statue have been observed: damages to the principal structural system manifested by displacement of the stone blocks from their original position leading to formation of gaps between the blocks; damages to the stones themselves particularly pronounced on their front side and manifested by local failure or cracks and erosion; and deterioration of bedrock/soil foundation, particularly expressed on the front side (Photo 9).

It is urgently necessary to intervene as the stability of the soil, i.e., bedrock has suffered from considerable deterioration and erosion in the course of time. Such an intervention is imposed by the need to prevent further erosion and make contact between the principal structure and the soil. The cavity caused on the front side might induce failure of the stone blocks leading to progressive failure of the entire structure.

The temporary stabilization done in 2002 campaign involved the cleaning of the base, the removal of tiny stones and failures and the incorporation of stone blocks in the form of walls and cramps. The new stone blocks basically transfer the load from the structure to the base and prevent occurrence of cracks in the lower stones and failure of the statue. Stabilization of soil was not done. Dry stone masonry was used with the intention that this intervention be temporary and the used material reversible.

#### Removal of Blocks (Partial Dismantling), Repair and Conservation

Based on analysis of the existing conditions and anticipated measures for conservation and stabilization as well as based on structural and seismic analysis (Appendix A) a complete dismantling of the statue is recommended.

Considering the efficiency of the use of the crane and the already adopted mode of lifting, transport and returning to the original place, a complete dismantling of the statue is recommended contributing to a better and easier stabilization of the soil and bedrock.

All the stone blocks that will be removed should be repaired from structural aspects which means repair of the cracks and connection of the broken parts. The stone blocks should also be treated from conservation aspects.

#### **Stabilization of Ground and Foundation**

As has already been presented previously, the ground under the statue is considerably deteriorated.

The process of stabilization shall be done by removal of unstable stones and cleaning down to sound bedrock. After cleaning by use of a strong water and air jet, the base is to be injected by "grouting" and the empty space is to be filled out with masonry in cement (or lime mortar).

The final layer of masonry in the empty space below the statue is to be constructed by pouring of a layer of cement (or lead). This layer will be the contact base of the stone blocks of the statue.

#### **Reconstruction of Statue**

Reconstruction is anticipated to start after stabilization of soil. First, the lower layers are to be reconstructed by placement of the stone blocks into the original position and then the stone blocks from the platform are transported by crane and placed one by one until the final layer 6.

The placement of the blocks is prefarably to be done under the supervision of an engineer or a restorator to minimize the possibility of possible damage.

The connection of the statue's head as well as the upper rows of stone blocks with SS wedges (due to provide the necessary safety against overturning in the case of an earthquake) essentially changes the system and the entire upper part that, in static sense, starts to behave as a rigid part not as dry stone masonry. From this aspect a complete reconstruction up to the existing state (6 rows) without placement of the head, is done in this phase (2004 campaign).

For the placement of the head, sufficient data should be collected and a mode of achieving "controlled" behaviour should be proposed involving incorporation of special dampers in the hole where the head was.

From the analysis of seismic stability, the following needs and alternative solutions are imposed:

- In case the reconstruction is done to the level of the present condition, without placement of the head of the statue, than it is to be done only by bringing the stone blocks in their original position without any additional connections - pure dry stone masonry.
- In case the head of the statue is placed back to its original position, there is the need from the aspect of seismic stability to connect the stone blocks by SS wedges in the upper three layers including the head with layer 6.

#### **Structural Analysis and Seismic Stability**

Analyses have been done for both possible alternatives in accordance with the adopted safety criteria and seismicity of the region. These are presented in Appendix A.

The conclusion from the analysis is that, in the case of reconstruction of the six layers of the statue (without the placement of the head) with performed stabilization of ground, repair of the stone blacks and their placement back into their original position, the stability criteria referring to the maximum expected earthquake with a return period of 500 years and ground acceleration of  $A_{max} = 0.40$  shall be completely satisfied. For maximum expected ground acceleration induced by earthquakes with a return period of several thousands of years, the structure shall suffer partial damage - displacement of the stone blocks but shall remain stable as a whole.

