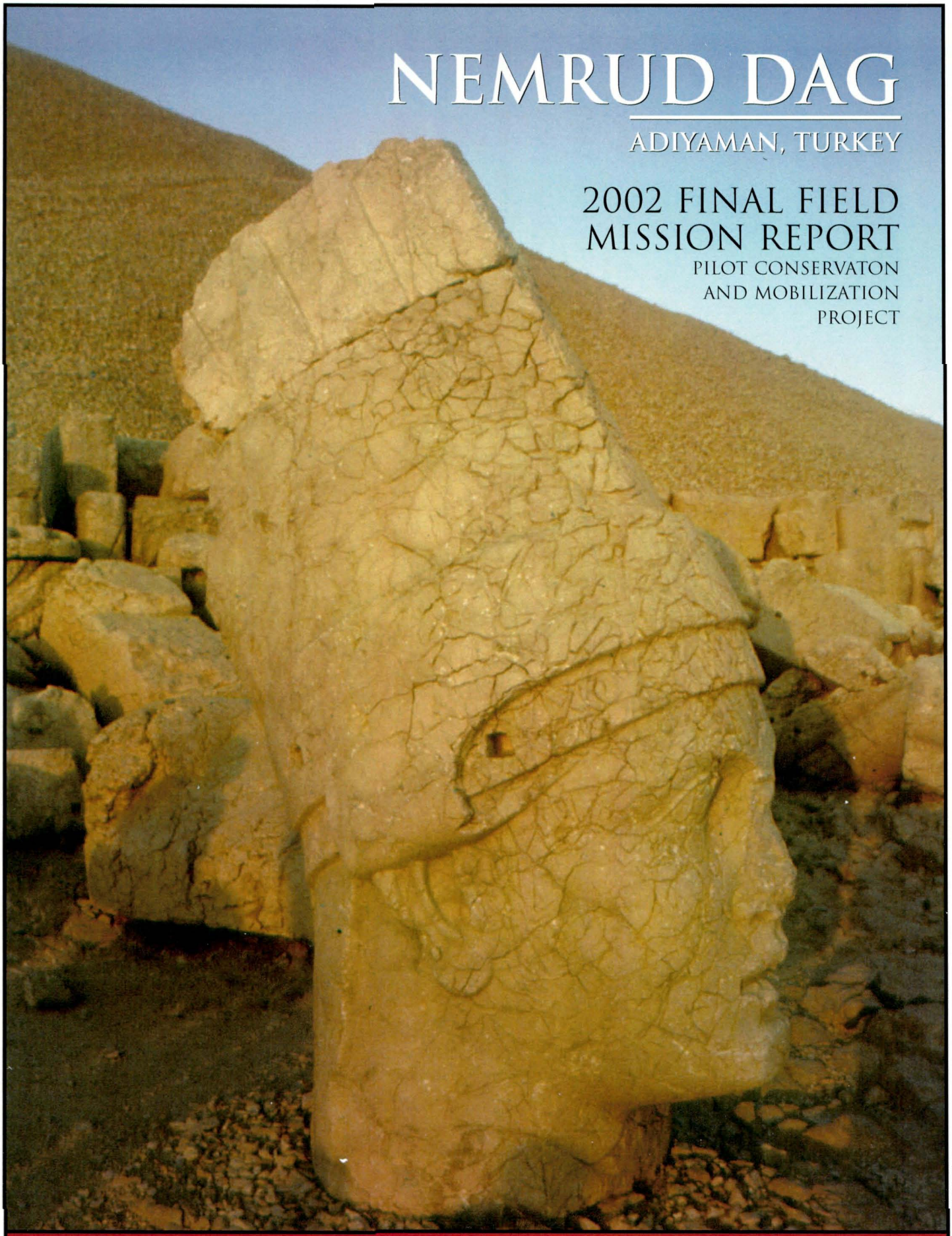
NEMRUD DAG

ADIYAMAN, TURKEY

2002 FINAL FIELD MISSION REPORT

PILOT CONSERVATON AND MOBILIZATION PROJECT



WORLD MONUMENTS FUND

TABLE OF CONTENTS

WORLD MONUMENTS FUND - NEW YORK

NEMRUD DAG FINAL FIELD MISSION REPORT

JUNE/JULY 2002

ACKNOWLEDGEMENTS

ACKNOWLEDGEMENTS

The World Monuments Fund's missions to Nemrud Dag, Kathta, Turkey in June and July of 2002 were made possible by the generous support of the American Express Company and Akbank, Istanbul, Turkey.

WMF wishes to extend its gratitude to the Turkish Ministry of Culture's Division of Monuments and Museums, the Turkish Democratic Foundation, and the Mayor's Offices of Kahta and Adiyaman, for helping to make possible the critical work completed on site during the 2002 work season.

Special thanks are due to those who made possible the missions of 2002 that resulted in the production of this document, in particular, the WMF Technical Team of Ms. A Elena Charola, Dr. Predrag Gavrilovic, Dr. Ing. Bernd Fitzner, Mr. Kurt Heinrichs, Mr. Dennis LaBoucardiere, and Mr. Paolo Pagnin, and to the Conservation Department at the Middle Eastern Technical University in Ankara.

The accomplishments made on site over the past several years would not have been possible without the hard work and advance planning by our colleagues at the International Nemrud Foundation, led by Mr. Maurice Crijns, and the University of Amsterdam's Archaeology Center, led by Prof. Dr. Herman A. G. Brijder, Director of the University of Amsterdam's Allard Pierson Museum and Prof. Dr. Eric Moormann.

Gratitude also goes to Arsan Travel in Gaziantep, the Hotel Kervansaray at Mt. Nemrud, and Cendere Travel who arranged for the mission's transportation and lodging needs.

WORLD MONUMENTS FUND - NEW YORK

NEMRUD DAG FINAL FIELD MISSION REPORT

JUNE/JULY 2002

INTRODUCTION

INTRODUCTION

The WMF-sponsored Nemrud Dag Pilot Project Field Missions of June and July 2002, were the culmination of a series of site visits and round table project planning sessions that began with a WMF reconnaissance mission to Nemrud Dag in August, 1999. The alarming conditions reported by the Turkish Ministry of Culture led to the successful nomination of the Mount Nemrud Archaeological Site to the *World Monuments Watch List® of 100 Most Endangered Site*s in 2000.

The immediate threats that secured the listing were the advanced stages of sandstone deterioration (stelae), the absence of a drainage system and the instability of the tumulus stones and statuary bases, uncontrolled tourist visitation around the fallen monuments, and a lack of a plan for stone conservation and site presentation. Nemrud Dag was previously inscribed on the World Heritage List in 1997.

In 2001, the International Nemrud Foundation (INF), a not-for-profit organization based in the Netherlands, was awarded a special concession from the Ministry of Culture of Turkey to research, stabilize, conserve, and present the Nemrud Dag site. The INF and its local partner, the Turkish Democracy Foundation, are responsible for the execution of work on site. INF has contracted the management of the Nemrud project to the University of Amsterdam's Archaeology Center. The project is supervised by the Turkish Ministry of Culture.

WMF INVOLVEMENT

The World Monuments Fund was invited by the Dutch team in 2000 to lead the stone conservation and structural consolidation programs required for the site. This role focused on developing the methods for documentation, diagnosis and conservation treatment as well as structural stabilization approaches to the limestone and sandstone monuments. WMF was also asked to assist with site presentation and the initiation of a long-term site management plan.

This development was coincided with generous financial assistance from the American Express Philanthropic Foundation and Akbank of Turkey for conservation planning and site stabilization work.

PLANNING THE PROJECT

Following Nemrud Dag's inclusion on the *Watch List,* two roundtable project planning sessions were held with the Turkish Ministry of Culture, Turkish Democracy Foundation TDV, INF, the University of Amsterdam, WMF and a team of invited international experts to outline a multi-year plan to conserve and stabilize the monuments.

ROUNDTABLE I

Nemrud Roundtable I was held at the Nemrud Dag site and in Adyaman, Turkey in August 2001. The 3-day conference concluded WMF's first technical mission to inspect the site by its

multi-disciplinary team of consultants. Stone conservation, repair methods, approaches to improving site presentation and protection, management and visitor reception facilities were among the many issues discussed by the participants. The findings and recommendations of the WMF team and conference proceedings were published in the report, *Nemrud Dag: World Monuments Fund® First Technical Mission, August 2001.*

ROUNDTABLE II

Nemrud Roundtable II, the final planning and consensus session for project activities was held in Amsterdam, November 2001. The meetings resulted in an Action Plan that included proposals for pilot projects for stone diagnosis, testing, and structural stabilization projects. The projects for conservation, structural consolidation work, and site management protection were developed by the INF/UofA, and WMF team and officially submitted by the University of Amsterdam to the Turkish Ministry of Culture in Ankara in December 2001 for review and approval for eventual implementation in the summer of 2002. The Turkish Government was represented by the Governor of Adiyaman, Mr. Halil Isik who later submitted his own report of the proceedings to the Ministry of Culture.

The Amsterdam meetings resulted in the report *Nemrud Dag: 2002 Pilot Project and Mobilization- Roundtable II: Final Planning and Consensus Session, November 2001.*

2002 FIELD MISSIONS: PILOT CONSERVATION AND MOBILIZATION PROJECT

The purpose of this Final Field Mission Report is to document and present the WMF technical team's field activities and recommendations resulting from two separate field missions to the site in June and July 2002. This document combines the previously published and circulated WMF field mission report entitled *Nemrud Dag: 2002 Pilot Conservation and Mobilization Project, June 3-14, 2002* and the report of the Structural Assessment and Consolidation Mission led by Dr. Prof. Predrag Gavrilovic, structural engineer and project consultant from the Institute of Earthquake Engineering and Seismology, Macedonia, in July 2002.

This report presents the full range of the WMF team's latest recommendations for priority work scopes and emergency interventions: continuation of stone diagnosis, stabilization and conservation of emergency conditions of sandstone stelae, and structural consolidation of the monumental statues and the supporting bases.

The collaborative WMF/INF/UofA team invited a team of Turkish conservators, geologists, and engineers from the Middle Eastern Technical University, Ankara to participate in the June 2002 field mission. The intention was to further the international collaborative project by including local counterpart experts that would participate in the diagnosis, laboratory testing, and treatment programs to be defined by the 2002 pilot conservation and structural consolidation projects. Additionally, their participation was critical to introducing the Nemrud Dag project to a wider professional audience in Turkey. Their executive summary and structural report (Appendix A) is included in this document.

CONCLUSION

As a result of the site stabilization work accomplished and the stone conservation diagnosis and treatment programs formulated during the 2002 Pilot Project Field Mission, the World Monuments Fund believes that the most urgent threats to the site have been removed. The advancements made over the course of the two-year project were instrumental in the removal of Nemrud Dag Archaeological Site from the *Watch List*. The World Monuments Fund is pleased to have been of assistance in moving the Nemrud Dag project to its present advanced stage of planning and has announced its official withdrawal from the project team.

WORLD MONUMENTS FUND - NEW YORK

NEMRUD DAG FINAL FIELD MISSION REPORT

JUNE 2002

FIELD MISSION I

JUNE 2002

WORLD MONUMENTS FUND - NEW YORK

NEMRUD DAG FINAL FIELD MISSION REPORT

JUNE 2002

1.1

MISSION OVERVIEW

BY MARK A. WEBER

1.1 MISSION OVERVIEW

The World Monuments Fund (WMF) mounted an expert mission to Nemrud Dag the first two weeks of June to initiate the mobilization phase of the proposed 2002 Pilot Project for the East and West terraces at Nemrud Dag, Kahta, Turkey. WMF was asked by the International Nemrud Foundation (INF) and the University of Amsterdam (UA) to assist with the determination of appropriate stone conservation and structural stabilization methods to help safeguard the World Heritage listed site.

The following report includes a review of the WMF consulting team's primary objectives and an overview of the mission's accomplishments and activities during the week of June 3rd, and field report executive summaries from the WMF stone conservation and structural team leaders. An expanded report by WMF Stone Conservation team leader A. Elena Charola and Paolo Pagnin detailing the activities of the stone conservators and other site issues follows the WMF consulting team executive summaries.

Also included are reports from the Turkish Team from Middle Eastern Technical University, Ankara, lead by Dr. Emine Caner-Saltik. They were invited by WMF/INF to assemble a team of conservation experts to collaborate in the survey and testing program activities planned for the June mission.

The 2002 June WMF field mission to Nemrud Dag was made possible through the generous support of American Express and Akbank.

IN ATTENDANCE

World Monuments Fund Team:

Mark A. Weber, WMF Technical Director and Team Leader
A. Elena Charola, Stone Conservator and Chemist, WMF consultant
Paolo Pagnin, Stone Conservator, WMF consultant
Dr. Predrag Gavrilovic, Structural engineer, WMF Consultant
Dr. Bernd Fitzner, Geologist and Director of Geological Institute of the RWTH, Aachen, Germany, WMF consultant
Mr. Kurt Heinrichs, Geologist, Aachen
Mr. Dennis La Bouchardiere, Geologist, Aachen

InternationalNemrud Foundation/University of Amsterdam Team:

Dr. Eric Moorman, University of Amsterdam and Nemrud Dag Site Team Leader
Maurice Crijns, Architect, International Nemrud Foundation (INF)
Jaap Groot, Structural Engineer, INF
Anne ten Brink, Secretary, INF
Ellen Thiermann, Archaeologist, INF
Tesse Stek, Archaeologist, INF
Omer Yorukoglu, Structural Engineer, Erdine, Turkey

Turkish Team, Middle Eastern Technical University (METU), Ankara:

Dr. Emine Caner-Saltik, Conservation Scientist, Director of Materials Conservation Laboratory, METU, Ankara
Dr. Ayse Tavukcuoglu, Conservation Architect
Evin Erder, MSc, Conservator
Dr. Tamer Topal, Geological Engineer
Dr. Ahmet Turer, Structural Engineer

Turkish Ministry of Culture:

Latif Ozen, Chemist and Conservator
Soner Atesogullari, Archaeologist

The project manager from the INF/ UA team was present at the site each day, and were in charge of all general site activity, daily plenary team meetings, transportation logistics and were in direct communication with the Ministry of Culture's representatives on site and in Ankara.

The Ministry of Culture's representatives, or *Commissars,* are responsible for reviewing the proposed work program and overseeing any work on the World Heritage site of Nemrud Dag.

MISSION OBJECTIVES

Initiation of the Pilot Testing, Conservation and Mobilization Project

The original objectives of the WMF June 2002 mission were to initiate the following activities proposed by the World *Monuments* Fund in their report, *2002 Pilot Project and Mobilization – Round Table II Final Planning and Consensus Session, November, 2001*:

- To begin the materials stone conditions survey and conservation testing program,
- To continue the structural engineering assessment, documentation and preparation of plans for the stabilization of the east and west terrace statuary platforms,
- To determine the feasibility of a materials testing program, both in the field and laboratory, to be developed by the WMF team and Turkish conservators at Middle Eastern Technical University, Ankara.
- To investigate and test a number of site mobilization issues including at least 2 different stone lifting/ handling techniques for the purpose of stabilizing dislocated stone blocks from the East terrace statues, consolidating the Eagle statue's base platform and re-assembling its upper level blocks.

The WMF team presented its proposed methodologies and recommendations for the work objectives listed above and submitted a proposal for field mission activities (*2002 Pilot Stone and Structural Conservation Program)* to the University of Amsterdam in December 2001. The WMF proposal was then included in an application for a site work permit by the University of Amsterdam and submitted to the Turkish Ministry of Culture.

OVERVIEW OF MISSION ACTIVITIES

All work proposed by WMF for the pilot conservation and structural work program were predicated on establishing the following preliminary survey activities which began or were continued during the first week of the June 2002 mission:

- Condition surveys of sandstone and limestone sculptural elements and corresponding documentation to determine the extent of the required conservation intervention. Comparisons of photographs taken in 1988 of sandstone and limestone were compared to present conditions that revealed an alarming rate of stone deterioration, particularly at the sandstone stelae.
- Non-destructive ultrasonic measurements of sandstone stelae and limestone statuary blocks were made to determine the presence and extent of interior cracking and micro-fissures.
- Material samples (limestone and sandstone) were selected or recommended for use in both *in-situ* and laboratory testing. However, field testing of ethyl silicate based consolidants was restricted because of the absence of Dr. Eberhard Wendler (health reasons).
- The extent of recommended stone conservation interventions were proposed, e.g. the degree to which microfissures should be filled.
- Continuation of the structural field survey of East terrace statues and base platforms, portions of the West terrace and other urgent structural conditions that would require immediate intervention. This work is to be incorporated into a comprehensive structural survey plan.

NEW CONDITIONS AND OPEN ISSUES

The World Monuments Fund's team was forced to alter its original field mission schedule of activities due to the new emergency conditions found on the West terrace. As a result of heavy snow accumulations this past winter, two of the five tuffite (sandstone) stelae were knocked over. The sandstone slabs fell with their *bas-relief* surfaces forward onto piles of snow that effectively softened their fall and reduced greater damage. The WMF team found them precariously supported off the ground with rocks, yet dangerously exposed to tourist traffic. Under the supervision of the Ministry of Culture's *Commissars,* and WMF's structural engineer, the WMF team and Mr. Omer Yorukoglu roped off the area and added supporting timber posts on Day 2 of the mission.

Due to the new emergency situation and the need to thoroughly brief the Ministry's Commissars on the pilot project's priority work scope, the INF requested the WMF team to prepare an updated conservation and structural assessment with recommendations for the East and West terraces. The purpose of these reports was to reevaluate and update all urgent conditions. These reports (included in this Mission Report) were prepared at the INF site office at the Hotel Kervansary on 6 June, submitted to INF and Ministry's Commissars and sent to the Ministry of Culture in Ankara.

It was agreed by all present that planning for the stabilization and protection of the West terrace stelae should take priority over all other work at the site.

Note

WMF's recommendations for the fallen West terrace stelae were not originally included in the current WMF/INF 2002 work program and were developed on-site to assist Turkish authorities with their further review, plan refinement and eventual stabilization and protection of the stelae.

At the start of the mission, WMF learned that the Ministry of Culture had dispatched two representatives to review the INF/WMF proposed pilot program in detail. They were given a full tour of the site and briefed by WMF and INF team leaders on all aspects and details of the project. They were given copies of the WMF *2002 Pilot Project and Mobilization Report* and the University of Amsterdam's 2001 application to the Ministry of Culture for site work.

STONE TRANSPORTING AND HOISTING TECHNIQUES

Upon arrival at the site and after discussions with the INF, the WMF team learned that due to the time constraints of the 8 week work period, only an 80-ton autocrane was being considered for the lifting and handling of the stone blocks. No provisions were made or materials purchased in advance to construct a traditional hoisting mechanism as was originally recommended by WMF.

WMF and INF agreed to present to the Ministry of Culture a pilot project that would stabilize dangerously dislodged statue blocks from the East statues, rehabilitate the damaged tumulus retaining walls and test a small re-assembly project (the Eagle statue) with tests of two or more stone lifting/handling techniques.

The autocrane was not at the site at the time of the mission, but its possible use and impact on the site was the subject of debate by the team members. Its utility in "transporting" fallen and dislodged stones was understood and merits further consideration, but it was widely agreed that only traditional hoisting techniques are appropriate and safe for lifting and hoisting the more fragile tuffite stelae and statue blocks.

The use of the crane and other hoisting techniques are now under review by the Ministry of Culture.

Comments on the use of the autocrane, recommendations for hoisting techniques and other related considerations are made in both the WMF and Turkish team structural reports.

Observations recorded by the collective team members during this mission and included in their enclosed reports underscore the necessity of carefully designing an integrated conservation program for Nemrud Dag from all the multidisciplinary requirements of conservation, architecture, structural engineering, archaeology, and site management and presentation.

WORLD MONUMENTS FUND - NEW YORK

NEMRUD DAG FINAL FIELD MISSION REPORT

JUNE 2002

1.2

WMF TEAM FIELD REPORT
EXECUTIVE SUMMARIES

WORLD MONUMENTS FUND - NEW YORK

NEMRUD DAG FINAL FIELD MISSION REPORT

JUNE 2002

1.2

WMF TEAM FIELD REPORT EXECUTIVE SUMMARY STONE CONSERVATION

BY A. ELENA CHAROLA & PAOLO PAGNIN

1.2 EXECUTIVE SUMMARY – A. CHAROLA AND P. PAGNIN

1. SCOPE

The scope of the mission was changed from the original proposal for three reasons:

- The emergency situation created by the toppling of two of the five standing stelae on the West Terrace;
- That Dr. Eberhard Wendler had to cancel his trip in the last minute for medical reasons;
- That materials shipped to Turkey were held at Customs and only released by Monday June 10th. The resin provided by Dr. Wendler was sent to Dr. Çaner-Saltik at the Architectural Laboratory of the METU for future tests.

2. ISSUES

During the first week, recommendations for the actual work to be carried out during this mission were drafted. These highlighted the need for:

- Presenting the stelae in a more stable form (on 30°-45°angled racks) both for the toppled and the remaining three standing stelae of the West Terrace;
- Using the proposed crane exclusively for the stabilization of the foundations and bases of the East Terrace statues, as well as the removal of the precariously positioned stone block on the Commagene statue on this same terrace.

The limestone sculpture blocks were examined in more detail to determine their state of conservation.

3. OBSERVATION AND CONCERNS

Following a more detailed observation of the limestone sculpture blocks, and in conjunction with the ultrasound examination of some of them by Prof. Fitzner and his team suggesting that the stone is far more deteriorated by interior cracking than is evident through visual examination, serious concerns about the possibility of using these blocks to re-erect the original sculptures are raised. In particular if pinning is considered and considering the earthquake probability of the site. This implies that prior to any re-erection attempt, each and every single block needs to be carefully and thoroughly examined with several non-destructive techniques to determine its condition.

The above information suggests that water is slowly deteriorating the bases of the blocks standing on the ground. Therefore, re-erection could be considered as a conservation alternative (only to the height that will not result in toppling during an earthquake) but then other considerations need to be taken into account, such as the fact that the contact between the blocks is not the same as it originally was. From a conservation point of view, a thin mortar layer would be required to regain uniform load distribution, but this would no longer qualify as an anastylosis.

The weight of the crane that was brought to the site requires a more solid road than originally considered. Construction of such a road has various implications—such as facilitating vandalism and theft—as well as its impact on the eventual presentation of the site and needs to be considered in detail prior to its implementation.

