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# Restauriranje antičke carske skulpture iz Visa
## Restoration of an ancient imperial sculpture from Vis

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U tekstu su prezentirani konzervatorsko-restauratorski zahvati na carskoj skulpturi iz fundusa Arheološkog muzeja u Splitu. Opisane su raznovrsne metode i zahvati primijenjeni u postupku, poput analize vrste mramora, radiografskog snimanja, 3D snimanja, izrade plastičnog modela, izrade rekonstrukcija i nosive konstrukcije, koji su prethodili spajanju dijelova skulpture, te razne vrste čišćenja površine skulpture.

***Ključne riječi:*** *Arheološki muzej u Splitu, viške carske skulpture, restauriranje skulpture, pentelički mramor, 3D skeniranje*

The paper presents the conservation and restoration works on the imperial sculpture from the collection of the Archaeological Museum in Split. Various methods and procedures applied in the process are described, such as analysis of the marble type, radiographic imaging, 3D imaging, plastic modelling, reconstruction and support structure making, which preceded the joining of the parts of the sculpture, as well as various types of sculpture surface cleaning.

***Key words:*** *Archaeological Museum in Split, imperial sculptures from Vis, restoration of the sculpture, Pentelic marble, 3D scanning*

## Uvod

U restauratorsku radionicu Arheološkog muzeja u Splitu sredinom listopada 2019. godine stigle su dvije rimske carske skulpture iz Priručne zbirke *Issa* smještene u Gospinoj batariji u Visu. Skulpture je potrebno pripremiti za obljetničku izložbu *Vis-à-Vis 200. Arheološka baština otoka Visa*. Skulpture pripadaju skupini od pet carskih skulptura koje potječu s područja podno Gradine u Visu. Dvije skulpture nalaze se u fundusu Područne zbirke *Issa* na otoku Visu, jedna se čuva u Arheološkome muzeju u Splitu, jedna u Arheološkome muzeju u Zagrebu, a jedna u Beču.[1] Kako se skulptura u Beču sastoji od tijela i glave koji ne pripadaju jedno drugome, možda se može pretpostaviti da se radi o šest viših skulptura.[2] U ovom tekstu opisana je problematika prezentacije skulpture kojoj nedostaju nosivi dijelovi te su kronološki obrazloženi procesi koji su primijenjeni na skulpturi inv. br. AMS 74350.

## Povijesni i vizualni pregled

Carska skulptura s inv. br. AMS 74350 prikazuje diviniziranog cara (Augusta?). Pripada Priručnoj zbirci *Issa* i čuva se u prostorima Gospine batarije u Visu. Datira se u 1. st. (sl. 1). Krajem 19. st. pronašla su je braća Dojmi u svome vinogradu na području Gradine, gdje se nalazio forum i trijem antičke Ise.[3] Do kraja sedamdesetih godina 20. st. bila je izložena u predvorju palače Dojmi u Visu, kao dio obiteljske zbirke. Poslije se kao dio Priručne zbirke *Issa* čuvala u dvorištu Gospine batarije. Izrađena je od penteličkog mramora.[4] Sastoji se od dva dijela; gornji dio, torzo, ulazi u donji dio na mjestu početka plašta, himationa.[5] Na mjestu spajanja zatečen je originalni vapneni mort, koji se očito koristio pri spajanju dijelova. Gornjem dijelu nedostaje glava, desna ruka od ramena te lijeva podlaktica. Donjem dijelu nedostaje dio draperije ispod lijeve ruke, lijeva noga ispod koljena te dio baze. Zanimljiv i rijedak detalj je potpis kipara, koji se nalazi na panju skulpture: *APO* (*Appolonios*). Isti potpis nalazimo i na drugoj skulpturi, koja prikazuje cara Vespazijana, a izložena je u *Kunsthistorisches Museum* u Beču, inv. br. I 669

1 Ivčević 1998, str. 76

2 Glava i torzo nalaze se u *Kunsthistorisches Museum* u Beču. Glava je atribuirana Vespazijanu te je sačuvana kao ulomak kojem nedostaju stražnji dio i vrat. Glava je postavljena na torzo kao cjelina, premda nema zajedničkih dodirnih ploha. Vizualno se doimlje puno manjom u odnosu na torzo te se može pretpostaviti da je pripadala nekoj drugoj skulpturi. Danas se u Muzeju ta glava i torzo vode kao zasebni eksponati. www.khm.at/de/object/67de0228d7/ (2. 12. 2020.).

3 Brunšmid 1901, str. 90

4 Vidi poglavlje „Analiza kamena".

5 Himation, grč. *ἱμάτιο*, ogrtač koji se u antičkoj Grčkoj nosio iznad hitona ili na golom tijelu. *Hrvatska enciklopedija, mrežno izdanje.* Leksikografski zavod Miroslav Krleža, Zagreb, 2020. http://www.enciklopedija.hr/Natuknica.aspx?ID=25550 (2. 12. 2020).