#### 4. CONCLUSIONS AND RECOMMENDATIONS

A conclusion can be drawn that the proposed methodology, techniques of realization and application of sophisticated equipment and materials are efficient and do not disturb the authenticity of the monument. The experience regarding the use of the crane in the 2002 and 2003 campaign (whose use aroused a lot of unnecessary disputes) has shown that it is efficient and does not inflict any damage wherefore it is recommended to be used also in future. The application of materials as are stainless steel, epoxies, grouting material, hydraulic lime mortar, cement, lead, etc. has also proved to be efficient and completely acceptable from the aspect of stone conservation.

It is proposed to completely reconstruct the North Platform with the Eagle and the Lion statues and place the Eagle's head back to its original position. From the aspect of stability, a structural intervention involving stabilization and conservation of the Herakles statue is also imposed as necessary.

Therefore the Herakles statue will be reconstructed in 2004 without the head. And further studies to put the head on top of the statue by dampers will be executed.



Photo 1. Antiochos statue - prior to intervention



Photo 2. Antiochos statue - temporary support (2002)



Photo 3. Antiochos statue – during reconstruction



Photo 4. Antiochos statue – stabilization of ground layer



Photo 6. North Platform with Eagle and Lion statues - soil degradation



Photo 7. North Platform with eagle and Lion statues-reconstruction



Photo 8 North Platform - proces of reconstruction of statue of Eagal



Photo 9. Herakles statue - present condition



Fig.1. East terrace - eagle statue

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Fic. 2 Seconstricti characteristics of taylors



#### APPENDIX A: STRUCTURAL ANALYSIS AND SEISMIC STABILITY OF HERAKLES STATUE

#### GEOMETRICAL CHARACTERISTICS OF THE STATUE

Fig. A-1 shows the geometrical characteristics of the Herakles statue. The data were taken during the survey carried out in the course of June/July 2003 and can be treated preliminary. This particularly refers to layers 1 - 5 given in Fig. A-2 related also to other data (area A, inertial moment  $J_i$ , resistance moment  $W_i$ , etc.)

#### STATIC AND DYNAMIC ANALYSIS OF EAGLE STRUCTURE

#### Gravity load:

- The structural system can be considered as a rigid system composed of blocks and horizontal joints (Fig. 3).

- Five layers of stone blocks should be taken into account considering the rigid body.

- On the basis of the geometrical characteristics of the statue and the blocks as well as the properties of the limestone, the weight of the blocks is:

Block 6	W <sub>6</sub> =	= 2.70 t
Block 5	W <sub>5</sub> =	= 7.50 t
Block 4	W4 =	= 7.80 t
Block 3	W3 =	= 9.90 t
Block 2	W2 =	= 13.0 t
Block 1	W <sub>1</sub> =	= 17.5 t
		6
	Total weight	∑ = 58.5 t
		1

#### ANALYSIS OF STRUCTURE FOR SEISMIC ACTION

The seismic action is defined by the Turkish Seismic Code of 1996. The structure is located in the highest zone I, with ground acceleration of  $A_0 = 0.40$  g (for a return period of 500 years).

According to seismic criteria, two levels of behaviour will be controlled: (i) For  $A_o = 0.40 \text{ g}$  - the behaviour of the structure should be in the elastic range without damage (ductility factor - factor of structural behaviour q = 1.0); (ii) For the maximum possible expected acceleration of  $A_o = 0.60 \text{ g}$ , some damage and disturbance of the structure will be accepted but the global stability should be preserved without collapse, overturning or heavier damage.

Analysis will be performed using equivalent seismic forces for a lump mass system of a rigid body.

#### ANALYSIS OF STRUCTURE FOR THE FIRST LEVEL OF SEISMIC ACTION Ao = 0.40 g - Seismic forces in the base of the structure

	A <sub>o</sub> . I <sub>o</sub> . W	
$\sum F = -$		$A_{o} = 0.40 \text{ g}$
	q	$I_o = importance factor$
	0.40.4.40.10	q = behaviour factor
	0.40.1.10.00	
∑ F =		A = 0.40 - acceleration
	1.0	I = 1.1 - importance factor
		q = 1.0 - elastic behaviour

 $\Sigma F = 0.40 . 1.1. . 58.5 = 26 t$ 

- Distribution of seismic forces over the height of the structure:

		W <sub>i</sub> . h <sub>i</sub>	$W_i$ = weight of the block
$F_i =$	$\Sigma F_i$		$h_i = height$
		$\sum W_i$ . h <sub>i</sub>	$F_i$ = seismic force at i-th level
			$\Sigma W_{ihi} = 32.4$

 $F_6 - 3.3 t$   $F_5 = 3.50 t$  $F_4 = 6.50 t$ 

$$F_3 = 5.50 t$$
  
 $F_2 = 5.0 t$   
 $F_1 = 2.20 t$ 

 $\begin{array}{l} M_6 = 1.40 \text{ tm} \\ M_5 = 6.30 \text{ tm} \\ M_4 = 10,60 \text{ tm} \\ M_3 = 16.42 \text{ tm} \\ M_2 = 18.3 \text{ tm} \\ M_1 = 31.80 \text{ tm} \end{array}$ 

Control of stresses and overturning in corresponding layers

#### Layer 5

 $\sigma_0 = 0.35 \text{ kg/cm}^2$  $\sigma_s = 0.20 \text{ kg/cm}^2$  $\sigma_{o} = \frac{N}{F} = 0.55 \text{ kg} / \text{cm}^{2} < \sigma_{AW}$  $\sigma_s = \frac{M}{W} = 0.24 \text{ kg/cm}^2$ M<sub>s</sub> 6.30 n = ---- < 1.0 Overturning: M<sub>G</sub> 6.6 Layer 3 M = 16.92 tm N = 28 tm  $\sigma_{max}$  = 1.40 kg/cm<sup>2</sup> compression  $\sigma_{o} = 0.40$  $\sigma_t = 0.20 \text{ kg/cm}^2$  tension  $\sigma_s = 0.60$ 16.9 = 0.45 < 1 28.5 . 1.30 Overturning: n = -Layer 1 M = 31.8 tmN = 58.5 tm $\sigma_{max}$  = 1.55 kg/cm<sup>2</sup> compression  $\sigma_{o} = 0.45$  $\sigma_t = 0.35 \text{ kg/cm}^2$  $\sigma_s = 0.6$ compression 31.3 = 0.47 < 1 58.5 . 1.3 Overturning: n =

The stresses are low, while the overturning is satisfied.

It can be concluded that the structure satisfies the seismic stability criteria

### ANALYSIS OF STRUCTURE FOR THE SECOND LEVEL OF SEISMIC ACTION Ao = 0.60 $\,\mathrm{g}$

This level corresponds to the maximum expected acceleration with a return period of over a thousand of years. This level should be used for controlling the structure against failure. The main criterion for this type of structures is overturning.

The equivalent seismic force can be defined as follows:

$$\Sigma F_{i} = \frac{A_{o} \cdot I \cdot W}{q}$$

$$A_{o} = 0.60 \text{ g}$$

$$I = 1.1$$

$$q = 1.50$$

$$W = \text{weight of the structure}$$

$$\Sigma F_{i} = \frac{0.60 \cdot 1.1 \cdot 58.5}{1.20} = 31.2$$

$$k_{i} = \frac{31.2}{26} = 1.20$$

Control of overturning per connections:

Layer 5: n = 0.96 < 1.0

Layer 3: n = 0.54 < 1

Layer 1: n = 0.56 < 1.0

The global stability is satisfied.