Apart from the five stelae of the Western terrace discussed in point 2.a, there are other stelae at this and the other terraces that also need to be presented in a more stable and less damaging form. This issue needs to be addressed and requires that the overall presentation of the site be considered.

It is important that winter sheltering be provided for all stone materials: both tuffite/sandstone stelae and limestone sculpture blocks. Development of emergency sheltering is necessary as well as considerations for long-term preservation of these sculptures and stelae, which might include the removal of some to a Museum (or eventual site Museum).

The flow of water and melted snow along and under the foundations of the statue rows should be studied to ensure that this does not contribute to the undercutting of these structures.

MISCELLANEOUS

Field Testing

During the two weeks the following activities were carried out:

- Preliminary roping-off of the toppled stelae on the West Terrace to prevent visitors from getting near or crawling under them.
- Consolidation tests using ethyl silicate were made on some tuffite stone samples and left on site for weathering and future laboratory studies.
- In the absence of Turkish conservators, two members of the Dutch team, Ms. Ellen Thiermann and Mr. Tesse Stek, were trained to:

    i) drill and epoxy set pins;
    ii) apply preventive conservation measures on stelae surfaces using Japanese paper and an acrylic resin; and;
    iii) mix hydraulic mortars of different texture and colors.

The site testing as outlined in the original program for this mission—in particular for the evaluation of the consolidation and filling of the voids in the stelae—will have to be carried out in a future mission. This should be complemented with the condition survey of each and every limestone sculpture block.

Laboratory Testing

Laboratory evaluaton of the few field tests carried out will be necessary. Furthermore, consideration should be given as to possible consolidation methods for the limestone sculpture blocks.

4. RECOMMENDATIONS

It is recommended that:

- The required field tests and laboratory studies should be completed.
- The stone samples and the silicate ester sample should be sent to Dr. Fitzner in Germany and the METU laboratory, respectively.
- Traditional hoisting materials should be readily available on site during work seasons.
- The racks for the presentation of the stelae, particularly the two toppled and the three standing ones, should be completed as soon as possible.
- Turkish conservators should be trained in the practical consolidation of stone, in particular the tuffite/sandstone stelae.
- Winter protection for both stelae and sculpture blocks has to be designed and implemented, starting with that of the five stelae moved to the eventual racks.
- The presentation of the terraces as appropriate for a World Heritage Site should be first defined within a cultural framework. Only then can the most appropriate technical solutions to the posed problems be found.

WORLD MONUMENTS FUND - NEW YORK

NEMRUD DAG FINAL FIELD MISSION REPORT

JUNE 2002

1.2

WMF TEAM FIELD REPORT EXECUTIVE SUMMARY STONE DIAGNOSIS AND CLASSIFICATION

BY DR.-ING BERND FITZNER

1.2 EXECUTIVE SUMMARY – B. FITZNER

In 1988 the Aachen working group "Natural stones and weathering" carried out the first studies on the Nemrud monuments. Preliminary results on the types of stone and their states of deterioration were presented in:

FITZNER, B. & DÜPPENBECKER, V. (1991): Gesteinseigenschaften und Verwitterungszustand der Monumente auf dem Nemrud Dag.- Begleitheft zur Sonderausstellung „Nemrud Dag – Neue Methoden der Archäologie" des Westfälischen Museums für Archäologie und des Westfälischen Museumsamtes Münster, 39-45, 62-72, Bönen, Westfalen.

Information and documents obtained from these first studies in 1988 were compiled as the basis for the 2002 field campaign. The studies in the framework of the 2002 field campaign focussed mainly on the sandstones used at the Nemrud monuments. Detailed studies on the limestones are proposed for the 2003 field campaign. However, at the request of the project management, preliminary studies on limestone statues were already carried out during the 2002 field campaign.

ACTIVITIES IN THE FRAMEWORK OF THE FIELD CAMPAIGN 2002

Studies on Sandstones

- Survey on variability of the sandstones;
- Sampling (6 blocks, additionally 1 limestone sample), transportation to Aachen organized by the project management, the samples will also be used by the Conservation Team;
- Survey, photodocumentation and systematic classification of weathering forms/ deterioration phenomena according to types and intensities - stelae, sculptures, blocks on western terrace, northern terrace and eastern terrace;
- Comparison of visible weathering damage 1988/2002 - stelae, sculptures, blocks on western terrace, northern terrace and eastern terrace;
- Monument mapping – detailed registration and documentation of weathering forms on:

  (i) Lion horoscope, western terrace
  (ii) Antiochos – Apollo – Stela, western terrace
  (iii) Antiochos – Herakles – Stela, western terrace
  (iv) Xerxes (?) – Stela, western terrace

- Non-destructive ultrasonic measurements for the characterization of the sandstones, the quantification of their state of deterioration and the detection of non-visible damage on:

  (i) Lion horoscope
  (ii) Antiochos – Apollo – Stela

Preliminary Studies on Limestones

- First sampling (1 block)
- First survey and photodocumentation of weathering forms
- Mapping of weathering forms on head of the eagle (intended for anastylosis), eastern terrace
- Pilot ultrasonic measurements on:

(i) Head of Antiochos, western terrace
(ii) Head of Herakles, western terrace
(iii) Head of Zeus, western terrace
(iv) Head of Kommagene, western terrace

- Detailed ultrasonic measurements on:

  (i) Head of Apollo, western terrace
  (ii) Head of the eagle (intended for anastylosis), eastern terrace

Preliminary result: Compared to results of first few test measurements on several heads of the limestone statues by means of the ultrasonic method, the ultrasonic velocities determined for the head of the eagle are quite low, especially at the lower parts of the head. This appears to be the result of a dense net of microcracks and the visible crumbly disintegration resulting from that.

Participation in the Interdisciplinary Discussion of Preservation Measures for the Nemrud Monuments

FUTURE ACTIVITIES 2002/2003

Evaluation of all Information from the *In Situ* Investigation 2002

- Photodocumentation;
- Development of a classification scheme of weathering forms for the sandstones;
- Maps of weathering forms including quantitative evaluation of the weathering forms;
- Rating of weathering damage by means of damage categories and damage indices;
- Comparison of weathering damage 1988 / 2002. Rating of weathering progression;
- Evaluation of the ultrasonic measurements, isoline-illustration in maps. Comparison with results obtained from measurements made in 1988;
- Starting of various laboratory studies on stone properties (esp. sandstones);
- Initiation of laboratory studies on treated stone materials in cooperation with the Conservation Team.

Preparation of the Field Campaign 2003

WORLD MONUMENTS FUND - NEW YORK

NEMRUD DAG FINAL FIELD MISSION REPORT

JUNE 2002

1.2

WMF TEAM FIELD REPORT EXECUTIVE SUMMARY STRUCTURAL CONSOLIDATION

BY PREDRAG GAVRILOVIC

1.2 EXECUTIVE SUMMARY – P. GAVRILOVIC

1. SCOPE

The main scope of work concerning the structural aspects of the Nemrud Dagi sculptures was a realization of the "Proposal for Structural Conservation Program for 2002 WMF/INF Nemrud Pilot Project." (Nemrud Dag - 2002 Pilot Project and Mobilization - Round Table II - Final Planning and Consensus Session; November 2001. Presented in the pages vii-x).

From the aspect of structural conservation, the Program of Activities is divided into two parts:

- Emergency Program Activities
- Pilot Project - East Terrace: Eagle and Lion North Side

Taking into account the existing state of the integral monument regarding its stability and to prevent further failure of certain parts or complexes, priority has been given to emergency activities. The collapse of the stelae on the west terrace in the 2001-2002 season is a warning that these activities are necessary.

Emergency Program Activities

Based on the inspection of the site, the emergency program activities involve the following:

1. East Terrace

    - Stabilization of bedrock below the Apollo statue
    - Stabilization of bedrock below the Zeus statue
    - Temporary stabilization of the Antiochus statue
    - Removal of broken stone from the shoulder of the Tyche statue

2. West Terrace

    - Protection and stabilization of stelae on the west terrace

Pilot project - East Terrace: Eagle and Lion - North Side

According to the Work Plan, the following activities have been considered:

- Stabilization of bedrock
- Base consolidation of lion and eagle
- Re-erection of eagle

In the process of consolidating and rebuilding part of the platform, repair and/or strengthening techniques should be applied to the stone blocks. These techniques will utilize strengthening technology with materials such as stainless steel, hydraulic mortar and, if needed in specific cases, epoxy resin and mortar.

2. ISSUES

On the last day of the mission, the INF and the members of the Turkish team from the Ministry of Culture requested a proposal for protecting of the stelae by dismantling and removing them to a location in the vicinity of their existing position. A procedure has been proposed involving placement of the stelae on a timber base with steel frames. The stelae would be lifted and transported by local transport systems, and a portable chain crane.

The goal at the outset of the mission was to thoroughly comprehend the issues involved at Nemrud Dagi prior to initiating work. From the aspect of structural stabilization, there was no reason to deviate from the Emergency Program since there were no contradictory attitudes.
In the second part of the activities – the Pilot project at the East Terrace, and the Eagle and Lion East Side – disagreements arose within the conservation team concerning two issues:

- Previously applied conservation solutions;
- The use of cranes on the site.

3. OBSERVATIONS AND CONCERNS

All of the planned emergency measures have been informed by the general assessment of the conditions and conservation activities at the site; however, these measures might be reconsidered during the actual work.

Structural consolidation, repair, strengthening and rebuilding should be done with due respect for the conservation aspects that should be clearly and professionally defined. From a structural perspective, there are no serious problems that could not be solved during the course of work.

Seismic structural stability of the monuments should be taken into account according to maximum expected ground acceleration in the region and defined criteria of stability and safety. This type of study and analysis should taken into consideration for all details, but particularly in the case of rebuilding parts and anastylosis. Experimental investigation and testing will be highly appreciated and will be welcome especially in the later phase of the project, but they are not "conditionally necessary". Analytical modeling, as well as appropriate calculation and design should provide enough safety.

The slopes of the tumulus, built by placing stone rubble on top of the mountain rocks, are unstable and should be considered as a separate part of the project and studied in detail.

4. OTHER: USE OF THE CRANE OF RELATED CONSIDERATIONS

The use of cranes in conserving historic monuments is increasing throughout the world. At Nemrud, the crane shall be used for "transport", while lifting or hoisting is to be done in the traditional way and with traditional materials, which are less likely to cause further damage.
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.

Finally, 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. This influence can be measured using appropriate equipment for so-called "Ambient vibration tests."

5. Recommendations

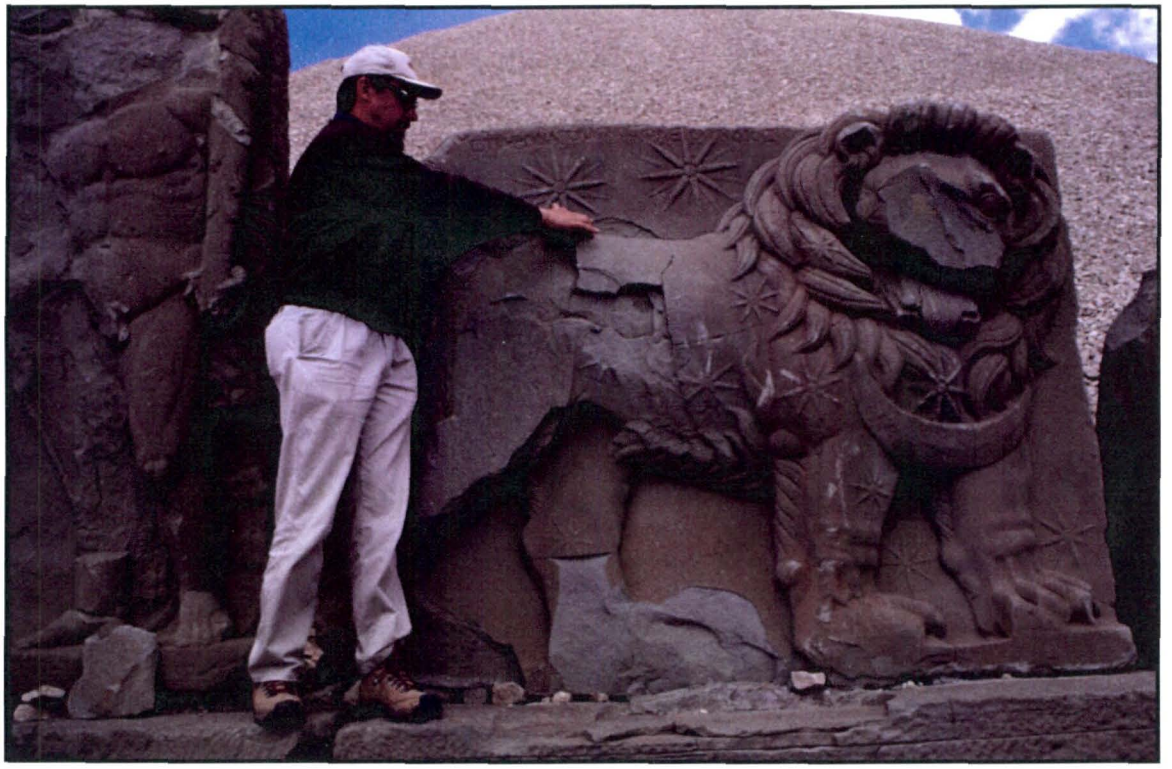
Based on the previous experiences at the site, as well as the complexity of the multi-disciplinary aspects to the project, my recommendations are as follows

- Clearly define the long-term program as well as short-term project activities for next year.
- Prepare "Project Designs" for each aspect of the conservation activities in the form of "Project Documents," which can be circulated among the participants before being submitted for review and approval.
- Expand the working session to June through September.

WORLD MONUMENTS FUND - NEW YORK

NEMRUD DAG FINAL FIELD MISSION REPORT

JUNE 2002



1.3

EXPANDED MISSION REPORT
STONE CONSERVATION

BY A. ELENA CHAROLA & PAOLO PAGNIN

1.3 EXPANDED MISSION REPORT

EXECUTIVE SUMMARY

The program mission could not be accomplished as anticipated for two reasons. The first is that the materials shipped to Turkey were held at Customs and were only released by Monday 10th. The second is that Dr. Eberhard Wendler had to cancel his trip in the last minute for medical reasons. Furthermore, upon arrival to the site, it was seen that two of the five standing stelae on the West Terrace had toppled over during this past winter and had been precariously propped up leaving an emergency situation that had to be addressed immediately. The area around these was roped off during the first week to prevent visitors from crawling underneath the propped up toppled stelae.

Also during the first week, a revision of the site testing program was made and recommendations for the actual work to be carried out during this mission were drafted. These highlight the need for a more stable presentation of the stelae (both the remaining three standing stelae as well as the two toppled ones) on a rack at a 30°-45° angle, and the use of the crane exclusively for the stabilization of the foundations and bases of the East Terrace statues as well as the removal of the precariously positioned stone block on the Commagene statue.

A better visual evaluation of the limestone blocks was made—in view of the considered re-erection of the eagle statue on the north side of the East terrace—and this was complemented by ultrasound measurements carried out by Dr. Fitzner and his team. From the results of both, it appears that the limestone blocks may not be as solid as considered. Especially the base of the eagle head was found to have a high density of microcracks. These may pose a threat to the integrity of this block, especially if the reconstruction of the eagle requires insertion pins and taking future possible earthquakes into account.

During the second week—in the absence of Turkish conservators—two members of the Dutch team were trained in the application of preventive conservation treatments to the surface of the delaminating tuffite stelae and in basic operations, such as drilling and epoxy-setting of pins and mixing of hydraulic mortars, as required for the stabilization of the foundations of the sculptures in the East Terrace. However, it is recommended that they should only perform these operations under supervision of more experience personnel.

Several recommendations are given with regards to the long-term preservation of the site. The most important highlights the fact that the presentation of the terraces as appropriate for a World Heritage Site needs to be defined first within a cultural framework Only then can the most appropriate technical solutions to the posed problems be found.

1. WEST TERRACE

Sandstone/ Tuffite Stelae

Upon arrival to Nemrud Dag it was learnt that two of the five standing stelae had toppled over during this past winter. Once on site, we saw that they had been precariously propped up in a horizontal position, with the carving face down. This situation called for immediate action since

the bas-relief carvings are delaminating, following the natural bedding planes of this sandstone/tuffite stone. This situation was discussed during the first general meeting held in the evening of Monday, June 3rd.

The problem of these stone stelae can be traced to their original positioning on site. Firstly, they are set with their bedding planes in a vertical position, allowing rainwater and snow to percolate easily along bedding planes and enhancing delamination of the stone. Secondly, they are set with a tenon-and-mortise system, where the tongue is relatively narrow with regards to the width of the stelae and not very deep. Furthermore, the resin used (most likely an epoxy or polyester resin) was not the most adequate and/or was poorly applied resulting in weak adhesion to the stone. The pins used were not uniform with regards to material, some were in stainless steel, others in common steel, and were to smooth to allow good adhesion at the metal-resin-stone interface resulting in the poor performance observed under stress. Therefore, any movement or pressure applied to the stelae, such as an earthquake or snow piling up in winter, will tend to topple the stelae and break the tongue off. This has already occurred to some of the stelae, i.e., the lion horoscope one, and this was then re-set with concrete, and in the case of this particular stele, without consideration of the pressure points that could develop along the base—the lower edge is not that perfectly flat—thus inducing cracks into the stele. The stelae were re-set into position during the first archaeological missions, and since then, they have been routinely re-set each time they have toppled. This has increased significantly to their overall deterioration and can be evaluated with regards to the state of conservation of those stelae that have been left lying, or propped at an angle on this same terrace.

It was therefore recommended that as a first emergency measure, these five stelae be set on appropriate racks at a 30°-45° angle. The back of these stelae require a uniform support, otherwise, the delamination will be enhanced by creep phenomena, as has been observed in the lower part of those stelae along the north terrace that have been propped only at the ends, leaving the center to buckle downwards by its own weight. Furthermore, it is important to develop as soon as possible some winter protection that will keep the snow off these stones. This could be accomplished with watertight case custom made for each stele, but these need to be designed and constructed. As an alternative, and to assure future preservation, their re-location to a museum, if possible to a site-museum to be constructed where the trailers sit near the East Terrace, should also be considered.

As a first emergency intervention, the immediate area around the toppled stelae was roped off to prevent visitors from crawling under them—they did so to look at the carvings or sometimes just as a protection against wind and sun—with total disregard of their precarious support, with a wooden beam or only some rocks piled up underneath them. Furthermore, some more wooden beams were installed to stabilize them. It was recommended that once the supports were constructed, the stelae be moved with traditional systems unto these racks. All stelae are in a poor state of conservation, with the carved surface delaminating to a large extent. Those that are now in the facedown position may lose some flakes from the surface. It would be important to have a conservator present at the time this manoeuvre takes place to ensure that all fragments that fall off are recovered and re-attached immediately, even if only with some temporary adhesive. The stelae that are standing have been protected by applying strips of Japanese paper or cotton gauze attached to the stone using an acrylic resin water emulsion (Primal AC 33 at 80%). The resin has been applied exclusively on to the strips, and these were positioned only on the areas that showed maximum detachment to reduce the risk of loss during the eventual moving. This emergency intervention must be controlled and eventually substituted during the next mission or once the stelae are repositioned. It is to be noted that the strips and the resin can be removed using water vapor or hot water.

Apollo Head

The head of the Apollo statue showed a wide crack that was of concern and that had been scheduled for filling during this mission. The nature of the limestone and its weathering of a micro-karst type is based on its dissolution and re-deposition. Hence, the stone presents many fractures, fissures and cracks, which may not be very deep and that may, over time, also be filled by re-deposited calcite. In the specific case of the Apollo head, the crack is fairly wide at the surface and appears to go slightly parallel to it. However, its depth cannot be gauged by means of a visual examination. As Prof. Fitzner and his team had an ultrasound measuring device, he examined the head and it was determined that the crack went far deeper than had been considered. Therefore, the intended conservation measure—filling with a simple hydraulic mortar—needs to be reassessed and the intervention was postponed until the full data, analysis and interpretation to be carried out by Prof. Fitzner is available.

2. East Terrace

Eagle Statue

The pieces of the eagle statue that are standing on the east terrace: head, two pieces of the breast and wings, the back part of the statue, were carefully re-examined in view of their possible re-erection. Although the limestone is in principle a sound, good quality stone, it may exhibit deep cracks not visible from the exterior as discussed for the case of the Apollo head. Prof. Fitzner and his team were asked to examine as a first measure these sculpture pieces with ultrasound. It was found that the head block showed lower ultrasound velocities than other preliminary measurements on other statue heads. In particular, the lower part of the eagle head showed lower velocities indicating the presence of a dense net of microcracks and the visible crumbly disintegration resulting from that. This could be attributed to the fact that water will remain trapped below the base of the head for a longer time. These results suggest that the re-erection of the eagle statue should be reconsidered, especially if pinning of the head is required to stabilize it. During the discussions held on site, six metal or glass fiber pins were considered to prevent the head from moving during an earthquake. However, given the poor condition of the lower part of this block, rather than moving the block may shatter under the influence of an earthquake.

Other concerns regarding the re-erection of the eagle statue are the fact that the surfaces that will be in contact with each other, have weathered and are no longer smooth, so that some material to relieve point stresses between the contact surfaces may be required, such as lead sheeting, a mortar mix or even a rubber-like material to prevent movement during earthquakes. However, if such materials are used, the re-erection will not follow the original dry-laid construction. Finally, the concern regarding the possibility of the head of the statue falling off during an earthquake was also discussed. This may require an even more intrusive intervention, such as the installation of pins—four to six pins were considered—since the original statue did not have a peg-and socket joint as some of the larger statues have.

In Situ Testing

Field tests were severely restricted because of the absence of Dr. Wendler and the fact that the testing materials were held by customs until June 10th. Nonetheless, some tuffite stone samples were treated with Funcosil KSE 500 E and Funcosil 300 E (both products are based on ethyl silicate). The samples were treated from one side only to determine the effective product penetration. The samples have been left on site, position on the roof of the site guards.

During the second week—in the absence of Turkish conservators—two members of the Dutch team, Ms. Ellen Thiermann and Mr. Tesse Stek, were trained to:

- Apply preventive conservation treatments to the surface of the delaminating tuffite stelae with Japanese paper strips and an acrylic resin;
- Drill and epoxy-set pins, as required for the stabilization of the foundations of the sculptures in the East Terrace. However, it is recommended that they should only perform these operations under supervision of more experience personnel;
- Mix hydraulic mortars of different texture and colors, as required for the stabilization of the foundations of the sculptures in the East Terrace.