## Introduction

In mid-October 2019, two Roman imperial sculptures from the *Issa* Reference Collection, located in Gospina batarija in Vis, were brought to the restoration workshop of the Archaeological Museum in Split. The sculptures had to be prepared for the anniversary exhibition entitled *Vis-à-Vis 200. The archaeological heritage of the island of Vis*. The sculptures belong to a group of five imperial statues that originate from the area near Gradina in Vis. Two sculptures are in the holdings of the *Issa* Regional Collection on the island of Vis, one is kept in the Archaeological Museum in Split, one in the Archaeological Museum in Zagreb, and one is in Vienna.[1] Since the body and head of the sculpture in Vienna do not belong to each other, perhaps it can be assumed that there are six sculptures from Vis.[2] This text describes the issues of presenting sculptures lacking the load-bearing parts, and chronologically elaborates the processes applied to the sculpture Inv. No. AMS 74350.

## Historical and visual overview

The imperial sculpture with Inv. No. AMS 74350 depicts a divinised emperor (Augustus?). It is part of the *Issa* Reference Collection and is kept on the premises of Gospina batarija in Vis. It is dated to the first century (Fig. 1). It was discovered by the Dojmi brothers at the end of the 19th century in their vineyard in the Gradina area, the site of the forum and portico of ancient Issa.[3] Until the end of the 1970s, it was on display in the entrance-hall of the Dojmi Palace in Vis, as part of the family collection. Later it was kept in the yard of Gospina batarija, as part of the *Issa* Reference Collection. It is made of Pentelic marble.[4] It consists of two parts: the upper part, the torso, which enters the lower part at the beginning of the outer garment, the himation.[5] The original lime mortar was discovered at the juncture, apparently used to join the parts. The upper part is missing the head, the right arm from the shoulder down, and the left forearm. The bottom part is missing a portion of the drapery under the left arm, the left

1 Ivčević 1998, p. 76

2 The head and torso are kept in the *Kunsthistorisches Museum*, Vienna. The portrait head of Vespasian is preserved as a fragment missing the hind part and the neck. The head is placed on the torso as a whole, although there are no common contact surfaces. It appears to be much smaller relative to the torso, and it can be assumed that it belonged to another sculpture. The head and torso are kept in the Museum as separate exhibits. www.khm.at/de/object/67de0228d7/ (2/12/2020).

3 Brunšmid 1901, p. 90

4 See chapter "Stone analysis".

5 Himation, Gr. *ἱμάτιο*, the outer garment worn by the ancient Greeks over a chiton or next to the skin. *Croatian Encyclopaedia, online edition.* Miroslav Krleža Institute of Lexicography, Zagreb, 2020. http://www.enciklopedija.hr/Natuknica.aspx?ID=25550 (2/12/2020).

*Slika 1.*
*Skulptura u predvorju obiteljske kuće Dojmi (izvor: Arhiv Arheološkog muzeja u Splitu)*

*Figure 1.*
*Sculpture in the entrance-hall of the Dojmi family house (source: Archives of the Archaeological Museum in Split)*

(sl. 2, 3), te se može pretpostaviti da je djelo istog kipara.[6] Vidljivi su i metalni trnovi koji su držali ostale dijelove tijela i draperije; trnovi su korodirali i prouzročili oštećenja mramora. Površina skulpture mehanički je oštećena i erodirana zbog uvjeta u kojima se skulptura nalazila tijekom vremena. U površinu su urezani grafiti nastali u vrijeme kad je skulptura bila izložena u predvorju palače Dojmi u Visu, a zamijećena su i oštećenja površine nastala u vrijeme kad se skulptura nalazila u dvorištu Gospine batarije. Upravo je izloženost atmosferilijama u dvorištu Batarije pogodovala i nastanku organskog obraštaja (lišajevi i mahovina), koji je znatno utjecao na stanje sačuvanosti skulpture.

6 Brunšmid 1901, str. 91.

leg below the knee, and a part of the base. The signature of the sculptor – *APO* (*Appolonios*) – located on the stump of the sculpture, is an interesting and rare detail. The same signature can be found on another sculpture, depicting Emperor Vespasian, exhibited in the *Kunsthistorisches Museum* in Vienna, Inv. No. I 669 (Figs. 2, 3). Therefore, it can be presumed to be the work of the same sculptor.[6] Metal tangs holding other body parts and the drapery are also visible. They are corroded and hence damaged the marble. The surface of the sculpture is mechanically damaged and eroded due to the conditions in which it was kept. Graffiti was carved into the surface when the sculpture was exhibited in the entrance-hall of the Dojmi Palace in Vis. It also suffered surface damage when it was located in the bailey of Gospina batarija. It was the exposure to weather conditions in the Batarija bailey that facilitated the emergence of organic growth (lichens and moss), which significantly affected the state of preservation of the sculpture.