#### **ATTACHMENT 6**

#### Dr. E. Wendler Repair Mortar for Tuffite (Ethylsilicate bound)

Site:	Turkey, Nemrud Dag
Material:	Tuffite
Date:	18.11.03

	0306-	0306-	VO-0306-	VO-0306-	VO-0306-	VO-0306-
	NEM.T-	NEM.T-	NEM.T-	NEM.T-	NEM.T-	NEM.T-
	MLT-6[8].1	MLT-6[8].2	MLT-6[8].1	MLT-6[8].2	MLT-2[6].1	MLT-2[6].2
	Laboratory	Laboratory	In situ	In situ	In situ	In situ
			0306-	0306-		
			NEM.T-	NEM.T-		
Compare with			MLT-6[8].1	MLT-6[8].2		
Aggregates [g]						
F36	44,89		63		63	
Quartz sand						
Nr. 58630	21,38	32,94	30	56	30	56
Tuffite						
125-250µ		43,43		70		70
Tuffite						
250-500μ	69,48	63,63	97,5	105	97,5	105
Aggregate A	6,06	4,55	8,5	7,5	8,5	7,5
Aggregate B	8,19	5,46	11,5	9	11,5	9
Umbra						
Nr. 40720	0,50	0,50	1,00	1,00	1,00	1,00
Binder [ml]						
Ethylsilicate						
333-STE	35,00	35,00	37,00	41,00		
Ethylsilicate						
500-STE					35,00	35,00

#### Mixtures of repair mortar

#### Valuation of repair mortar

	0306-NEM.T-MLT-6[8].1	0306-NEM.T-MLT-6[8].2
workability	+/-	+
grain structure	+	+
cohesion	+/-	+
adhesion	+/-	+

+ very good +/- middle - bad

#### Refilling grout [RG] for Tuffite Scales (Ethylsilicate bound)

Site:Turkey, Nemrud DagMaterial:TuffiteDate:18.11.03

	not pigmented	dark grey	grey-yellow	grey-green
	0312.RG.NEM.2.1	0312.RG.NEM.2.1a	0312.RG.NEM.2.1b	0312.RG.NEM.2.1c
Aggregates [g]	130	132	136,5	136,5
Aggregate A	64	64	64	64
Aggregate B	40	40	40	40
Glass Powder <50µ	26	26	26	26
Pigment [g]				
Kremer Nr. 48440		2,0	2,0	2,0
(black)				
Kremer Nr. 40280			4,5	
(yellow)				
Kremer Nr. 40630				4,5
(green)				
Binder [ml]	100	100	100	100
Ethylsilicate 500 STE	75	75	75	75
Ethanol	25	25	25	25

Pre-wetting with ethanol is neccessary. It is possible to mix the different colour types to match the colour. Addition of pigments is not essential for functioning, but recommended in case of unexpected run out of the grout.

#### **ATTACHMENT 7**

#### Dr. E. WENDLER Repair Mortar for Fissures in Limestone (Lime bound)

Site:Turkey Nemrud DagMaterial:LimestoneDate:18.11.03

	0306-	0306-	VO-0306-	VO-0306-
	NEM.HFM.3	NEM.HFM.4	NEM.HFM.3	NEM.HFM.4
	Laboratory	Laboratory	In situ	In situ
			0306-	0306-
Compare with			NEM.HFM.3	NEM.HFM.4
Aggregates [g]				
Sand "Ulmer Weiß"		230,00		276,00
Quartzsand Nr. 58630	100,00	60,00	125,00	75,00
Marble 125-250µ	115,00		172,50	
Marble 250-500µ	20,00	25,00	30,00	37,50
Aggregate A	5,00		3,75	
Binder [g]				
Lime "HL 5"	100,00	100,00	100,00	100,00
Binder [ml]				
Aqua dest. + 5 % Primal	110,00	120,00	110,00	120,00

	0306-	0306-	VO-0306-	VO-0306-
	NEM.HFM.3	NEM.HFM.4	NEM.HFM.3	NEM.HFM.4
	Laboratory	Laboratory	In situ	In situ
			0306-	0306-
Compare with			NEM.HFM.3	NEM.HFM.4
Mixture [ml]				
Sand "Ulmer Weiß"		192,00		230,00
Quartz Sand Nr. 58630	80,00	48,00	100,00	60,00
Mable 125-250µ	77,00		115,00	
Marble 250-500µ	13,50	17,00	20,00	25,00
Aggregate A	6,7		5,00	
Binder [ml]				
Lime "HL 5"	100,00	100,00	100,00	100,00
Binder [ml]				
Aqua dest. + 5 % Primal	110,00	120,00	110,00	120,00

#### Valuation of Repair Mortar for Limestone

	0306-NEM.HFM.3	0306-NEM.HFM.4
workability	+/-	+
grain structure	+	+
cohesion	+/-	+
adhesion	+/-	+
+ very good +/- middle	- bad	