However, it is recommended that they should only perform these operations under supervision of more experience personnel.

Condition Survey of the Statues

The documentation program carried out by Prof. Fitzner and his team focused primarily on the sandstone/tuffite stelae, and only incidentally on the statue pieces. It is fundamental that a thorough condition survey be carried out on each piece of limestone statue. This should include also such non-destructive testing (NDT) as ultrasound velocity measurement, thermography, surface temperature, moisture readings. In preparation of this, the Turkish team, in particular Evin Erder and Ayse Tavukçuoglu, installed some temperature and humidity recording devices to be able to monitor the local climate close to the statues.

It is recommended that they eventually complete the condition survey of all the statue pieces, both those in their original positions and those that are sitting on the terraces. For this purpose, copies of the photogrammetry of these pieces carried out by the Dutch team in 2001 will be required.

Laboratory Studies

The stone group discussed the eventual studies that need to be completed before any conservation intervention can be carried out. In the first place, the identification of the quarry site, both for the sandstone/tuffite and the limestone is fundamental, since extra stones are required for treatment testing and evaluation.

The development of appropriate mortars, both for the sandstone (based on silicate ester mortars) and for the limestone (based on pozzolanic lime mortars) needs to be carried out. The first, are to be developed in collaboration with Dr. Eberhard Wendler and Paolo Pagnin, while the second will be tested by the staff at the Middle East Technical University (METU). Since

some tests may require the use of instrumentation available in other departments of the University, or of equipment to be rented for use on site, some funding will be required. As graduate students will be needed to carry many out these tests, funding for them will also be required. The Turkish team will prepare a program description and budget.

Further tests consider the evaluation of surfactants for the sandstone/tuffite (Dr. Wendler & Dr. Fitzner).

Finally, the documentation, study and evaluation proposed by Dr. Fitzner and his team has first priority in funding so that is may be completed as soon as possible.

3. Considerations and Recommendations

- The required field tests and laboratory studies should be continued. For this purpose it must be ensured that the stone samples selected by Prof. Fitzner and the consolidant (provided by Dr. Wendler) should be actually sent to Prof. Fitzner in Germany and to the METU laboratory, respectively.
- During the working seasons, traditional hoisting materials should be readily available on site so that they can be used at any moment.
- The flow of water and melted snow along and under the foundations of the statues should be studied since the flowing water may help in undercutting and eroding these structures.
- It is fundamental that the long-term preservation of the site be considered. For this purpose the following points need to be considered:

Road Construction to the Site

The weight of the crane brought to the site requires a more solid road than originally considered. Construction of such a road has implications for the eventual presentation of the site and needs to be considered in all details prior to its implementation such as:

- The road would permit direct access of motorized vehicles to the site facilitating vandalism and theft of archaeological materials.
- It is recommended that if such a road is to be constructed this should only take place once the decision was taken on any other required construction, i.e., that of the site museum, so as to make full use of the road.
- It is furthermore recommended that the road be removed once the works have been completed, so as to avoid the above outlined problems.

Sandstone/ Tuffite Stelae

The presentation of all stelae (not only the five discussed in this report) should be considered. For their long-term preservation the following points need to be taken into account:

- Emergency as well as long term winter protection of these stelae must be developed.

- The possibility of locating some (or the most important) of these stelae in a Museum should be considered since long term preservation of these sculptures can best be achieved in a museum environment.
- For this purpose, the construction of a site museum should also be contemplated.
- It would be important that Turkish conservators be trained in the consolidation of these stelae, particularly if some are to remain on site, so that regular interventions can be done as needed in the future.

Limestone Blocks

The presentation of the statue blocks lying on the terraces must be discussed. Several points need to be considered:

- The contact of the blocks with the ground extends the time that water can enter these blocks resulting in their deterioration, as exemplified by the lower part of the eagle head on the East Terrace).
- A solution could be a partial re-construction (for those elements in a sufficiently good state of conservation to allow this intervention) of the statues to a height where earthquake intensity would not dislodge the remounted elements.
- This solution however poses other problems such as the fact that the surfaces of the blocks that will be in contact with each other, have weathered and are no longer smooth, so that some material to relieve point stresses between the contact surfaces may be required, such as lead sheeting, a mortar mix or even a rubber-like material to prevent movement during earthquakes. This however, can no longer be considered an anastylosis although it would help the preservation of the blocks.
- In this case it is critical to identify the original limestone quarry, or one of compatible stone to be used for any needed integration.
- And a qualified stonecutter who can prepare the necessary pieces has to be identified.
- Other points that would need to be addressed are: the surface finish that these new pieces would require; the use of this intervention as a didactic tool to train Turkish conservators and/or local people.
- Another and/or complementary solution would be setting up the remaining pieces on appropriate (wooden?) bases to diminish to a minimum the contact with water.
- Long term winter protection for these latter blocks should also be considered.
- This raises the question, particularly for the West terrace, how this site is to be presented, since the statue row can be considered an archaeological ruin and, according to the Charter of Venice, should be kept as such implementing only conservation and protection measures.

A maintenance program, site development and site management plans as well as tourist information and visiting programs should be developed.

A conservation intervention is a cultural intervention with technical implications. Hence the cultural approach to the presentation of the terraces as appropriate for a World Heritage Site needs to be defined first to allow determining the most suitable technical solutions to ensure the long-term preservation of the site.

ACTIVITIES SCHEDULE

Saturday, June 1st	Arrival in Istanbul.
Sunday, June 2nd	Travel Istanbul-Gaziantep and to Hotel Kervanseray.
Monday, June 3rd	Site visit and program discussion with stone group. General meeting at hotel.
Tuesday, June 4th	Site visit and general meeting in the evening.
Wednesday, June 5th	Site visit with Commissars from Ministry of Culture. Redefinition of Work Program and preparation of recommendations document.
Thursday, June 6th	Site visit, safety fence installation for fallen stelae on East Terrace and visit to sandstone/tuffite quarry.
Friday, June 7th	Finalizing recommendations document. Departure of A.E.Ch. to Gaziantep and Istanbul.
Saturday, June 8th	Departure for the US (A.E.Ch.). Site visit (PP).
Sunday, June 9th	Day off (PP's Birthday)
Monday, June 10th	Arrival of materials. Training of Dutch team members in preventive conservation methods.
Tuesday, June 11th	Trip to town to buy materials and drill.
Wednesday, June 12th	Training cont'd.
Thursday, June 13	Consolidation with ethyl silicate of some stone samples and training on mortar preparation.
Friday, June 14th	Preparation of a report on site activities and departure to Gaziantep (PP)

WORLD MONUMENTS FUND - NEW YORK

NEMRUD DAG FINAL FIELD MISSION REPORT

JUNE 2002

1.4

TURKISH TEAM/METU FIELD REPORT

BY DR. EMINE CANER-SALTIK,
DR. TAMAR TOPAL, DR. AHMET TURER,
DR. AYSE TAVUKCUOGHU, EVIN ERDER

1.4 TURKISH TEAM/METU FIELD REPORT EXECUTIVE SUMMARY

1. SCOPE

The Turkish Team, invited by the World Monument Fund to Nemrud Dag between 3-5 June, 2002 (Prof. Dr. Emine Caner-Saltık, Assoc. Prof. Dr. Tamer Topal, Assist. Prof. Dr. Ahmet Türer, Dr. Ayse Tavukcuoglu and Evin Erder) has visited the site, read previous reports and attended discussions, and developed a set of priorities for the conservation of the site. This report summarizes these priorities and proposes a work plan for conservation activities required at the site.

2. ISSUES

Research and planning activities must focus on the following issues for immediate and long-term conservation:

- Damage assessment and diagnosis of stone deterioration,
- Structural problems,
- Stone treatments,
- Site management and maintenance.

Given the cultural values of the site, the conservation approach must be guided by three ruling principles:

- Minimum intervention,
- Materials compatibility,
- Re-treatability/ reversibility.

3. OBSERVATIONS AND CONCERNS

Immediate and long-term conservation activities and studies are of primary importance for the site. These activities require:

A. Damage Assessment and Diagnosis of Stone Deterioration

1. As revealed in observations made on site, the tuffite stelae on the West Terrace and all the tuffite sculptures, stelae and fragments on the East and North Terraces are in a highly deteriorated condition.
2. Therefore, their condition must be assessed, and if they are deteriorating very rapidly, they must be re-located to safer positions at the site, or removed and placed in a museum.
3. Diagnosis of tuffite and limestone deterioration and their durability must be carried out by field and laboratory analyses.

B. Structural Problems

1. The Nemrud site is located in the 1st degree earthquake zone. Structural analyses for the existing stone elements on the East and West Terraces and their possible behavior in the event of an earthquake should be investigated and proper precautions should be taken against instability and any potential damage.
2. The tumulus, built by placing stone rubble on top of the mountain rock, is likely to be unstable. The tumulus surface is weak and the stone rubble prone to movement. The process of erosion and the risk these stones present in the event of an earthquake must be properly analyzed.

C. Stone Treatments

1. Based on the diagnostic studies, conservation methods (e.g., consolidation treatments), and compatible repair materials must be developed (e.g., jointing, filling, structural and material repairs) and their long-term performance must be examined in the laboratory and at the site.
2. Stone objects requiring such treatments must be well documented before their treatments, and their potential effect on the objects' values considered, following the principle of minimum intervention.
3. Any anastylosis work must be done in light of the damage assessment and required emergency repairs of individual stone elements.

D. Site Management and Maintenance

1. A site visit plan and implementation of site visits with greater control and security for the benefit of the fragile materials and visitor safety.
2. Site monitoring studies, including microclimatic investigations and follow-up damage assessments and trial conservation treatments.
3. Design and installation of a drainage system to remove surface water from the site and prevent further erosion of the tumulus and terraces.
4. The development of a site management plan in order to improve its presentation to the public and allow for more organized and better controlled tourist visits to the site.

4. Other: Proposed Work Plan

Priorities of Summer, 2002

1. The tuffite stelae on the West Terrace must be re-arranged in safe positions and protected from the snow by a seasonal cover.
2. There are several unidentified sculpture fragments which have slipped down the slope below the West Terrace. These stone fragments must be documented and re-located to safer positions.
3. Taking precautions for east side stone blocks that might cause instability and properly filling large gaps under stone bases.
4. The graphic documentation of the site and its objects must be completed.
5. Damage assessment by mapping the damage types throughout the site and infrared thermographic survey must begin.

6. Microclimatic investigations per season by periodical measurements must begin and a weather station installed on a hill close to Nemrud Dag.
7. Examination of geological maps of the area and information shared by colleagues. Identification of the location of the original quarries for the limestone and tuffite/sandstone.
8. Sampling of tuffite blocks at the site and quarries.
9. Trials on selected conservation materials at the site (silicate ester mortars and consolidants).

Priorities until Summer 2003

1. Laboratory studies for damage assessment of the stone elements at the site.
2. Structural analysis of stone elements based on their graphic documentation and the physical and mechanical parameters provided by the laboratory.
3. Dynamic analysis of monuments (preliminary).
5. Identification and duplication of historic photographs of Nemrud Dag for comparison with photographs from 1988 and 2002 by Prof. B. Fitzner, and analysis of these photographs to determine weathering states and rates of decay.
6. Laboratory studies on untreated, rock/quarry, treated and treated/weathered samples of tuffite/sandstone and limestone. Treatments will include silicate esters, consolidants and pozzolanic lime mortars.
7. Many of the sculptures on the East and West Terraces are in direct contact with the ground and show damage. These stones must be protected from further damage by placing each stone element/sculpture on new bases.

5. RECOMMENDATIONS

- The tuffite steale on the West Terrace which have fallen during the past winter must be carefully moved, using traditional methods, and relocated to safe positions, placed horizontally at a slight angle from the ground.
- The tuffite stelae in this area must be protected from the snow by seasonal covers or blankets.
- There is a request for anastylosis of the eagle and lion heads on the East Terrace. Any anastylosis would be dangerous at this stage.
- All conservation activities at Nemrud Dag must be consistent with the cultural values of the site and on-going site and laboratory research for its conservation.

WORLD MONUMENTS FUND - NEW YORK

NEMRUD DAG FINAL FIELD MISSION REPORT

JUNE 2002

1.5

WMF CONSERVATION RECOMMENDATIONS STRUCTURAL STABLIZATION PROGRAM

BY WMF TECHNICAL TEAM

1.5 WMF CONSERVATION RECOMMENDATIONS

The following recommendations are in addition to the WMF's report *2002 Pilot Project and Mobilization – Round Table II Final Planning and Consensus Session, November 2001* and the "2002 Work Program" –included in the University of Amsterdam's December 2001 proposal submitted to the Turkish Ministry of Culture –in response to the emergency situation found at the west terrace after site observations carried from June 3 to 6, 2002. These recommendations were prepared at the request of the International Nemrud Foundation for submission to the Turkish Ministry of Culture.

EMERGENCY STELAE STABILIZATION PROGRAM AND OTHER RELEVANT MEASURES

West Terrace

The two fallen and the three standing stelae are to be removed from their present location and repositioned at a 30-45 degree angle in front of their present base.

For this purpose:

1. They are to be moved using manual techniques with readily available materials and with due care given their delicate condition.
2. The surfaces of the vertical steale should be protected with Japanese paper and polyvinyl alcohol immediately prior to moving.
3. Appropriate wooden racks should be constructed to provide uniform support for the stelae.
4. Upon re-examination of the crack(s) on the Apollo head it is suggested that ultrasound measurements be made to confirm that these are deep enough to require filling.
5. Stone samples are required for laboratory testing at METU and RWTH Aachen, and for the latter some 100 kg should be shipped to Germany.
6. The temporary roping-off of the section with the fallen stelae should be extended in a more substantial manner to the whole working area while the stelae are being repositioned.

East Terrace

With respect to the proposed "2002 Work Program" for the east terrace the following recommendations are presented:

1. Stabilization and reconstruction of the foundation (bedrock) at the north end of the statuary row should be carried out.
2. Stabilization of the bedrock under the statues where needed should be completed.
3. Removal of any statue pieces that have been dislodged and are in a precarious position should be carried out.
4. All urgent structural conditions for the preservation of the statuary row have to be implemented during this work season following the conservation principle of minimum

intervention as suggested in section III on "Existing Conditions and Structural Consolidation of Nemrud Sculptures" of the *2002 Pilot Project and Mobilization* report.

5. Documentation and condition survey and evaluation of all statuary pieces should be completed before any re-erection is attempted.

RECOMMENDATIONS FOR WORK IN FUTURE MISSIONS

1. Appropriate water tight containers to isolate the repositioned stelae from the snow should be designed and constructed for winter protection.

2. The final location of important stelae and other tuffite/sandstone carvings should be considered since their long-term preservation can only be achieved indoors given their present extremely deteriorated condition.

3. For the long term preservation of the statues and/or their pieces protective winter sheltering should be developed. To this end, the eventual presentation of the terraces as appropriate for a World Heritage Site needs to be addressed.

4. It is recommended that the protective fence installation be installed in a sensitive manner and as a temporary measure until the presentation of the terraces as appropriate for a World Heritage site has been developed.

5. It is recommended that the World Monuments Fund's original objective be maintained for the pilot project's re-erection of the eagle satue as described in the *2002 Pilot Project and Mobilization – Round Table II Final Planning and Consensus Session, November 2001* report. The pilot project's re-erection of the eagle was considered for the purpose of understanding original construction procedures and confirming that traditional hoisting methods are feasible.

STRUCTURAL STABILIZATION PROGRAM 2002

CONTENTS

INTRODUCTION

This report has been prepared on the base of project document *2002 Pilot Project and Mobilization- Round Table II Final Planning and Consensus Session.November 2001* prepared by WMF with particular reference to the "2002 Work Program" and the "Proposal for Structural Conservation Program for 2002 WMF/INF Nemrud Pilot Project"included in the Executive Summary as well as section IV "Considerations for Reconstruction".

1. EMERGENCY PROGRAM ACTIVITIES

A. Stabilization of Bedrock Below the Apollo Statue

- To put in place temporary struts to distribute the weight to the underground more equally than is the case now.
- Clean all the soft patches of broken stone and soil around those new supports.
- Refill the existing gap between the foundation with a mixture of stone, gravel and hydraulic mortar. This concrete is to be well compacted with a ram to ensure good contact between the base of the statue and the ground below.
- This process is to stop approximate 20 cm from the front elevation. After that, blocks of limestone should be inserted below.

B. Stabilization of Bedrock Below the Zeus Statue

- The same approach should be adopted as for the statue of Apollo.

C. Temporary Stabilization of the Antiochus Statue

- Having in mind the visible, almost vertical cracks on the front side blocks, temporary consolidation is required.
- Wooden supports will be inserted inside the statue to relieve the weight on the front blocks.
- Further forward movement of these front blocks will be prevented by means of a steel belt around the statue but avoiding direct contact of the belt with the stone by the use of wooden wedges.

D. Removal of the Broken Stone From the Shoulder of the Tyche Statue

- Carefully remove all the crushed stone to a storage place for further treatment.

General Note

All planned emergency measures have been proposed on the base of a general assesment of condition and of conservation activities but might be reconsidered during the actual work.

2. Pilot Project: East Terrace Eagle and Lion at North End

A. Stabilization of Bedrock

- The first stage of this intervention in this part of the monument will be cleaning of the embankment in order to enable the assesment of the soil condition.
- Stabilisation of bedrock will be done according to engineers' judgment and using appropriate materials and methods.

B. Base Consolidation of Lion and Eagle After Finishing Consolidation of the Bedrock and Surrounding Soils

- The consolidation and rebuilding of the base of the Lion and Eagle will start.
- Missing parts will be rebuilt to obtain a rigid and complete platform as a whole base for the lion and eagle statue.
- Part of this work will be done according to the conservation principles using original indentified stone pieces.
- The original stone pieces will be aproppriately treated, and if necesary will be repaired and/or strengthened.

C. Re-Erection of the Eagle Statue

- The re-erection will start after consolidation of the base as well as consolidation of the upper parts of the existing statue.

- The method of re-erection will be a combination of traditional means of hoisting and a crane for the purpose of transportation.
- The contact surface area of the head of the eagle and the lower parts of the statue will be prepared on the basis of its existing condition and the required safety level. We will consider the use of lead and, if necessary, steel pins.

General Note

In the process of consolidation and rebuilding part of the platform repair and/or strengthening techniques for the stone blocks will be applied using strengthening technology with materials such as stainless steel, hydraulic mortar, and if needed in specific cases, epoxy resin and mortar.

WORLD MONUMENTS FUND - NEW YORK

NEMRUD DAG FINAL FIELD MISSION REPORT

JULY 2002

FIELD MISSION II

JULY 2002

WORLD MONUMENTS FUND - NEW YORK

NEMRUD DAG FINAL FIELD MISSION REPORT

JULY 2002

2.1

SITE MEETINGS AND FIELD PROJECT REVIEW

BY JOHN H. STUBBS & GAETANO PALUMBO, WMF

2.1 SITE MEETINGS

JULY 13, 2002

Site Meeting on Nemrud Dag with members of the International Nemrud Foundation (INF), the University of Amsterdam team, and John Stubbs, Vice President, Programs WMF/New York and Gaetano Palumbo, Director of Archaeological Conservation, WMF/Paris. The works conducted by the INF and the University of Amsterdam team on the site subsequent to the World Monuments Funds Team's June 2002 Field Mission are as follows:

- Placing a post and chain-link fence to direct and limit tourist circulation in East and West Terraces. The project was conducted under request of the Turkish commissar in sight of the arrival of the Minister of Culture. When it became clear that the Minister would not be available for such visit the project was suspended. The posts are painted green and their style is not appropriate for the site. Also, their installation included the excavation of small holes in the debris where stones with embedded bolts were placed. The stones were in turn cemented into the holes and the posts were bolted in place. We expressed concern that this operation would also be done where bedrock is present and we received formal assurance that this would not be done.
- The use of a large crane (90 tons) was donated by the company ENKA. The crane has not operated so far, but it is parked in the area between the East and the North Terraces.
- Preparation of a 10-meter sloped path to the East Terrace to allow the crane to be placed there in case the permit to operate it was given. The slope was prepared by adding stones and debris above the existing surface.
- Opening of a 20-meter long, 1 meter wide path around the eastern edge of the northern side of the stelae row, East Terrace, flanked by the new fence, in order to direct the tourists away from the stelae row and towards the North Terrace.
- Preparation of an avalanche/snow shelter consisting of steel supports over which wooden posts are set horizontally to support the weight of the snow and keep the backs of the stelae free from this pressure.

JULY 14, 2002

The second celebration for the site of Nemrud has taken place in the Zeus Hotel in Kahta. The Dutch Ambassador opened the speeches by mentioning the importance that the Netherlands place on this joint project and their pride in helping the Turkish government in helping to conserve one of the most important sites in the world.

Mentioning the dangerous conservation conditions of the site, the Ambassador hoped that the project could be completed rapidly.

The representative of the Minister of Culture mentioned the presence of the site in WMF's list of the 100 most endangered sites. He briefly described the work to be conducted, in a sequence that sees documentation and stone consolidation preceding conservation and restoration. He sees the conservation of the fallen stelae as one of the most urgent tasks.

A Member of Parliament for Adyaman Province mentioned the possibility (and the hope?) that 200,000 tourists a year would visit the site. This would go together with the promotion of other tourist destinations in the province, possibly more archaeological research in the Commagene area, and the construction of a new museum in Adyaman. He also hoped that the conservation of the stelae could be conducted *in situ*, possibly under a shelter, and that this conservation work could proceed with minimum bureaucratic interference.

The Governor of Adyaman Province also mentioned the importance of further archaeological research in the area, of the fact that Nemrud is the recipient of this year's Golden Apple Award of the International Federation of Journalists and travel writers (http://www.fijet.net), and he mentioned draft masterplans for the area prepared by the Ministry of Environment and Department of Wildlife, and a promotion project for Mount Nemrud prepared by the Ministry of Tourism.

The director of the project, Professor Hermann Brijder, described the conservation work to be conducted on site and mentioned the erection of a laboratory on the West Terrace to conduct conservation of the stelae.

Professor Eric Moormann described the archaeological and documentation work, including the GPS survey of the mountain, the laser scanning of the statues and the laser scanning of the inscriptions. He also described the ultrasonic work on the tuffite stelae conducted by Professor Fitzner and the protection of the lion horoscope conducted by Paolo Pagnin. He defended the use of the large mechanic crane, citing the problems connected with moving to other locations large and heavy blocks using manual methods.

The ceremony in Kahta was followed by a visit to Nemrud Dag that included a Classical music concert on the East Terrace and a demonstration of the crane capabilities using a natural boulder. Medals were given by INF and the Dutch Ambassador to the representative of ENKA Company, the Governor, and the Representative of the Minister of Culture.

JULY 15, 2002

A meeting between the Minister of Culture committee in Adana with the directors of the INF project was set for the afternoon. In the morning John Stubbs and Gaetano Palumbo had another meeting with the INF management team where further issues were discussed. The INF team had prepared a draft of a memorandum of understanding based on the recent events and looking to streamline future problems. The same had been done by John Stubbs. The two documents were shared and points were discussed. The resulting document is presented separately. The issue of involvement of Turkish conservators was also discussed and the idea is to contact the Ankara Institute of Conservation.

JULY 16, 2002

At the Gaziantep airport we met Professor Brijder who reported on the meeting in Adana. The Ministry of Culture did not give the permit to conduct work on the eagle of the East Terrace, and only allowed work to concentrate on the conservation of Herakles statue base and move the displaced blocks of Tyche/Commagene, Apollo, and the heads of Antiochos and Tyche to the front, although the latter may not be done by the team. Work on the fallen stelae is also postponed to next year given the need for pre-consolidation.

2.2 SCOPE OF WORK PROTOCOL

Based on a meeting of Ministry of Culture, University of Amsterdam and International Nemrud Foundation representatives on July 15, 2002, the following tasks are permitted at Nemrud Dag prior to the close of the current archaeological field campaign. The Ministry of Culture will articulate these items in writing in the following days.

EAST TERRACE

- The autocrane can be moved to the East Terrace and the construction of a temporary ramp up one particularly steep slope is permitted.
- The following stones in precarious positions can be removed to the terrace level: the dislodged pieces of the Antiochos and Commage statues, the dislodged head and top of the Tege statue, the shoulder of Apollo.
- The void below the base of the Hercules statue may be filled with a 'hydraulic mortar with small stones set into it' (quote of Proffessor Hermann Brijder) finished in a facing that is set back from the front edge of the current statue base.
- It is permissible to move various stones strewn about the plaza level on the East Terrace if the INF wishes.
- The Antiochos statue to the south, and the Eagle to the north of the East Terrace cannot be touched due to a lack of a clear plan for the reconstruction and conservation of these statues. After approval of acceptable conservation proposals – detailed sequential reassembly analyses – the conservation of these two statues will presumably occur next year.

WEST TERRACE

- The two fallen stelae should be left in their current positions.
- It is permissible to erect a snow shelter to protect vulnerable stelae.
- A restoration studio can be built at an agreed-upon location at the mountaintop in anticipation of the conservation of various tuffite stelae.

MISCELLANEOUS

There was no discussion of the fence construction that is underway to separate visitors from the archaeological fabric that comprises the site.

WORLD MONUMENTS FUND - NEW YORK

NEMRUD DAG FINAL FIELD MISSION REPORT

JULY 2002

2.3

STRUCTURAL CONSOLIDATION OF NEMRUD SCULPTURES

BY PREDRAG GAVRILOVIC

TABLE OF CONTENTS

PREFACE

This report has been elaborated based on participation in the Mission 2002 with a total duration of two weeks. The report should be treated integrally with the previous Mission Report of August 2002.

The main purpose of the report is presentation of the activities done and providing of directions toward organization of future activities within the project.

ACKNOWLEDGEMENTS

The author wishes to extend his gratitude to WMF – New York for the trust that they placed in him by inviting him to perform the mission. He is particularly grateful to Mr. John Stubbs, Vice President of WMF and Mr. Mark Weber, Technical Director of WMF for the opportunity for participation in the project and their cooperation during and after the mission.

The author is also grateful to the members of the team of the International Nemrud Foundation for their assistance in the realization of his mission, particularly Mr. Jacob Groot, structural engineer, for the extraordinary cooperation and sincere and useful professional discussion.

Predrag Gavrilovic

1. INTRODUCTION

The main scope of work concerning the structural aspects of the Nemrud Dag sculptures was the realization of the "Proposal for Structural Conservation Program for 2002 WMF/INF Nemrud Pilot Project" (Nemrud Dag – 2002 Pilot Project and Mobilization – Round Table II – Final Planning and Consensus Session; November 2001).

From the aspect of structural conservation, the Program of Activities is divided into two parts: Emergency Program Activities, and Pilot Project – East Terrace: Eagle and Lion North Side.

Taking into account the existing state of the integral monument regarding its stability and to prevent further failure of certain parts or complexes, priority has been given to emergency activities. The collapse of the stelae on the west terrace in the 2001-2002 season is a warning that these activities are necessary.

Based on the inspection of the site, the emergency program activities involve the following:

EAST TERRACE

- Stabilization of bedrock below the Heracles statue;
- Stabilization of bedrock below the Zeus statue;
- Temporary stabilization of the Antiochus statue;
- Removal of broken stone from the shoulder of the Tyche statue.

WEST TERRACE

- Protection and stabilization of stelae on the west terrace.

According to the work plan for the pilot project – East Terrace: Eagle and Lion – North Side, the following activities have been considered:

- Stabilization of bedrock;
- Base consolidation of lion and eagle;
- Re-erection of eagle.

In the process of consolidating and rebuilding part of the platform, repair and/or strengthening techniques should be applied to the stone blocks. These techniques will utilize strengthening technology with materials such as stainless steel, hydraulic mortar and, if needed in specific cases, epoxy resin and mortar.

At the end of the first week of the mission, the INF and the members of the Turkish team from the Ministry of Culture requested a proposal for protecting of the stelae by dismantling and removing them to a location in the vicinity of their existing position. A procedure has been proposed involving placement of the stelae on a timber base with steel frames. The stelae would be lifted and transported by local transport systems, and a portable chain crane.

The goal at the outset of the mission was to thoroughly comprehend the issues involved at Nemrud Dag prior to initiating work. From the aspect of structural stabilization, there was no reason to deviate from the Emergency Program since there were no contradictory attitudes. In the second part of the activities – the Pilot Project for the East Terrace, and the Eagle and Lion East Side – disagreements arose within the conservation team concerning two issues:

(i) Previously applied conservation solutions;
(ii) The use of cranes on the site.

All of the planned emergency measures have been informed by the general assessment of the conditions and conservation activities at the site; however, these measures might be considered during the actual work.

The original objectives of WMF June 2002 Mission are presented in the WMF Report 2002 with the proposed activities including also the Pilot Project for structural consolidation.

Due to the new emergency situation and the need to thoroughly brief the Ministry's Commissars on the Pilot Project's priority work scope, the INF requested the WMF team to prepare an updated conservation and structural assessment with recommendations for the East and West terraces. The purpose of these reports was to reevaluate and update all the urgent conditions. These reports were prepared at the INF site office at the Hotel Kervansary on June 6, submitted to INF and Ministry's Commissars and sent to the Ministry of Culture in Ankara.

The activities presented in item 2 of this report were realized in the second part of the Mission that took place in the period July 15 – July 31, 2002 and based on the conclusions drawn at the meeting in Adiyaman. All the activities can be considered as emergency and temporary ones.

For the needs of further activities from the aspect of structural conservation, consolidation, repair and strengthening of the Nemrud statues, some bases and proposals for the activities to be realized in some of the next missions are given in items 3, 4 and 5 of this report.

Structural consolidation, repair, strengthening and rebuilding should be done with due respect for the conservation aspects that should be clearly and professionally defined.

Seismic structural stability of the monuments should be noted according to maximum expected ground acceleration in the region and defined criteria of stability and safety. This type of study and analysis should be taken into consideration for all the details, but particularly in the case of rebuilding parts and anastylosis. Experimental investigation and testing will be highly appreciated and will be welcome especially in the later phases of the project, but they are not "conditionally necessary". Analytical modeling, as well as appropriate calculation and design should provide adequate safety.

The slopes of the tumulus, built by placing stone rubble on top of the mountain rocks, are unstable and should be considered as a separate part of the project and studied in detail.

The use of cranes in conserving historic monuments is increasing throughout the world. At Nemrud, the crane shall be used for "transport", while lifting or hoisting is to be done in the traditional manner and with traditional materials, which are less likely to cause further damage. 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.

Finally, the weight of the crane, amounting to 90 tons, and the microtremors produced cannot affect the stability of the statues considering that they represent massive, heavy and rigid structures. Lighter cranes located on the spot of the conservation activities are recommended for use in the future.

2. STRUCTURAL CONSOLIDATION FIELD CAMPAIGN

As already mentioned, all the activities that were done in this period can be treated as emergency and temporary.

2.1. STABILIZATION OF BEDROCK BELOW THE HERACLES STATUE

Present condition:

The Heracles statue is composed of three parts: (i) throne or base; (ii) body – central part and (iii) head. The head of the statue has fallen and lies on the platform, whereas the throne and the body are generally in the original position (Photo 1).

The statue is constructed of stone blocks, whereat the base is directly placed on bedrock.

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, then damages to the stones themselves particularly pronounced on their front sides and manifested by local failure or cracks and erosion and deterioration of bedrock – soil foundation, particularly expressed on the front sides (Photos 1, 2).

Diagnosis:

As to the stability of the statue in the present condition (without the head), it is assessed that structural intervention for improvement of its entire stability is necessary in the process of conservation and restoration.

It is urgently necessary to intervene as to the stability of the soil, i.e., bedrock because it has suffered considerable deterioration and erosion in the course of time (Photo 2). 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.

Stabilization:

The program of activities for 2002 anticipated stabilization of bedrock below the statue but due to the circumstances, insufficient time and materials, the statue was only temporarily stabilized.

The temporary stabilization involved the cleaning of the base, removal of tiny stones and failures and 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 (Photo 3).

Recommendation:

It is recommended to perform permanent stabilization with improvement of the existing soil by injection of rock mass and incorporation of new, stable and regularly shaped blocks below the existing blocks of the statue.

The contact between the new blocks and the existing ones (belonging to the statue) should be dry, if possible or should be made by use of hydraulic mortar or lead. This detail should be agreed with the conservators and should be in compliance with the conservation principles and the conservation strategy of the project.

2.2. TEMPORARY STABILIZATION OFANTIOCHUS STATUE

Present Condition:

The existing state of the Antiochus statue can be assessed as critical because of the large displacements of stone blocks, particularly manifested through the vertical separation – the gap on the south side (Photo 4).

Analyzing the stability of both lower parts of the statue (the head had fallen off the statue previously), it can be assessed that these are in the state of "structural instability" and disturbed structure of dry masonry.

Diagnosis:

Possible minimal motions caused by natural phenomena or man might lead to abrupt progressive failure of the entire statue. Certain contacts, i.e., supports of stone blocks from the inside part are so weak and critical that they require urgent and immediate intervention for structural stabilization.

Stabilization:

Emergency – temporary structural stabilization was proposed by means of extensive support by timber blocks on the inner side and connection by steel ties on the lateral – external side.

At the meeting of the representatives from the Ministry of Culture of Turkey (Adiyaman – July 2002), steel ties or any other ties were not allowed to be used on the external side of the statue. Therefore, the stabilization done consisted of supporting the statue by timber struts with timber cramps. Please Note: Not only is this intervention temporary but insufficient as well (Photo 5).

Recommendation:

It is recommended to carry out, with previous agreement of conservators, stabilization that will provide greater safety until the performance of the permanent conservation treatment and thorough reconstruction.

2.3. Removal of the Heads of Statues and Broken Stones and Bringing the Statues into Proper Condition

One of the activities approved for realization at the "Adiyaman Committee" Meeting in July 2002 was the removal of the heads of the statues and other stone blocks from their existing position on the east terrace and their placement in an appropriate place. For this activity, a crane with a bearing capacity of 90t was made available. To successfully perform the operation, it was necessary to place a telescope crane in the centre of the east terrace. For this, the following preparations were necessary:

(i) Making available an access road to the terrace;
(ii) Making the motions of the crane safe against damage to the statues and generally to the archaeological site.

The access road was constructed with random natural stone, which was well compacted and under the necessary inclination, in cooperation with the operators from "ENKA" and INF. The road is temporary, does not disturb the milieu and can be removed, if necessary, in any phase of the project activities. The slope and the base were appropriately done so that the transport of the crane was successful, fast and efficient. Its transport and fixation to the platform did not induce any damage to the existing structure and the monument as a whole (Photo 6).

As to the anxiety and the discussions among the conservators, archaeologists and architects regarding possible damage to the sculptures and the monument, I as consulting engineer responsible for the stability of the structure, personally guaranteed that no additional damage shall take place. This guarantee was based on analysis of possible vibrations and dynamic characteristics of the sculptures.

During the transport and the operation of the crane, observation of critical points and places on certain sculptures was organized. A detailed inspection was also performed after the completion of the operation.

It can be stated that the crane did not induce any damage nor did it create conditions for any consequences in the process of its transport and operation.

Prior to reporting the performed removal of the heads of the statues and the entire operation, it is necessary to note that the telescope crane with a capacity of 90t owned by "ENKA" company and made available for the performance of the activities 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 precision 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 with a soft contact surface so that no damage can be induced upon contact with stone surfaces.

The highly professional and specialized team of operators contributed also to the successful, timely and efficient performance of the entire operation.

The team of archaeologists from INF prepared the bases (stone stands) for the placement of the heads according to the previously defined position of each head or stone as approved by the Turkish Commissars overseeing the site work.

The stone stands consist of a metal ring filled with stones to prevent penetration of moisture from the soil, surrounded by dry stone masonry.

The removal operation began with the binding of the heads with the ties, precise lifting of the heads from the soil, and control of connections and transportation by a higher speed to the new position. The lowering of the heads was done by slow, precise motions until they were securely fixed to the base (Photo 7).

Removal, or better to say, lifting and replacement of the heads and the stones was done by using the crane and its equipment for lifting and transportation, i.e., its special plastic ties providing the possibility to apply pre-tension for better contact.

It can be concluded that all the heads – five statues, three of Eagle and Lion – the busts of Apollo as well as other pieces of stone were lifted and moved without any damage and/or crushing of stones and no color changes, except for the small crushing on the head of the Kommagene statue. This head is composed of two parts and while putting the head on place, a small crush occurred at the contact between the two parts. It is an area of approximately 10cm x5 cm, which was repaired by the Turkish Commissars. So, it can be said that no other damage or any kind of defect occurred during the operation that was effectively and rapidly completed within a few working days. Attempts were made to simulate traditional techniques involving placement of wooden pints into the existing holes, but the quality of the wood was not appropriate (very soft wood) and the operation was not as effective as it should be.

All the 5 + 3 heads were removed from the platform of the East terrace down to the aforementioned specially prepared stone stands. The Apollo's bust, which was on the slope and in a very unstable position, was also removed from the terrace. Other stones were also removed to clean the terrace. These activities were strictly controlled and approved by the Commissars.

Photo 8 provides a clear insight into the conditions of the East Terrace.

2.4. Stabilization of Stelae, Protection by a Snow Shelter

As already mentioned, one of the stelae on the west terrace fell down during the winter period. It was placed in a horizontal position on the very spot and supported by timber struts and a base of dry stone masonry (Photo 9). This is only a temporary solution until a decision is made about its permanent protection.

Adequate measures for temporary or permanent protection shall be undertaken dependent on the decision made by the conservators and the archaeologists and upon approval by the Ministry of Culture of Turkey. The present state of the stelae with steel anchors, epoxies and

concrete is not only inadequate but unstable as well. The decision will involve special structural treatment as necessary, stabilization of the soil and the base as well as connections between the slabs and the bases.

As a temporary measure for protection of this part of the locality of the West Terrace against snow proposed at the Adiyaman Committee Meeting, a protective show shelter was designed and constructed by INF (Photo 10).

The structure of the snow shelter is made of steel with timber beams – braces. The steel frames are precast and rest on bedrock (on the east side) and on "stone supports at the connections of the steel mesh". The whole structure is precast and can easily be dismantled prior to the tourist season.

3. STRUCTURAL ANALYSIS AND SEISMICITY

Presented in the WMF Nemrud Dag First Technical Mission Report – August 2001, in Part 5 (Participants' Reports) is the mission report of this author "Structural Consolidation of Nemrud Sculptures", pp. 47-66. This reports provides a detailed presentation of the existing state with structural analysis and identification of problems, including analysis of damage as well as proposals for intervention, methodology and techniques.

This part of the report should be conceived as a continuation of the previous report with concretely defined proposed activities considering the incurred conditions after the mission of June-July 2002 and the presented remarks by the individual participants in the expert team coming from other countries and Turkey.

3.1. STRUCTURAL SYSTEMS, MATERIALS ANDPRESENT CONDITION

The Nemrud monument statues on the East and West Terrace are constructed to have the same structural system and almost identical proportions.

The principal structural system is composed of dry stone masonry consisting of large blocks of yellowish-whitish limestone constructed in horizontal rows – joints. The connection between the heads of the statues and the lower massive structure is done by "shear keys", whereas the remaining connections between the blocks, including also the connections of the heads of the eagles and the lions are direct. The foundation is performed directly upon the surface layer of the bedrock.

The structure of the statues consists of three parts: base (throne), which is directly placed on bedrock (representing disintegrated rock mass composed of limestone), body of the statue and head of the statue connected to its body by "shear key" connection (see Ref. 1, 2).

The structure and the structural system of the sculptures of the eagles and the lions is basically the same, the difference being that both the sculptures are constructed on a common platform and the heads are not connected to the lower massive structure.

It should be pointed out that, from structural aspects, the structure of the sculptures on the east and the west terrace is not identical although their outward appearance and proportions are. The main difference is that the statues on the east terrace are constructed of massive large blocks with smaller inner openings, filled with small stones in the lower part and specially shaped in the upper one.

The statues on the west terrace are constructed of smaller stone blocks with larger inner openings in the lower part (the pedestal) and are placed on variable and nonuniform soil conditions, with weaker characteristics and pronounced erosion. The different structure and the weaker characteristics of the main material – stone, the inconsistency in foundation point to the possibility that these structures are not constructed at the same time and perhaps not by the same masters.

From the analysis of the structural system, materials used and existing condition, i.e., extent of damage in respect to stability and reasons for damage, taking into account the regional conditions (seismicity), the local conditions (soil and mode of foundation) as well as the climatic conditions and period of construction, the following conclusions can be drawn:

(i) These monuments have undoubtedly been exposed to strong earthquakes in the past, which is one of the reasons for their failure (on the west terrace) and severe damage and partial failure on the east terrace. The fact that the heads of the statues are displaced from the original position points out that these statues have experienced the "overturning" effect as a result of amplified acceleration at the top of a rigid body, which can be proved by an analytical model and a dynamic response analysis.

(ii) The second decisive cause for the extent of damage has been the local conditions and erosion of the surface rock on which the structures are directly placed. This particularly refers to the west terrace and the slopes on the north and the south side of the east terrace.

(iii) The severe climatic conditions – cold winters with low temperatures and hot dry summers in the course of more than two thousand years have contributed to extensive deterioration of both the stones of the structural system and the surface layer of the soil - rock. This has caused modification of the main characteristics of soil and erosion leading to creation of conditions for relative displacement and deformations with separation of the rigid structure up to total failure.

The interactive effect of all these three factors is the main reason for the failure and the damage of the sculptures of the Nemrud Dag monument.

As to the existing state, the same structure on the west side has completely failed, whereas on the east side, at a distance of several hundreds of metres, it has sustained and resisted all the ravages of time.

Presented further should be the specific characteristics of the sculptures with the purpose of not repeating the assessment presented in the previous report but pointing out certain specificities of interest for the newly planned activities for the coming period and the next missions.

It can be concluded that the structures of the sculptures, although constructed of massive large stones and dry masonry, possessed extensive lateral seismic resistance. One of the photos from the archived documentation (the book by Terese Goel) shows that the head of the Tyche statue was still in its original position in 1956 which points to the fact that the statue was able to resist the effect of earthquakes in the course of 2000 years. This exactly proves the thesis about the interactive effect of a number of factors and can be explained only in that way.

(i) Eastern Terrace

On the Eastern Terrace, high above the level of the rock plateau, there are placed five colossal statues. The figures of the lion and the eagle are placed on a plateau to the left and the right of these statues.

The rests and the central area of all the five statues are preserved, whereas the heads are scattered over the terrace plateau.

Photo 11 provides the front view of all the five statues, while Photo 12 shows the back view. It can generally be noticed that almost all of the statues are in their original form, with a small number of missing or broken stones. However, they have all suffered damage and displacement of stone blocks that require consolidation.

On the statue of Heracles, the following is observed: the base and the second part of the statue are in a stable condition, i.e, in the condition of a generally preserved original form; the damages to the stone structure particularly on the front side (Photos 1, 2) are extensive and due to erosion and damage to the base; the erosion and the deterioration of the bedrock on the front side have been one of the main factors along with other natural phenomena and effects for the incurred damage; there is damage to individual stones in the upper part; and the disturbed structure-soil contact (Photo 3) where a stone block has turned into a beam due to erosion and deterioration representing a potential threat for complete - progressive collapse of the entire statue.

The central statue of Zeus is generally in the same condition as the previously described one, with a visible dislocation of a stone in the second part and occurrence of vertical separations. This points to initial "general instability" that has resulted also in the crushing of the stone blocks in the lower rows.

From the aspect of structural stability, it is necessary to consider the Tyche statue that bears visible remains of the head and the body of the figure. Based on analysis of the state of the statue some thirty-forty years ago when the head was still in its original place and from the analysis made to determine the reasons of failure, it is concluded with certainty that failure has occurred due to reasons different from those affecting the other statues. The crushed stone from the blocks and the head points to direct effect of a natural phenomenon, i.e., lightning or man's hand. Whichever is the case, the lower part is in a relatively good condition, whereas the broken stone from the upper part should urgently be eliminated (see the emergency planning activities). The crushed stones from the top have been put down during the mission of July 2002.

The statue of Apollo (Photo 4) provides an insight into the failure mechanism of stone structures constructed of dry masonry consisting of vertical separations – cracks as a consequence from changes in the base resulting in "structural instability".

From the aspect of structural stability, this statue is in the worst condition wherefore urgent measures for its consolidation are necessary to avoid collapse.

On the northern side, the base of the lion and the eagle is considered partially collapsed. The base of the eagle is ruined, whereas the part with the lion's figure is in a good condition (the base and the body of the lion), the head of the lion being on the plateau. All the stones forming the base of the eagle are present and undamaged since failure must have taken place not so long ago. The south base with the figures of the lion and the eagle is in ruins.

From the aspect of structural consolidation and based on the analysis of the existing state of the sculptures, the following can be concluded:

- All the five sculptures are in a condition requiring necessary structural consolidation;

- Structural consolidation can be done without disturbance of the authenticity of the monument by not using concrete, mortar or other materials;
- The structural consolidation of the Apollo statue should be treated urgent so that, in the case of longer time necessary for an intervention, some temporary measures will have to be taken;
- The base of the lion and the eagle (on the northern side) can successfully be reconstructed by consolidation of the existing part and rebuilding of the torsos whereby there shall be created conditions for returning the figures of the eagle and the lion into their original position.

(i) Western Terrace

The Western Terrace is generally in a worse condition than the Eastern one. It is all in ruins. Only a minor part of the bases of the statues is in its original position, i.e., the two rows of stones on the east side and one row of stones laterally. The front wall as part of the base is ruined and the stone masonry is crushed. The heads lie scattered over the platforms and require stone conservation treatment.

In the case of conservation of the archaeological site, minimal measures of intervention shall be necessary to be carried out on the remains of the existing walls and then the stones should be arranged according to the archaeological needs.

In the case of anastilosys, measures for strengthening of the base, corresponding rebuilding and introducing of elements for providing seismic stability shall be necessary.

As to the stelae, which are constructed of gray sandstone and has already undergone conservation works, the following can be concluded from structural aspects:

- The stability of all the elements is endangered from both erosion of the soil base and inappropriately completed structural repair by reinforcement, concrete and epoxies whose degradation is also visible. Should a decision is made that this part of the monument remains *in situ*, it should undergo special and detailed structural treatment. The existing condition can be assessed as critical, meaning that measures for its protection are urgently necessary.

(ii) Tumulus (Slopes)

The stability of the slopes of the Tumulus should be analyzed and measures of protection should be designed for the entire complex, particularly over the west and east terraces.

While analyzing the stability, possible seismic effects should be taken into account.

3.2. Seismicity of the Region and the Location. Historic Earthquakes. Turkish Code Recommendations

The Turkish peninsula is known as one of the most seismically active regions, at a high risk of occurrence of earthquakes. From seismotectonic aspects, it can be said that there are sufficient

data for evaluation of the seismicity and the expected effects. The well-known North Anatolian fault that runs along the entire length of the peninsula is one of the most active faults.

The East Anatolian Fault (see Fig. 1, Major Earthquake Faults in Turkey) is also an active fault.

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, which is an official document and a constituent part of the regulations, the entire territory of Turkey is divided into four seismic zones (see Fig. 2, Seismic Zoning Map of Turkey). 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 said location is a seismically active area, which should be taken into account in the reconstruction of the structures.

The connecting of the failure of the statues directly with the effect of some of the strongest earthquakes was not a successful part of the investigations. According to the study of the earthquakes that occurred in this region in the period from 1500 till present, there were recorded the earthquake in Malatya on January 3, 1544 with an intensity of most probably IX degrees (according to the description of damage) and the earthquake of June 14, 1964 with magnitude of M = 5.5 and intensity of VIII degrees MCS also in Malatya.

There are no data to directly relate damages to the monuments to these earthquakes, but this element can be studied in the next investigations by corresponding mathematical models that can enable evaluation of the behaviour of the structures with a greater reliability.

In Turkey, there are Codes for Protection against Earthquakes that 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, the materials, etc.

3.3. DEFINITION OF SEISMIC SAFETY CRITERION FOR CONSOLIDATION, REPAIR AND/OR STRENGTHENING OF THE NEMRUD SCULPTURES

The Nemrud monuments are of a particular importance and as such should be classified as structures of a special category.

Taking into account the seismicity of the region and the site as well as 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 for a 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 global 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.

4. METHODS AND TECHNIQUES FOR CONSOLIDATION, STABILIZATION AND REPAIR

4.1. GENERAL APPROACH, PRINCIPLES AND TECHNIQUES

The proposed concepts for structural consolidation of Nemrud should comply with the basic principle: "minimum intervention – maximum protection". The proposed procedures employ methods and materials that are both appropriate and reversible.

Structural consolidation is one of the many interventions within the full range of possibilities in archaeological conservation. The use of a multidisciplinary approach that recognizes a carefully developed set of conservation priorities for a given site has proved to be the best procedure to follow in complicated architectural and archaeological conservation projects.

Within the multi-disciplinary approach to protection of monuments, structural intervention should be performed at places and to a scope necessary from the aspect of preservation of stability and safety without changing the principal structural system and by sticking to the principle of "minimum intervention – maximum protection" as well as the main principles in modern conservation practice. Should new materials be used, they need to be reversible and care should be taken to avoid the effects from interaction of materials.

From structural aspect, it is extremely important to make a decision about the approach to be taken and adopt the main criteria on which shall also depend the type of the intervention.

It is only on the basis of the decisions, long- and short-term planning of the activities to be performed for the integral complex, each statue or group of statues that conditions can be created for definition of a corresponding methodology as a basis for a special "project for structural consolidation" of each structure taken separately.

For each statue separately, a decision should be made regarding the conservation approach and then a structural solution should be proposed in the form of two final possible alternatives:

(i) Alternative – conservation of the structure with structural consolidation;
(ii) Alternative – conservation, stabilization and rebuilding of ruined parts
(iii) Alternative – anstelosys of the integral structure

This means that, in the case of the first alternative (conservation with structural consolidation), the structure is integrally preserved in its existing shape and undergoes conservation works, consolidation, repair and necessary strengthening (example: the Heracles statue on the east terrace is repaired and consolidated but the head is not placed on the statue).

The second alternative involves repairing the existing state and giving the structure (statue) its original shape (example: the Heracles statue on the East Terrace to be repaired, consolidated, strengthened and the head returned to its original position).

The third alternative is recommended for ruined structures that are to be rebuilt and undergo anastelosys (example: the Zeus statue on the west terrace).

Depending on the decision, a corresponding structural intervention shall be designed for each structure in cooperation with archaeologists, stone conservators, architects and other participants in the project.

The methods and techniques of consolidation are the subject of detailed studies and projects, but in this phase of the project, discussed as a proposal could be a simplified method that enables preservation of authenticity and avoiding of damages to the stone blocks, particularly those bearing inscriptions, decorations, etc. My proposal is to build a scaffold around the statues and perform the works by simple and light equipment, small cranes, hydraulic presses and other equipment. The cranes to be used should be lightweight and mobile.

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 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.

To illustrate the previously stated approach, alternative solutions for two possible pilot projects for the Eagle and the Lion statues on the East Terrace and the Heracles statue on the East Terrace shall be presented in the form of a proposal.

4.2. Structural Consolidation of Eagle and Lion Statues on East Terrace – North Side (Proposal)

Present Condition:

The Eagle and the Lion statues are placed on a same platform, which is completely ruined (the lion statue being ruined as well) on the north side, whereas on the east side, there are remains of the Eagle statue (Photos 13, 14).

On the north side, the soil has suffered erosion to the extent of failure, whereas on the south one, the erosion has taken place within the contact and the surface zone.

The Eagle statue is partially ruined, its lower part is composed of large blocks resting on a common terrace consisting of stone blocks filled with crushed stone.

Diagnosis:

The entire structure is in an extremely critical state wherefore it requires intervention to stop the process of progressive failure.

Proposal for Structural Consolidation:

The proposal shall be presented in the form of alternatives and, depending on the decision, a project for realization shall be prepared.

Alternative 1: Conservation and Structural Consolidation

It is necessary to stabilize the soil, repair the pedestal of the Eagle statue and rebuild the ruined part of the Lion's pedestal.

The existing parts of the Eagle statue should be brought into their original position and each stone block should be repaired and treated from conservation aspect.

Alternative 2: Conservation and Structural Consolidation with Re-Erection of the Head of the Eagle

In the case the proposal accepted in the plan for 2002 is adopted, this would involve not only stabilization, but also placement of the Eagle statue on the pedestal. In addition to the already mentioned works, the stone blocks that have fallen down and constitute the pedestal for the Eagle head should be treated and placed in their original position. The head of the Eagle should be placed on the previously prepared base after the performance of all the preparations.

Based on the analysis of the structure for the expected earthquake effects, the following should be pointed out:

- Stabilization of the soil should be thorough and performed by injection of corresponding material;
- The stone structure of the Eagle should remain as dry masonry;
- The Eagle head should be connected to the pedestal by corresponding pins to prevent overturning effect in the case of an earthquake.

The works should be implemented with a platform and use of lightweight cranes for transportation in the traditional way of lifting and placement of the stone blocks.

Alternative 3: Complete Rebuilding and Placement of the Eagle and Lion Heads – Anastilosys

This alternative involves the complete cleaning of the area, stabilization of soil and complete rebuilding.

In the process of rebuilding, each stone should be repaired and should undergo conservation treatment. The missing stones should be replaced by new ones.

No matter which alternative is adopted, the following activities should be carried out prior to beginning of the works on the terrace:

- Detailed inspection and presentation of graphic documentation with necessary dimensions;
- Laboratory tests of characteristics of the main material – stone (mechanical, physical and chemical characteristics of this material should be defined);
- Elaboration of a project for structural consolidation with a corresponding analysis and details of repair, strengthening and performance of the works.

4.3. Structural Consolidation of Heracles Statue – East Terrace (Proposal)

Present Condition:

The statue is in its original form. The head of the statue has fallen down on the platform and lies on it. The lower part of the statue is in a relatively good condition, with minimal displacement of the stone blocks. The soil on which the lower part rests has eroded and has cavities. In the upper part of the statue, the stone blocks are partially damaged, which is particularly manifested on the front side where the displacement of the blocks is greater (Photos 1, 2).

Diagnosis:

From a structural aspect, interventions for stabilization of the ground and the contact as well as repair and consolidation of the upper part of the statue are necessary.

Proposal for Consolidation:

Alternative 1: Conservation and Structural Consolidation of Existing State

It is necessary to perform permanent and thorough stabilization of soil with the necessary injection as well as repair of the contact between the soil and the statue.

As to the upper part of the statue, repair and strengthening of existing stone blocks and their bringing into the original state should be done.

No additional measures of strengthening of the connection between the stone blocks are necessary. There shall remain the dry masonry, while the works can be done in situ by use of a scaffold and small cranes.

Alternative 2: Conservation, Structural Consolidation and Placement of the Head of the Statue

For this alternative, it would be necessary to perform the works referring to stabilization of soil and contacts as was the case with the first alternative. The upper part of the statue (the body) should be repaired by removal of this part of the statue and rebuilding. During rebuilding, it would be necessary to incorporate additional joints between the head of the statue and the stone blocks and partially use wedges in the upper part of the statue. The consolidation of the soil and the lower part of the statue can be done in situ without displacement of the stone blocks from the throne.

To realize the works, the following activities should be carried out:

- Inspection of the structure and presentation of each stone block with corresponding proportions.
- Elaboration of a project for structural consolidation with mathematical analysis and control of seismic stability.

The works could be realized by construction of a scaffold platform and small cranes within one season lasting from June to September.

5. CONCLUSIONS AND RECOMMENDATIONS

Structural consolidation and stabilization of the Nemrud monuments should be done on the basis of the data obtained from the detailed field survey, experimental and analytical investigation, as proposed in this report.

As to the future activities, it will be necessary to prepare short- and long-term plans.

LIST OF PHOTOS

LIST OF FIGURES

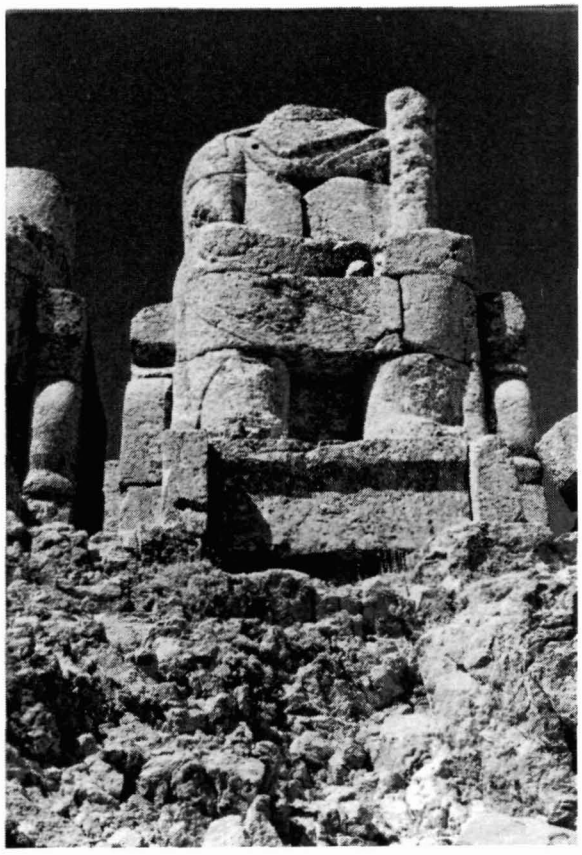


Photo 1: Heracles statue, East Terrace – present condition

Photo 2: Heracles statue, East Terrace – ground deterioration

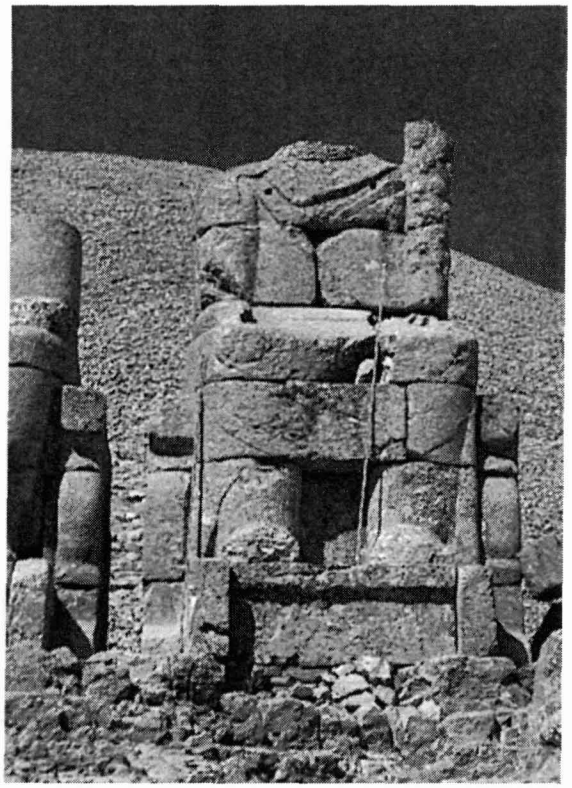


Photo 3: Heracles Statue, East Terrace – temporary stabilization

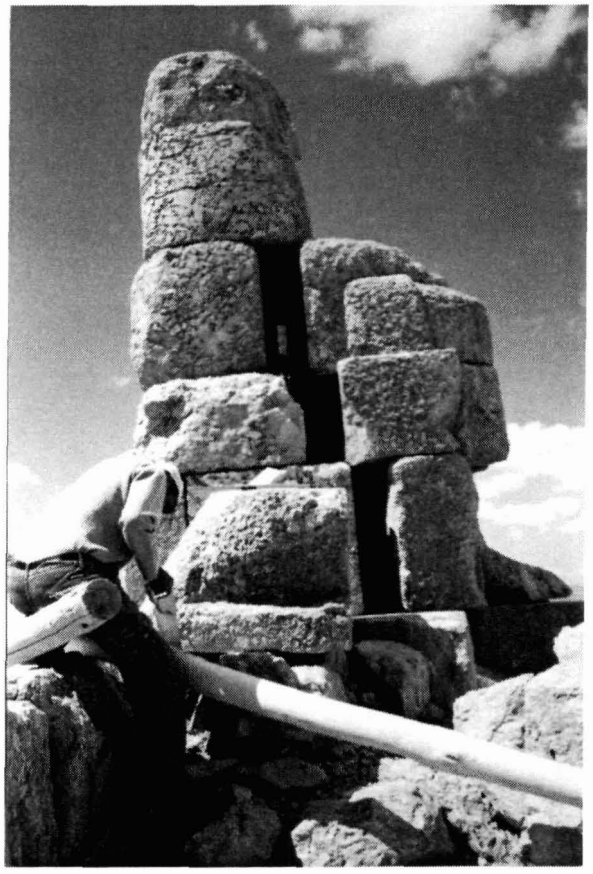


Photo 4: Antiochus statue – present condition

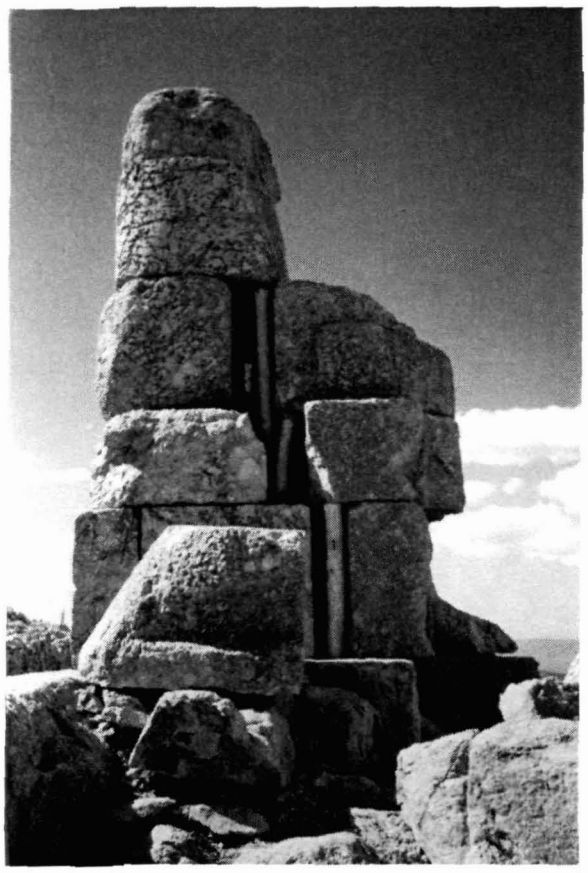


Photo 5: Antiochus statue – temporary support

Photo 6: East Terrace – crane location and operation

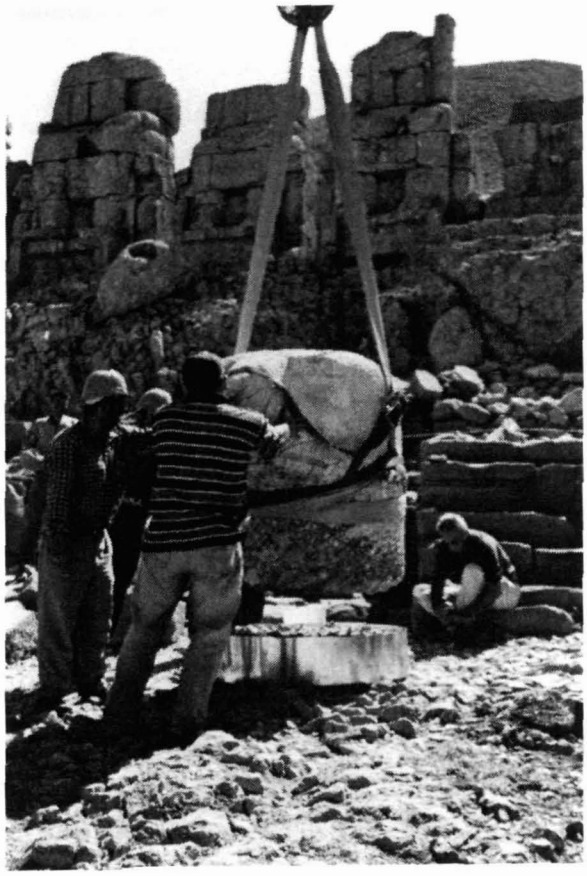


Photo 7: East Terrace – crane location and operation

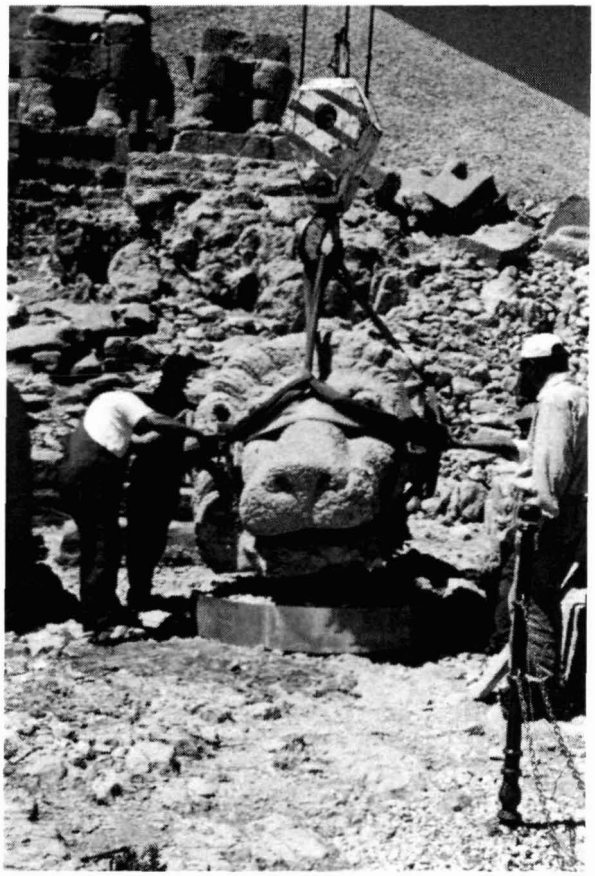


Photo 8: Process of lifting and placement of the heads of the statues

Photo 9: Process of lifting and placement of the heads of the statues

Photo 10: Process of lifting and placement of the heads of the statues

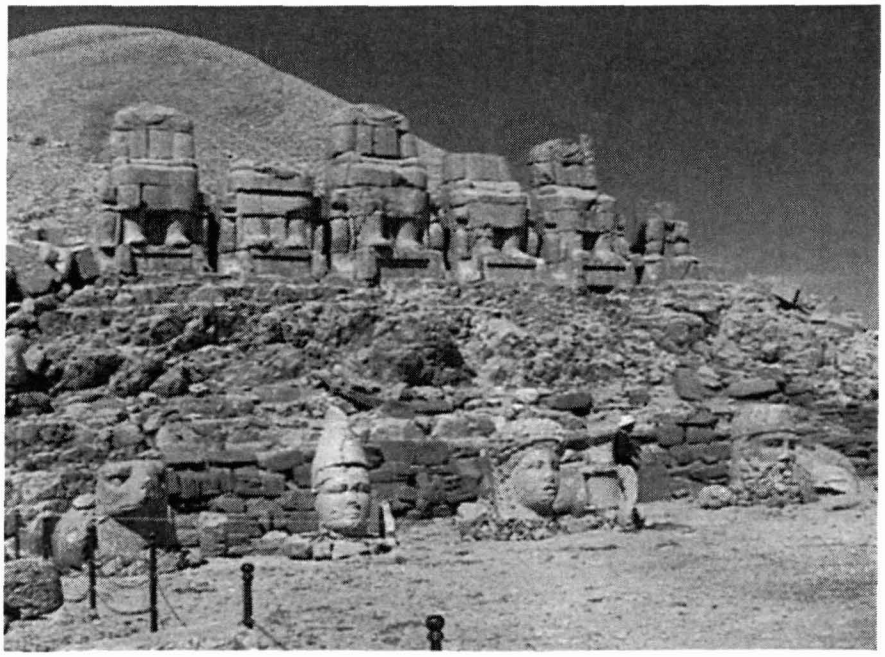


Photo 11: East Terrace – new arrangement of the heads of the statues

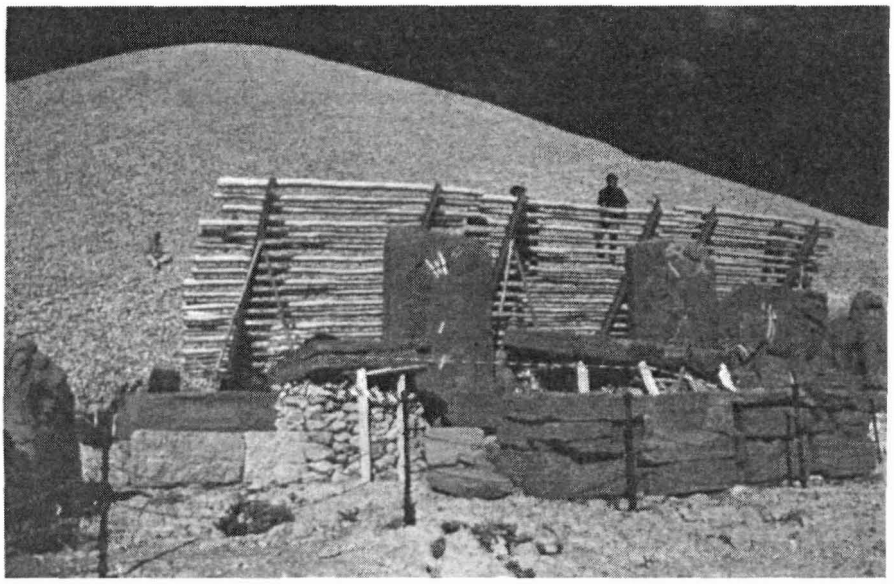


Photo 12: West Terrace – support of the fallen stelae

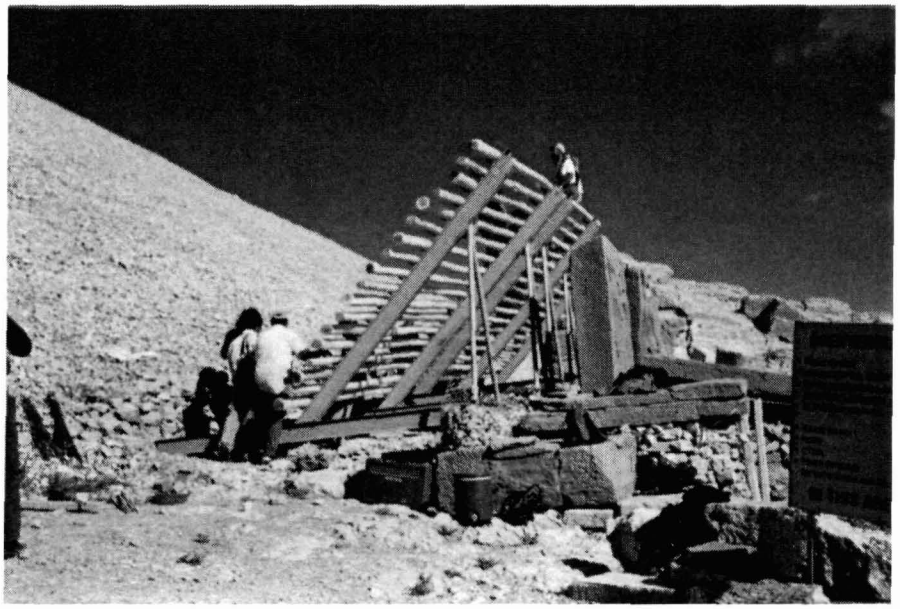


Photo 13: Snow Shelter, West Terrace

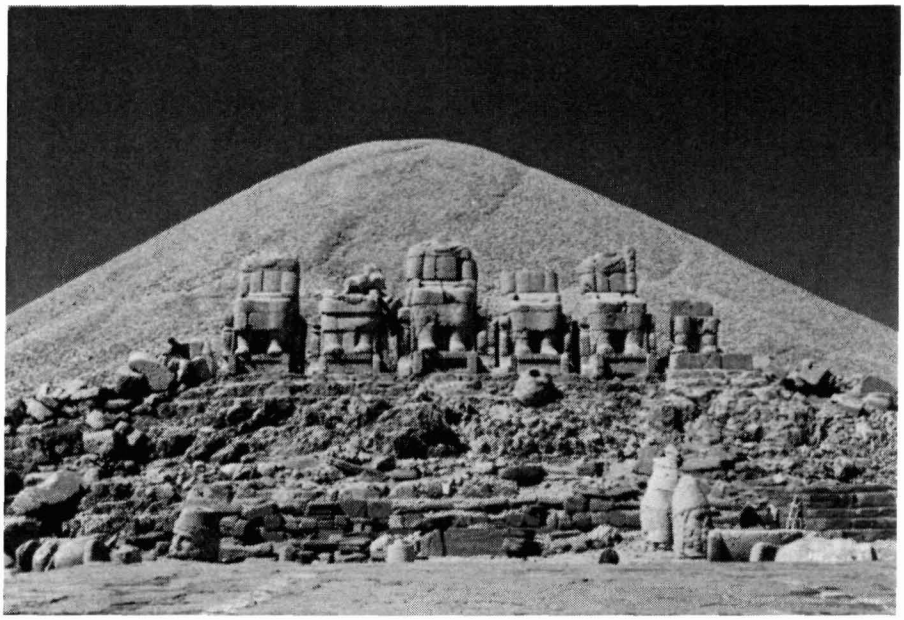


Photo 14: East Terrace – front view of the statues

Photo 15: East Terrace – back view of the statues

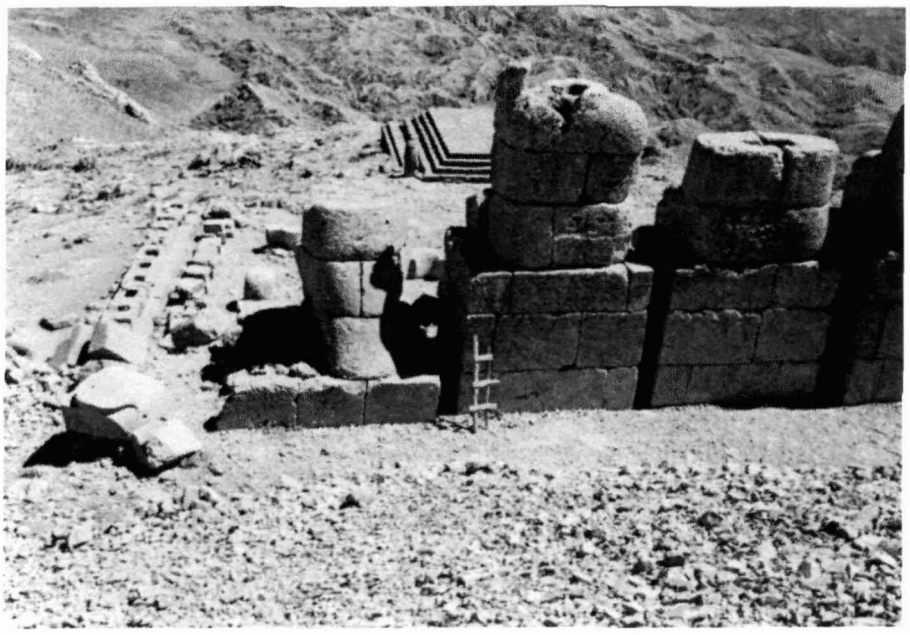


Photo 16: Eagle and Lion, East Terrace – north side

Photo 17: Eagle and Lion, East Terrace – north side

WORLD MONUMENTS FUND - NEW YORK

NEMRUD DAG FINAL FIELD MISSION REPORT

JUNE/JULY 2002

APPENDIX

APPENDIX A

STRUCTURAL STABILITY AND EARTHQUAKE VULNERABILITY

BY DR. AHMET TURER. MIDDLE EASTERN TECHNICAL UNIVERSITY, ANKARA

LOCATION OF NEMRUD DAG WITH EMPHASIS ON SEISMIC ISSUES

The artificial tumulus of Nemrud Dag, a World Heritage Site, is located within boundaries of Adiyaman City at 47.73.47E and 420.39.24N UTS global coordinates (Figure 1). Turkey exists in the junction of many plates as shown in Figure 2. These plates form numerous active fault zones, which have the capability of generating intensive earthquakes. Nemrud Dag is located very close to the East Anatolian Fault (Figure 3). The distance to the fault line can be approximately calculated using Adiyaman and Kahta as reference points, then extrapolating the distances on the zoomed active fault maps as shown in Figure 4c. As seen from the figures, the site is located very close, 5 to 10 km proximity, to the East Anatolian Fault, which is seismically active.

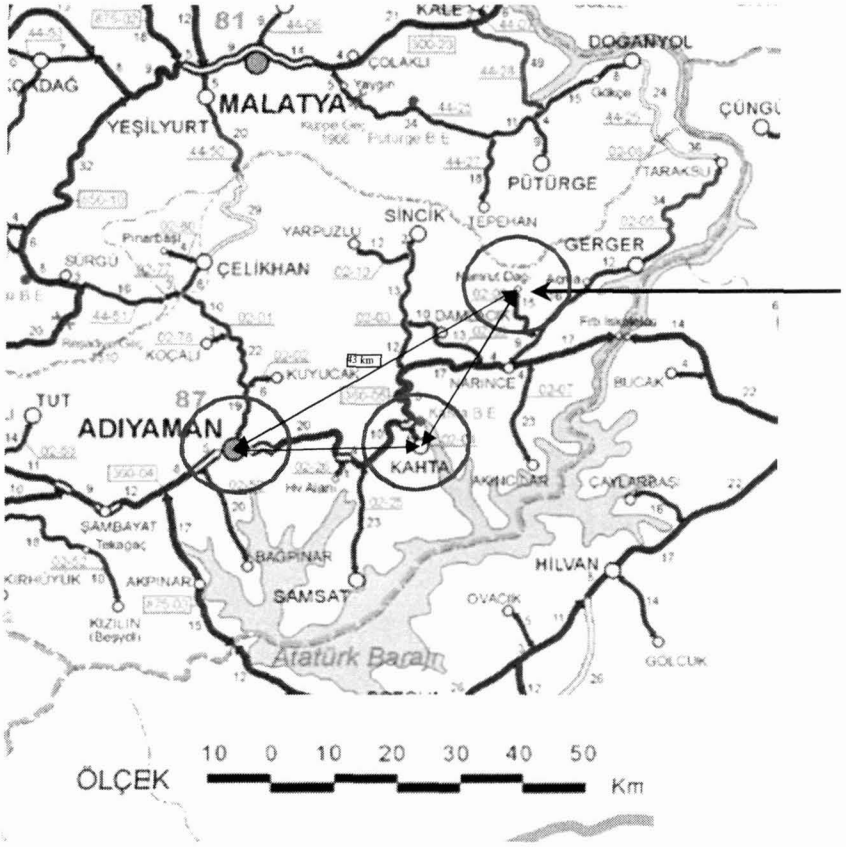


Figure 1: Road Mapof Adiyaman with Shown Distances

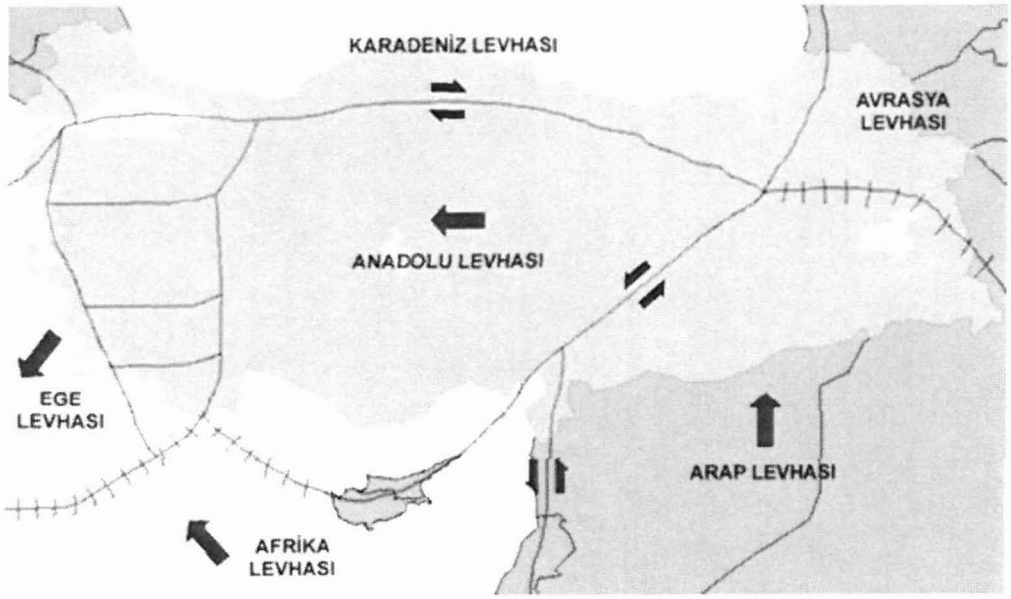


Figure 2: Major Plates in Turkey

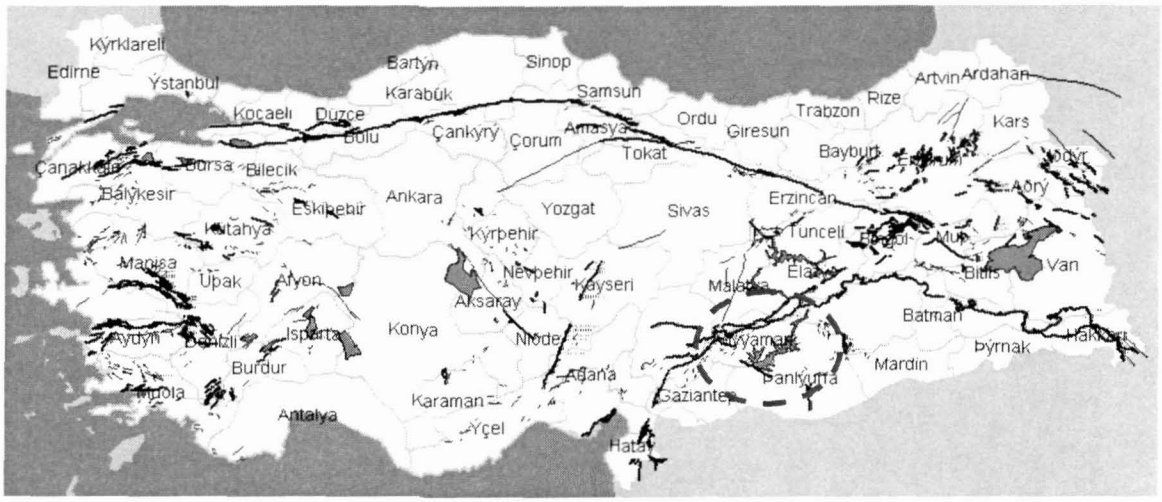
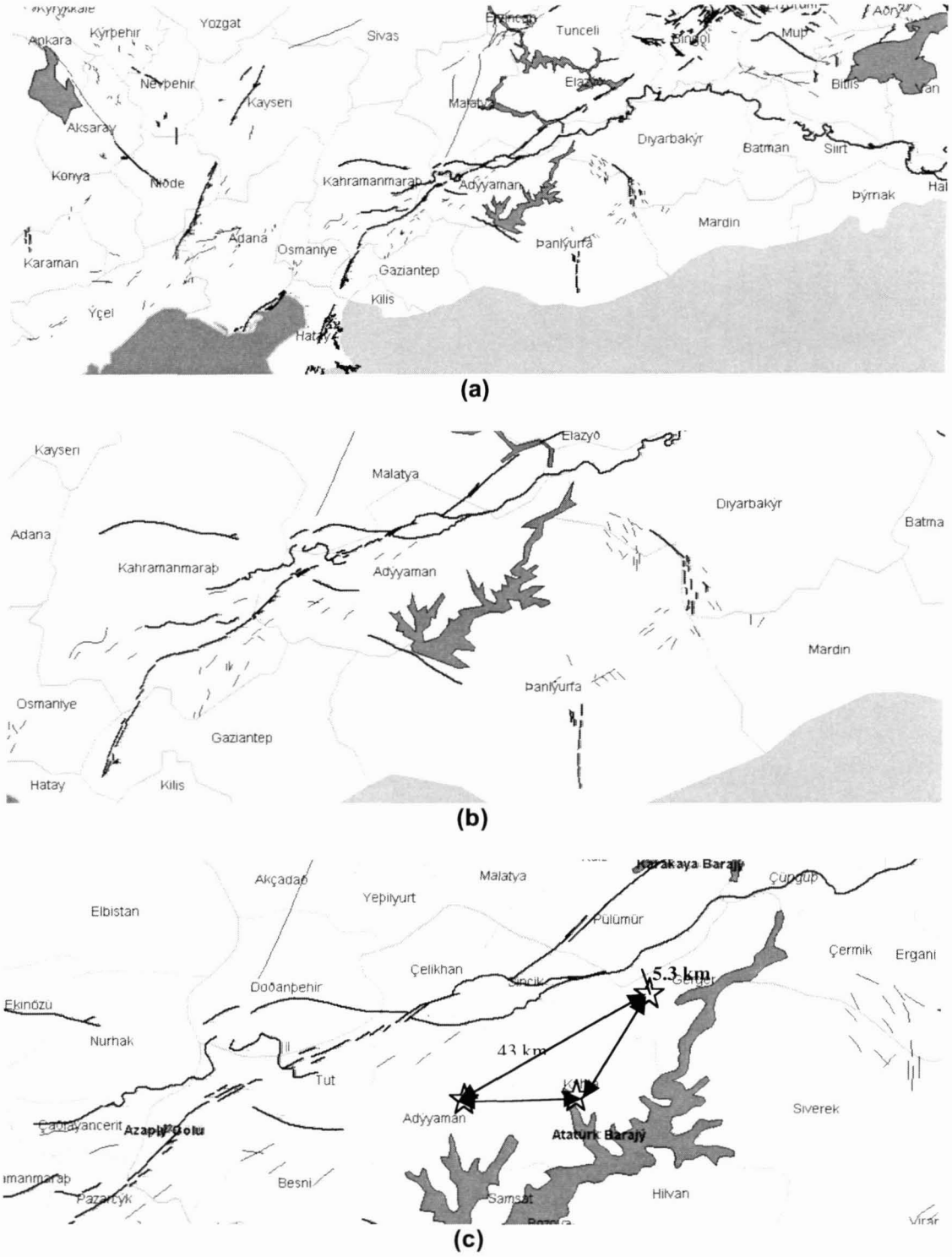


Figure 3: Major Active Faults in Turkey



(a)

(b)

(c)

Figure 4: Location of Nemrud on Major Active Faults Map of Turkey (zoomed)

The activities recorded on the East Anatolian Fault can be seen using the *Earthquake Location and Magnitudes* map from USGS database for 3.0 to 9.9 and 4.0 to 6.9 ranges in Figure 5 and Figure 6, respectively. The Nemrud site is marked with a 'star' in both figures. As clearly seen from these figures, the faults are seismically active and capable of generating large earthquakes.

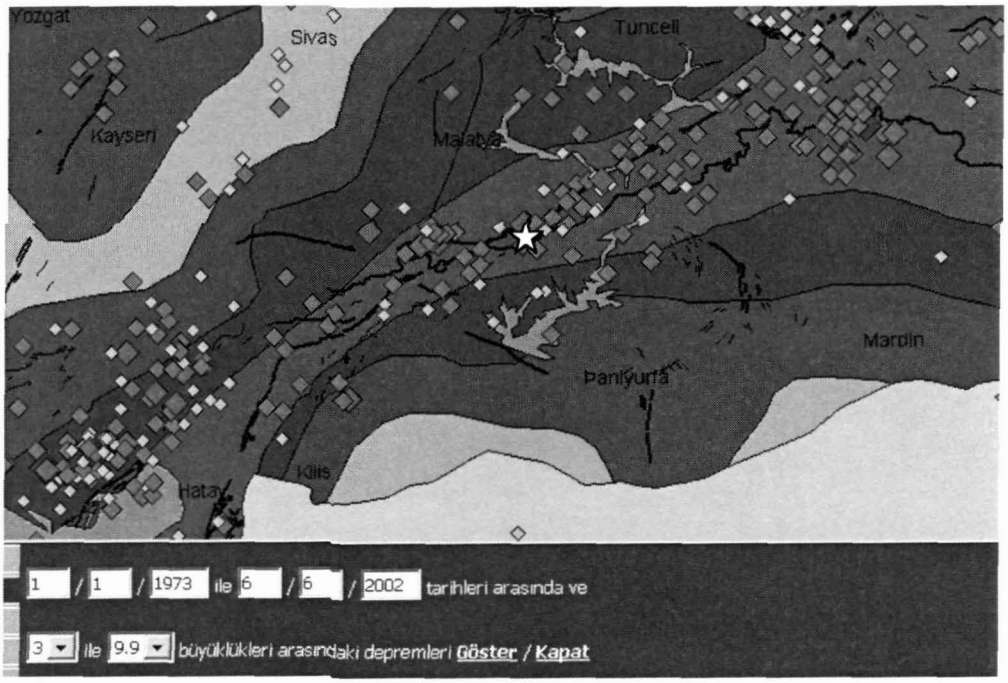


Figure 5: Earthquakes in the Region Since 1973 for Magnitudes Between 3.0 and 9.9

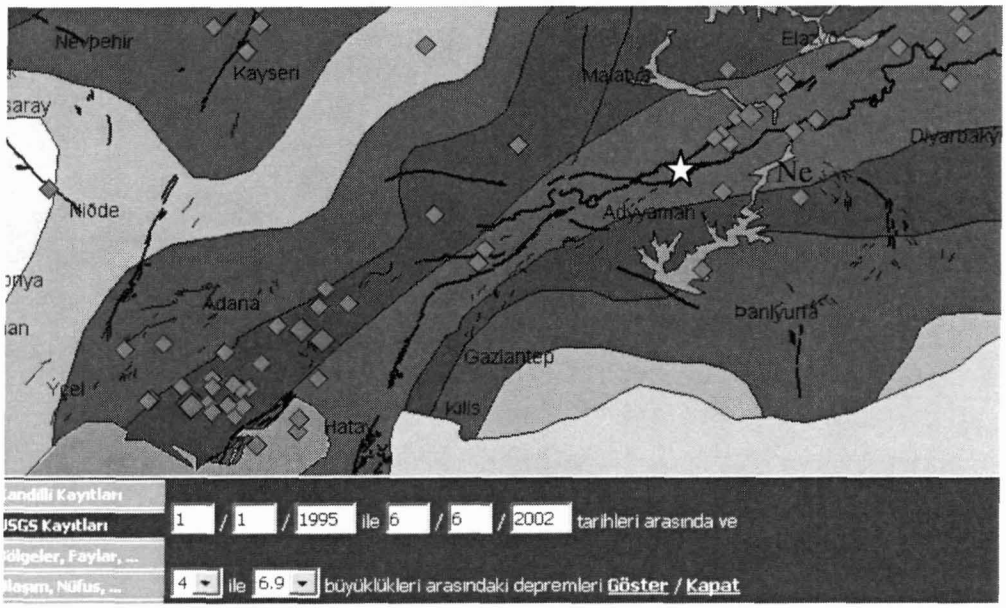


Figure 6: Earthquakes in the Region Since 1973 for Magnitudes Between 4.0 and 6.9

Both maps are shown in the above figures overlapped with the *Earthquake Zoning Map of Turkey.* It is clearly seen that the Nemrud site is located within the 1st degree earthquake zone. The earthquake zone map of Adiyaman (Figure 7) is also provided below for further examination.

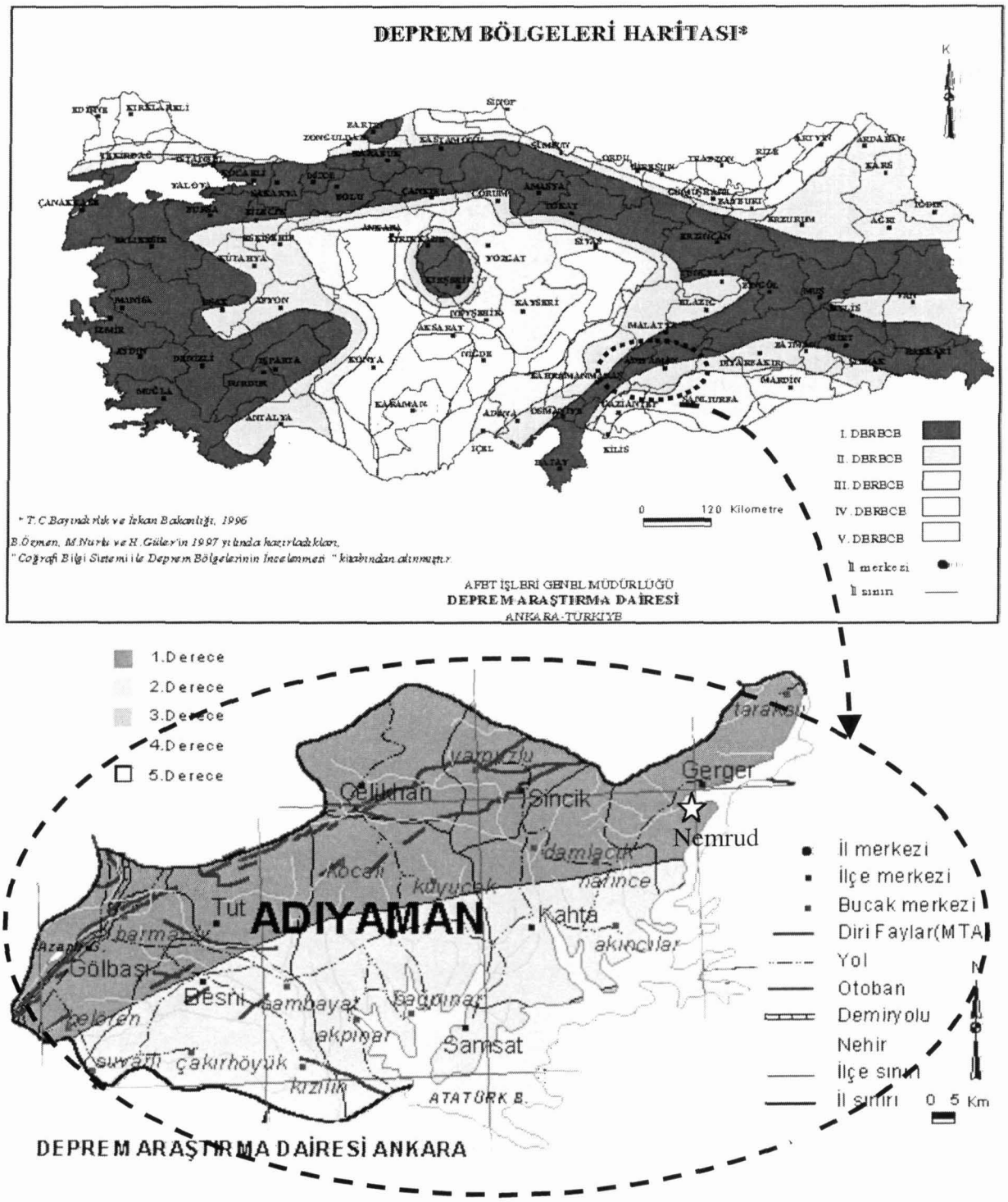


Figure 7: Adiyaman Earthquake Zone Map

The *Earthquake Zoning Map of Turkey* is prepared by the Ministry of Public Works and Settlement considering the latest knowledge and approved by the Government of Turkey and published in 1996. The earthquake zones are determined by using the acceleration contour maps (which were calculated using probabilistic methods). It assumes that a normal construction, which has 50 years of economical life, may not be exposed larger than these expected maximum acceleration values with 90% probability. This is equivalent to an earthquake with return period of 475-500 years. For the important constructions or buildings that have a longer economical life, maximum acceleration values should be calculated.

Earthquake zones of Turkey are classified as fallow due to expected acceleration values:

1st degree earthquake zone: more than 0.4g
2nd degree earthquake zone: between 0.3g - 0.4g
3rd degree earthquake zone: between 0.2g - 0.3g
4th degree earthquake zone: between 0.2g - 0.1g
5th degree earthquake zone: less than 0.1g
g: gravity(981 cm/s*s)

It is evident from this data that an earthquake of 500 year return period with maximum peak acceleration **larger** than 0.4g might be expected in this region in the next 50 years. The 90% of survival probability is assumed for civil engineering structures and does not comply with the monuments located at the Nemrud site.

The monuments of Nemrud are built using blocks of stones that are piled on top of each other. There are no connection between the stones and any shear keys. As the ground starts to move with accelerations larger than 0.4g, large inertial forces will be generated due to the mass of each stone. The force on each stone is going to be a linear function of mass and acceleration (F=m*a). The stone pieces are going to be pushed horizontally trying to slide or overturn them in pieces or as a whole.

In addition to the horizontal forces generated during a possible earthquake, there will be "near field effects" associated with the closeness of the Nemrud site to the active fault. Nemrud is located 5 to 12 kilometers away from the fault line (see Figure 4). When a site is located too close to a fault line, the permanent displacement and vertical accelerations combined with the horizontal accelerations generate an even worse condition on existing structures. The pieces of stone blocks piled on top of each other (without shear keys) are extremely vulnerable to earthquakes. Re-erection of monuments should definitely be prohibited without making any detailed analysis and tests on scaled lab models.

Only the heads of the large monuments (human figures) have shear keys (at the head level only). The lion and the eagle do not have a similar shear key. The heads will definitely fall off in the first earthquake causing further damage at the surface level, even possibly damaging the integrity of individual stones (probably splitting them into pieces). From a structural and seismic point of view, **re-erection of the extant sculptural fragments (anastylosis) should be strictly prevented and prohibited** until all the necessary calculations, analysis, modeling, simulation activities are conducted, stability concerns are addressed, and possible strengthening or other alternative approaches are fully discussed. Re-erection of the monuments is an open invitation to damaging a historical heritage in the first earthquake.

The stone blocks of the west side are all dislocated and resemble rubble (Figure 8). The east side monuments suffer serious dislocation although the larger monuments still stand up

excluding the heads. The eagle and lion statues are down at both sides of the mountain. The standing portions on the east side have serious structural conditions that must be addressed as an emergency.

EAST SIDE:

- Base stone of Herakles, the one next to the eagle, has a base stone with a critical cavity underneath (Figure 9). The base stone is carrying a large load in flexure, simply supported at both ends and might possibly let the whole massive weight go soon with the initiation of the first crack. Although the void underneath the stone is in the range of about 10cm, a failure in the base stone tension zone would lead to instability of the remaining stones.

- Herakles again has a seriously fractured stone block, as shown in Figure 10, which may lead to structural failure. The stabilization of the fractured blocks should be addressed immediately.

- Monument of Apollo, the first standing one from the left, has a series of dislocated stone blocks (in the second and third layers) which may lead to failure if they move outwards a little bit more. They should be carefully pulled back to original locations.

- The shoulder of Antiochus is instable over the slope, and may come down breaking and smashing against the heads at the ground level.

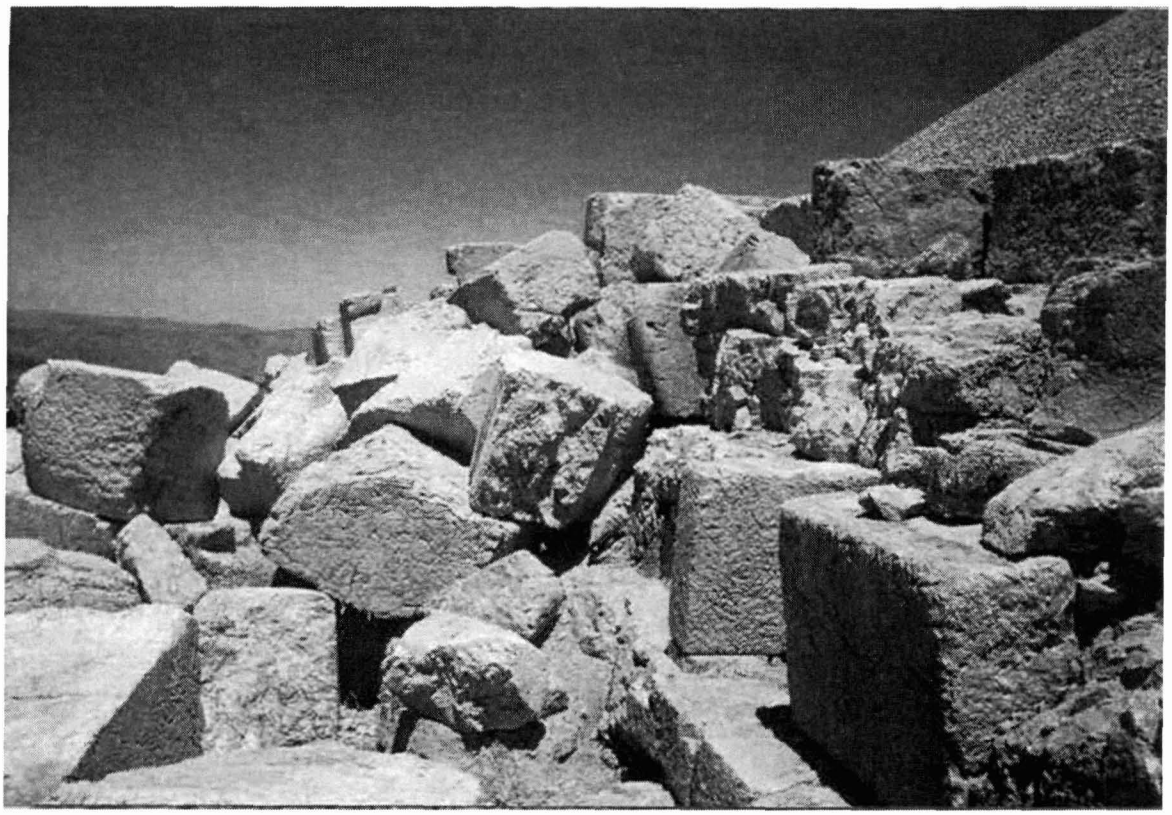


Figure 8: Totally Collapsed Statues at the West Side

Figure 9: Base Stone of Herakles, Simply Supported and Fracture Critical (East)

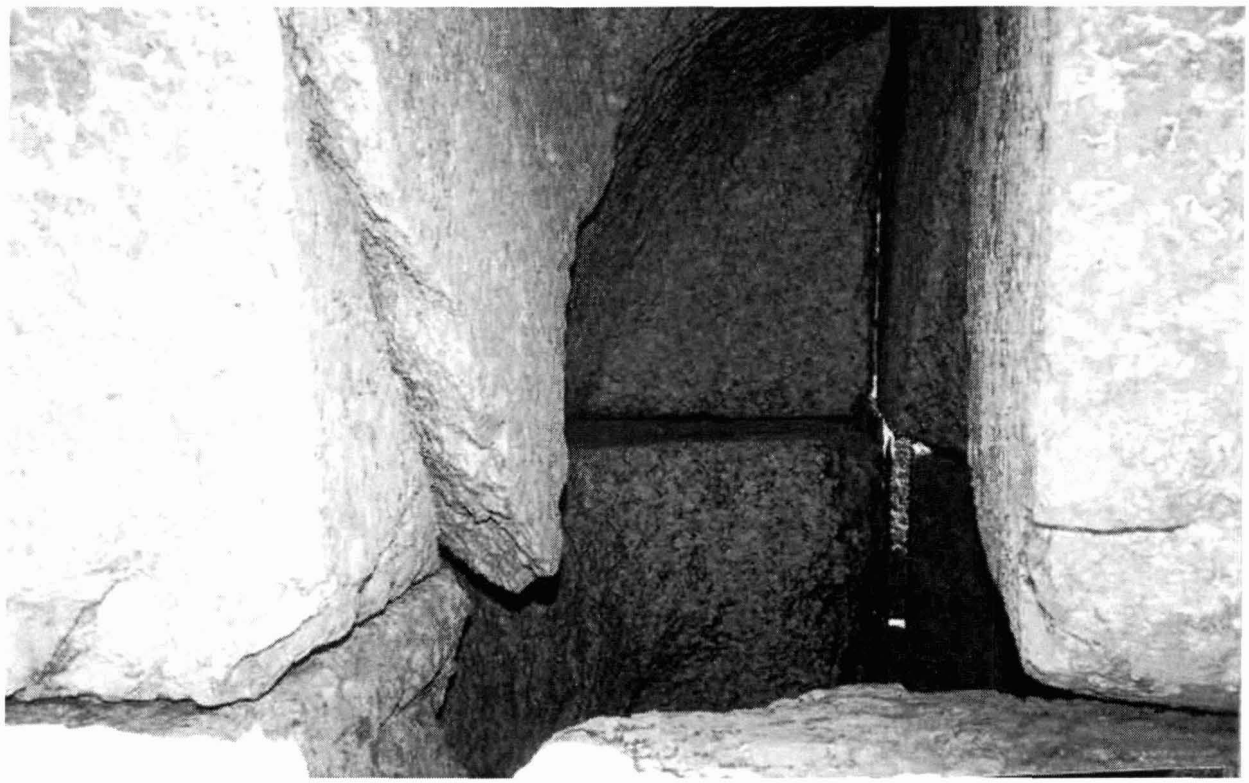


Figure 10: Fractured Upper Block of Herakles, May Lead to Sudden Failure

WEST SIDE:

- The second stelae from the left has been tipped and fell face forwards during snowy season (Figure 11). "Before" damage condition can be seen from the local postcards (Figure 12). The current condition of the stone is very unstable and in a dangerous condition for itself and for the visitors. The stelae must be urgently stabilized.

- Other (still standing) stelae are poorly designed for lateral forces. The contact areas at the base are very small. Concrete mortar was used in a previous attempt to fix the base of the Lion Stelae (see Figure 13. Only about _ of the base is keeping the stelae up and all stelaes are very vulnerable to earthquake forces. Even the snow pressure from behind (the mountain side) is enough to tip the stelae (Figure 11). Combined with degrading and deteriorating stone structure of stelaes (due to freezing and thawing) it may be recommended to place them on the ground with full base contact to prevent any bending moment formation. They may be preserved in plastic airtight wraps during off-season and from precipitation.

- Base stone of stelae are in bad condition and should be strengthened.

- Stability of the stone pieces over the tumulus must be addressed.

- Snow pressure on stelae must be addressed.

Stabilization studies conducted in 1980's on the Lion Stelae at west side were very badly designed and actually ended up damaging the stelae even more. The steel rods placed inside the two facing stone pieces were very short compared to 'development length' to fully make use of the steel rods (Figure 14). Therefore, the rods slipped out of the drill holes without resisting overturning. The epoxy used had no use holding the pieces together. The two rods placed at the cross section were of different diameters and different material properties (rusting and stainless steel) as it can be seen in Figure 15. The rods were located close to the center of the stone cross section where the neutral axis is expected to exist. Over a cracked section, the rods would have better be placed close to the edges of the section for improved overturning resistance. **Careful planning and investigation should be conducted at the Nemrud site to prevent further similar mistakes and losses.**

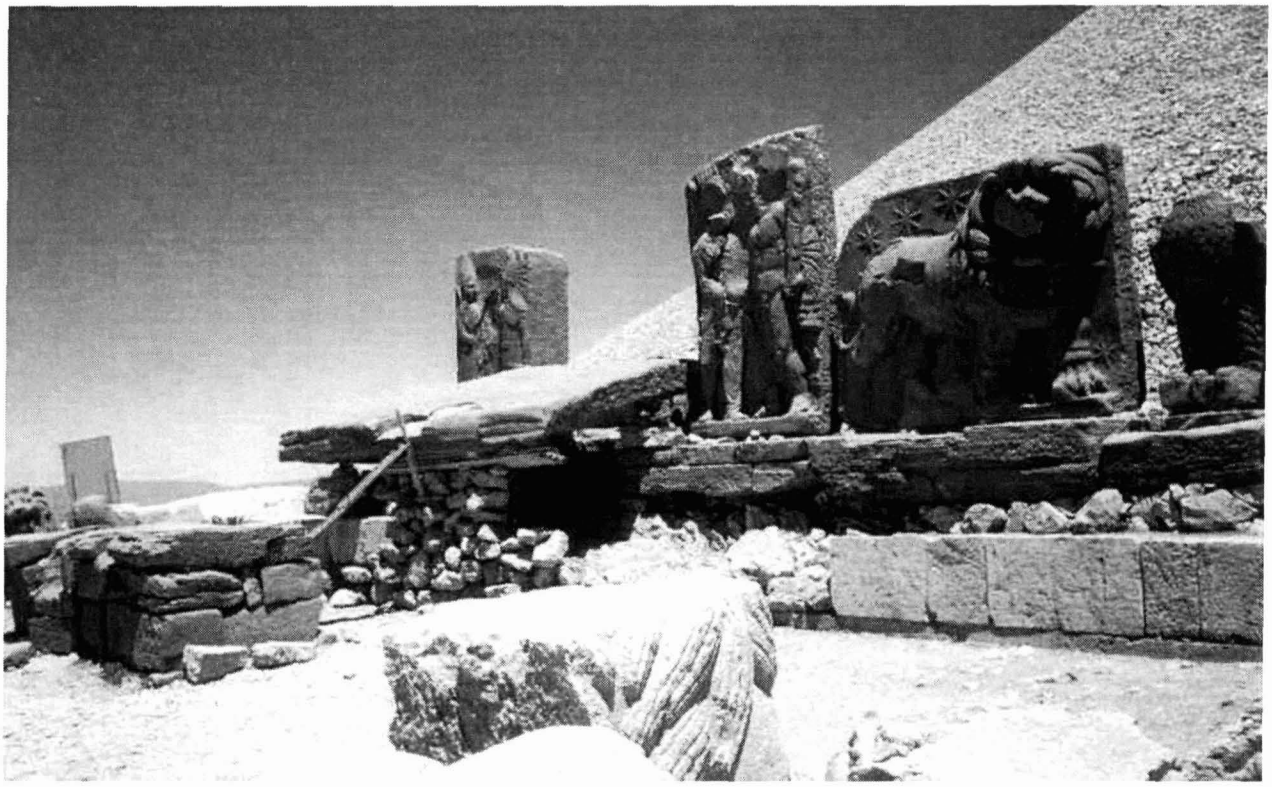


Figure 11: Tipped Stelae on West Side

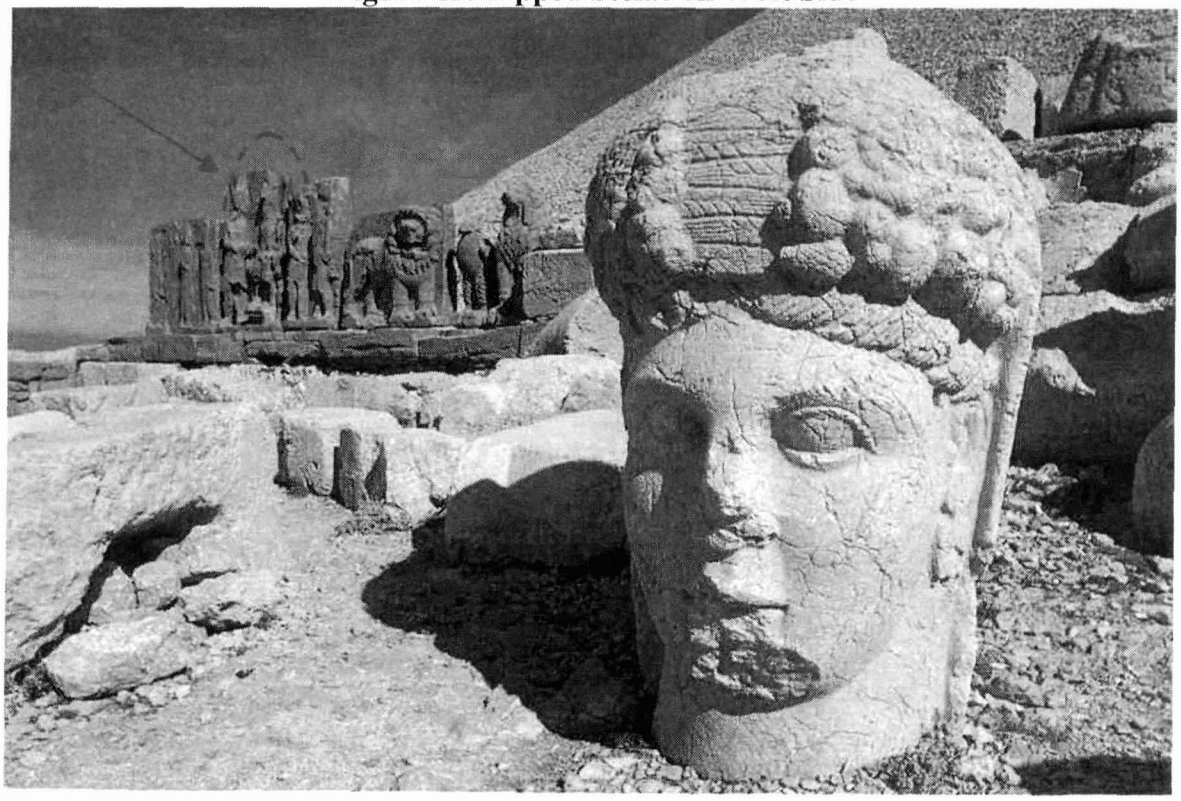


Figure 12: Stelae on West Side before Damage

Figure 13: Poor Base Design of Stelae (West Side)

Figure 14: Very Short Rod Length Incapable of Generating Axial Force

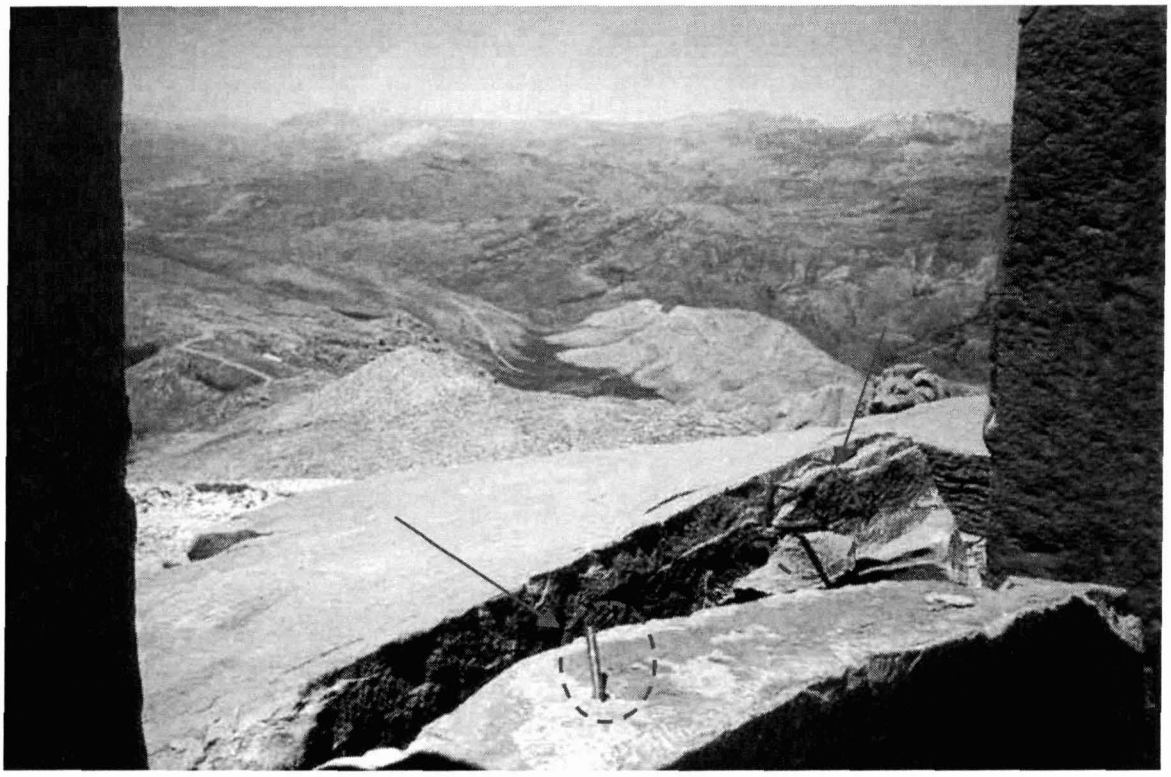


Figure 15: Different Diameter and Materials (Stainless-Rusting) Used for Re-bars

There are issues that must be addressed at Nemrud site in addition to the emergency issues:

- International Nemrud Foundation (INF) should share the documents that they have gathered so far including the detailed drawings of the stones, studies-analyses conducted so far, and the remaining work they have done with the Turkish team.

- INF proposed re-erection of the eagle and lion statues. Most of the stone blocks remained in the field exposed to various aging processes following the dislocation from their original locations. There are concerns about the integrity and strength of each block prior to any re-erection process:

    - The strength and integrity of stone blocks should be addressed, and necessary conservation and strengthening studies must be conducted on the stones.

    - Due to erosion, the stone blocks may not be leveled.

    - If any earthquake (EQ) analyses are carried out for the monuments, they should be shared by the Turkish team.

    - The 90-ton crane should not be placed inside the garden. The dislocation of any stone block should be carefully planned and minimized to prevent any possible damage.

    - The road constructed in June 2002 makes the site susceptible to stealing pieces from the site. Existence and possible usages of the road should be re-evaluated.

- The material properties of the stone blocks must be determined. The material properties should include (but not limited to) Modulus of Elasticity (E), Stress-Strain behavior, Ultimate Compressive Strength, Ultimate Shear Capacity, Friction Coefficient, Unit Weight, etc.

- Simple overturning and sliding analysis must be conducted followed by more complex nonlinear Finite Element Modeling (FEM). The computer model should be excited using measured earthquake accelerations, as well as response spectrums given by the code. (i) Overturning the heads and/or the monument as a whole or (ii) sliding off the cliff or between the blocks are two possible collapse scenarios. As a third option, the failure might be a combination of these two.

- The monuments might be strengthened against EQ using base isolators and (plastic) shear keys between blocks.

- Each activity conducted on site must be recorded using video camera(s).

PROPOSED WORK PLAN FOR NEMRUD MONUMENTS FROM A STRUCTURAL POINT OF VIEW

Nemrud monuments are located in the 1st degree earthquake (EQ) zone, and carry overburden of poor initial design. Stelaes, tumulus, and statues are all vulnerable against earthquake and in part against snow loading. Stelaes might be secured by lowering flat on the ground against EQ and snow loading. Instability of the stone rubble over tumulus during an EQ may not be an issue since it has been fairly stable over the 2000+ years, and there seems to be trenches underneath the stone rubble for added stability. However, statues are formed of massive stone blocks that are not interconnected and probably exhibit to be the most critical structure on site.

The structural studies can be grouped under the following headings:

Material Tests

3 months – about $765 USD

- Obtaining stress-strain relationship for axial and shear forces of stones: tensile strength, modulus of elasticity, ultimate strength, shear modulus, Poisson's ratio, etc.

Analytical Studies and Tests

18 months – $38,000 USD

- Simplistic dynamic analysis of monuments

- More complex FE analysis of monuments

- Lab tests and simulations on scaled-down replicas of the monuments using shaking table

- Investigation of structural strengthening options, testing each alternative, and repeating tests to improve behavior under EQ loading

Field Studies

2 years to 4 years – the cost is expected to be about $50,000 USD, however there are many uncertainties

- Application of the best option, found in the lab tests and analyses, on one of the actual monuments.
- Repeated field tests on dynamic behavior of the strengthened monument for pre- and post-strengthening conditions.
- If selected strengthening method proves to be as successful as it was in the lab, sturdy, and durable in the long run, the strengthening method would be repeated for the rest of the monuments to improve their behavior against earthquakes

Detailed listing of Part 2 expenditure (as planned):

	months		
$300	18	$5,400	A. Turer
$250	18	$4,500	PhD Student
		$5,000	Travel expenses
		$9,950	Material, testing utilities, setup, shaking table rent, etc.
		$24,850	Total
		$4,473	VAT 18%
		$8,698	University overhead 35%
		$38,021	**TOTAL**

LIST OF FIGURES:

APPENDIX B

BIBLIOGRAPHIC COMPILATION ON DETERIORATION AND CONSERVATION FOR THE STONE MONUMENTS

BY A. ELENA CHAROLA, WMF CONSULTANT

OBJECTIVE

The aim of this compilation is to provide the necessary background material for the discussions to be held during the proposed Stone Conservation Workshop that is planned to be held in conjunction with the next mission to Nemrud Dag (summer of 2002).

For this purpose the key conservation documentation relevant to the stones used in the sculptures at Mount Nemrud is brought together. Since no other study on these particular stones has been carried out except for the paper by Düppenbecker and Fitzner (1991), studies dealing with similar types of stones have been included. For the particular case of the tuffite, given that their general behavior is similar to that of sandstones, studies of these stones have been included in so far as they correspond to the deterioration patterns developed by the tuffite.

The Düppenbecker and Fitzner (1991) study was carried out some thirteen years ago, and not all the information obtained during the study was published. Prof. Fitzner has indicated that he is willing to make this information available. Furthermore, his study shows the model that needs to be followed for documentation, deterioration evaluation and treatment development. Hence, papers dealing with the approach to document deterioration patterns have also been included in this bibliography, since it would be of fundamental importance to carry out a new condition survey, following the same approach, prior to any intervention. This will enable to evaluate changes in the deterioration over this past decade.

In some cases, papers with similar contents are included in both German and English. The rationale for this is that the papers are not direct translations. Although they discuss the same main topic they do include different data and details. Furthermore, some of these papers are published in reports or publications that are not readily available.

The compilation needs to be completed with papers dealing with the local geology of the area, such as provided by a geological map and survey; data on earthquake frequency and intensity; and, local climate data as far as can be obtained, including average, maximum and minimum temperatures and their frequency, wind orientation and speed, rain-fall, relative humidity and insolation data. This information has been requested from Prof. Çaner Saltik, Middle East Technical University, Ankara.

A. Elena Charola, Ph.D.
Scientific Consultant in Conservation
3618 Hamilton Street
Philadelphia, PA 19104

October 31st, 2001

EXECUTIVE SUMMARY

Introduction

The statues and stelae that adorn the three terraces built at the base of the tumulus on top of Mount Nemrud used two different kinds of stones. The large sculptures found on the east and west terraces are carved out of limestone blocks, apparently quarried from the same Mount Nemrud. The stelae, found on the east, north and west terraces are fashioned out of tuffite, a sedimentary rock formed from residues of volcanic tuffs and other minerals. Its appearance and general behavior is similar to that of sandstone. There are also some sculptures carved out of tuffite, such as the guardian lions and eagles flanking the stelae to the left of the large statues on the west terrace. The quarry from which the tuffite might have been obtained has been recently identified, however, confirmation that this is indeed the original quarry awaits results from chemical and petrographical analysis.

Mount Nemrud is located in an area with a harsh climate. Daily temperature fluctuations are large, winds are strong and winters are very cold with snow accumulations covering the entire site. Freeze-thaw cycles are common and are a key factor in the deterioration of the stones.

Limestone

As described by Düppenbecker and Fitzner (1991) the limestone is practically pure and constituted of different sized and shaped calcite crystals. However, clays may be present localized in stylolytes or in pockets, as seen in the limestone blocks surrounding the site. Even if the amount of clays is under 1%, because of their localized concentration, they induce the particular deterioration patterns of alveolization and microfissuring. Similar deterioration has been observed for other high purity limestones such as the Portuguese Lioz limestone (Aires-Barros et al. 1998).

Microfissuring is enhanced by the presence of microorganisms, differences in crystal size and by freeze-thaw cycling. Microfissures will retain water longer than larger cracks and hence will be susceptible to freeze-thaw cycling as well as to colonization by micro-organisms that require moisture for growth. If clay stylolytes are present, these will also trap moisture and provide an appropriate support for the development of microorganisms (Aires-Barros et al. 1998). These organisms can secrete acidic or complexing agents that will dissolve calcite, thus enhancing the deterioration (Ascaso et al. 1998). Similarly, rainwater—normally slightly acidic (pH~5.6) due to the presence of dissolved carbon dioxide from the air—will dissolve smaller calcite crystals faster than larger ones. The dissolved calcite will in part redeposit within the stone filling some of the fissures. The process, called microkarstification, is similar to that occurring on a geological scale when caves are formed.

Alveolization is also enhanced by the presence of microorganisms that favor areas where clays are localized and where moisture will be retained. Furthermore, some algae, i.e., endolithic algae, are capable of growing at a subsurface level, giving a grayish appearance to the stone, as can be seen both around the alveoles and the microfissures (Ascaso et al. 1998). Since these organisms secrete calcite-dissolving substances they weaken the stone structure at a subsurface level.

The weathering of the limestone proceeds at a slower pace than that of the tuffite, mainly because of the differences in porosity and pore size distribution, as discussed by Düppenbecker and Fitzner (1991).

Conservation treatment of the limestone should address the issue of preventing water from entering the fissures so as to retard the natural weathering of this rock and an eventual biocidal treatment to eliminate the colonization by microorganisms. Recent studies discuss the difficult question of eliminating endolithic algae (Ascaso et al. n.d.).

The application of a water repellent treatment should be considered carefully and, if deemed necessary, would require laboratory testing even before *in situ* testing could be carried out. The required caution is based on previous experiences showing that limestone presents an erratic behavior with regards to the application of water repellents as compared to other types of stone (Charola 2001). Furthermore, it is known that the application of two successive treatments, such as a biocide and a water repellent, may result in a negative interaction and therefore total loss of efficiency in one or both of these treatments.

Tuffite

Except for the study of Düppenbecker and Fitzner (1991), no other publication addresses this type of stone. However, since its behavior is similar to that of sandstones, conservation literature based on the study of this type of stone can serve as a basis for understanding the deterioration mechanism and the eventual treatments available to slow this process down.

The most important deterioration pattern observed is contour scaling, flaking and eventual powdering. The mechanism that induces this type of weathering has been studied in detail and attributed to the localization of the critical moisture content in the stone (Wendler 1991, Wendler et al. 1991, Snethlage and Wendler 1997). The critical moisture content defines the point at which the transport mechanism of water changes from capillary to water vapor diffusion. The presence of liquid water in the capillary system will allow freeze-thaw deterioration that results from the crystallization of water into ice irrespective of the expansion suffered by this fluid. The porosity and pore size distribution play an important role in determining the susceptibility of the stone to freeze-thaw damage (Fitzner 1994).

Changes in water content from wet-dry cycling will induce expansion-contraction in the stone particularly if clays present in it. The tuffite of these monuments contains a high amount of these minerals making this stone susceptible to this type of deterioration. The damage results from mechanic fatigue of the grain structure in the stone (Snethlage and Wendler 1997). Finally, since this stone also has an important calcite content, its dissolution and reprecipitation can induce similar mechanical stresses at the point where the evaporation of the water occurs, i.e., the point where the critical moisture content is held longest. However, this is a slow mechanism and contributes minimally given the two other dominant deterioration factors.

To address the hydric, for liquid water, or hygric, for water vapor, clay induced dilation treatments with special surfactants have been developed (Snethlage and Wendler 1991, Snethlage et al. 1996, Wendler 1997).

Consolidants based on silicate esters have been improved by the addition of elastifying compounds to reduce the brittleness of the final consolidant (Wendler 1997). Furthermore, this

material can be additioned with different aggregates to allow bridging larger—at a submicroscopic level—gaps between particles (Boos et al. 1999).

Application of biocides and water repellents are not as urgent as addressing the main deterioration problem of contour scaling thus allowing time for their necessary testing.

Documentation

Prior to any conservation intervention it is fundamental to carry out a thorough condition survey. Since Düppenbecker and Fitzner (1991) have documented the state of conservation of some of these monuments about a decade ago, it is important to re-document their present condition. For this purpose it is suggested to follow the same methodology used at the time, especially since this is the most thorough approach that has been developed so far (Fitzner et al. 1996, 1997). This would facilitate comparison of the changes that have occurred over the elapsed time.

REFERENCES

Aires-Barros, L., Basto, M.J., Graça, R.C., Dionisio, A., Delgado Rodrigues, J., Henriques, F.M.A. and Charola, A.E. (1998)
Stone Deterioration on the Tower of Belem
International Journal for Restoration of Buildings and Monuments 4 [6] 611-626

Ascaso, C., Wierzchos, J., Delgado Rodrigues, J., Aires-Barros, L., Henriques, F.M.A. and Charola, A.E. (1998)
Endolithic Microorganisms in the Biodeterioration of the Tower of Belem
International Journal for Restoration of Buildings and Monuments 4 [6] 627-640

Ascaso, C., Wierzchos, J., Souza-Egypsy, V., de los Rios, A. and Delgado Rodrigues, J. (n.d.)
In Situ Evaluation of the Biodeteriorating Action of Microorganisms and the Effects of Biocides on Carbonate Rock of the Jeronimos Monastery (Lisbon)
International Biodeterioration & Biodegradation (in press)

Boos, M., Grobe, J., Hilbert, G. and Wendler, E. (1999)
Möglichkeiten und Grenzen der Steinfestigung im Kieselsäureester-System. Einsatzmöglickeiten Elastifizierter Kieselsäureestertypen
In: Proceedings of the 5th International Colloquium Materials Science and Restoration, Esslingen, MSR'99, Aedification Publishers, Freiburg Germany, pp. 1305-1313

Charola, A.E. (2001)
Water Repellents and Other "Protective" Treatments: A Critical Review
In: Hydrophobe III – 3rd International Conference on Surface Technology with Water Repellent Agents. K.Littmann and A.E.Charola, Eds., Aedification Publishers, Freiburg, pp. 3-20

Düppenbecker, V. and Fitzner, B. (1991)
Gesteinseigenschaften und Verwitterungszustand der Monumente auf dem Nemrud Dag
In: Nemrud Dag. Neue Methoden der Archäologie. Westfällisches Museum für Archäologie, und Westfällisches Museumamt, Landschafsverband Wesfalen-Lippe, Bönen, pp. 39-45 and 51, 55, 67-72

Fitzner, B. (1994)
Porosity Properties and Weathering Behaviour of Natural Stones—Methodology and Examples
In: Stone Material in Monuments: Diagnosis and Conservation. 2nd Course 1993, C.U.M. University School of Monument Conservation. F. Zezza, Director. Mario Adda Editore, Bari, pp. 43-54
Fitzner, B., Heinrichs, K. and Kownatzki, R. (1996)

Weathering Forms—Classifiaction and Mapping
In: Denkmalpflege und Naturwissenschaft. Natursteinkonservierung I. R. Snethlage, Ed., Ernst & Sohn, Berlin, pp. 41-87

Fitzner, B., Heinrichs, K. and Kownatzki, R. (1997)
Weathering Forms at Natural Stone Monuments—Classification, Mapping and Evaluation
International Journal for Restoration of Buildings and Monuments 3 [2] 105-124

Sahin, S. (1991)
Gegenwärtige Arbeiten zur Erforschung des Tumulus und der Denkmäler

In: Nemrud Dag. Neue Methoden der Archäologie. Westfällisches Museum für Archäologie, und Westfällisches Museumamt, Landschafsverband Wesfalen-Lippe, Bönen, pp. 27-30

Snethlage, R. and Wendler, E. (1991)
Surfactants and Adherent Silicon Resins—New Protective Agents for Natural Stone
In: Materials Issues in Art and Archaeology II, P.B.Vandiver, J.Druzik and G.S.Wheeler, Eds., Materials Research Society, Pittsburgh, PA, pp. 193-200

Snethlage, R., Wendler, E. and Klemm, D.D. (1996)
Tenside im Gesteinsschutz—bisherige Resultate mit einem neuen Konzept zur Erhaltung von Denkmälern aus Naturstein
In: Natursteinkonservierung in der Denkmalpflege, R. Snethlage, Ed., Arbeitshefte des Bayerischen Landesamt für Denkmalpflege, Vol. 80, München, pp. 127-146

Snethlage, R and Wendler, E. (1997)
Moisture Cycles and Sandstone Degradation
In: Saving Our Architectural Heritage: The Conservation of Historic Stone Structures. N.S.Baer and R.Snethlage, Eds., John Wiley & Sons Ltd., Chichester, pp. 7-24

Wendler, E. (1991)
Zum Mechanismus der Schalenbildung bei Tonigen Sandsteinen
In: Jahresbvericthe aus dem Forschungsprogramm Steinzerfall-Steinkonservierung, Vol. I 1989, Ernst & Sohn, Berlin, pp. 71-76

Wendler, E., Klemm, D.D. and Snethlage, R. (1991)
Contour Scaling on Building Facades—Dependence on Stone Type and Environmental Conditions
In: Materials Issues in Art and Archaeology II, P.B.Vandiver, J.Druzik and G.S.Wheeler, Eds., Materials Research Society, Pittsburgh, PA, pp. 265-271

Wendler, E. (1997)
New Materials and Approaches for the Conservation of Stone
In: Saving Our Architectural Heritage: The Conservation of Historic Stone Structures. N.S.Baer and R.Snethlage, Eds., John Wiley & Sons Ltd., Chichester, pp. 181-196