**Stone analysis**

While determining the type of stone, we used laboratory data from 2003, when samples had been imaged and compared at specialised LEMLA laboratories in a joint effort of the Archaeological Museum in Split and the Department of Geology and the Department of Art History of the Autonomous University of Barcelona.[7] The analysis of the samples taken from the Vis sculptures revealed that it was Pentelic marble.

The report of sample analysis indicates that the sample of Vis marble is of an intense white colour, small crystal grains, extremely compact and medium transparent. Microscopic examinations revealed small flaky formations of muscovite.[8] This marble is largely calcareous, with minute quantities of dolomite.[9] The grains have polygonal shapes. There are occasional

6 Brunšmid 1901, p. 91.

7 Namely, the sensational discovery of a group of imperial sculptures from the *Augusteum* in Vid near Metković (ancient *Narona*) was the topic of the day at the time. In 2003, thanks to the engagement of Emilio Marin, PhD, the director of the Archaeological Museum in Split and the director of archaeological research in Vid, as well as Ivo Donelli, the director of the restoration works on the imperial group, a collaboration was started with Aurelio Alvarez PhD and Prof. Isabel Rodá de Llanza, PhD, from the LEMLA Laboratory of the Department of Art History at the Autonomous University of Barcelona. Samples of most of the sculptures from the Vid imperial group and two samples of imperial sculptures from Vis were submitted for laboratory analysis. We would like to thank Ivo Donelli for the provided documents.

8 The mineral muscovite – $KAl_2(AlSi_3O_{10})(F,OH)_2$ – is the most common member of the mica group. It crystallises in a monoclinic system, and the crystals are tabular. It is typically found in sheets or in flaky grains. It is transparent or translucent, with a white streak and most often pearly lustre, rarely vitreous or silky.

9 Dolomite – $CaMg(CO_3)_2$ – is the term used for a mineral and a rock. Dolomite crystallises in a trigonal system, and its crystals are

*Slika 2.*
*Kiparov potpis na skulpturi inv. br. AMS 74350 (foto: D. Ordulj)*

*Figure 2.*
*Author's signature on the sculpture Inv. No. AMS 74350 (photograph: D. Ordulj)*

*Slika 3.*
*Kiparov potpis na skulpturi koja se nalazi u Kunsthistorisches Museum u Beču, inv. br. I 669 (prema Ivčević 1998, str. 76)*

*Figure 3.*
*Author's signature on the sculpture located in the Kunsthistorisches Museum, Vienna, Inv. No. I 669 (after Ivčević 1998, p. 76)*

| | | |
|---|---|---|
| 3019 | Issa 01 A1 | Pentèlic |
| 3020 | Issa 01 A2 | Pentèlic |
| 3021 | Issa 01 B1 | Pentèlic |
| 3022 | Issa 01 B2 | Pentèlic |

*Tablica 1.*
*Rezultati uzoraka uzetih s viških skulptura (izvor: Laboratorij LEMLA, Universitat Autònoma de Barcelona, svibanj 2003.)*

*Table 1.*
*Results of samples taken from Vis sculptures (source: LEMLA Laboratory, Universitat Autònoma de Barcelona, May 2003)*

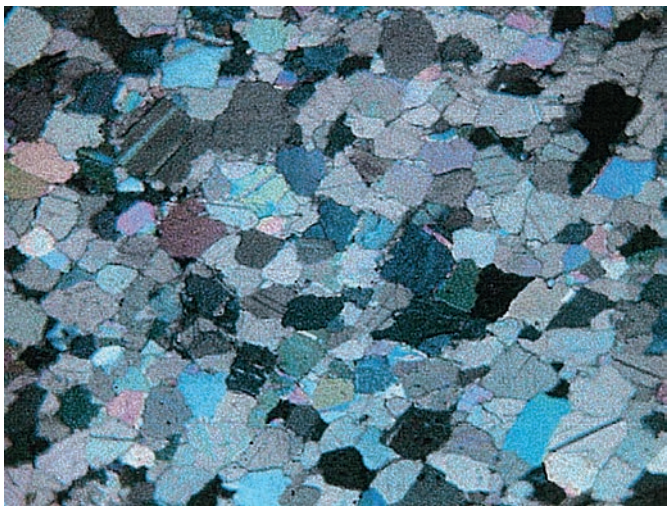
**Analiza kamena**

Pri određivanju vrste kamena služili smo se laboratorijskim podacima iz 2003. godine, kad je, u suradnji Arheološkog muzeja u Splitu te Odjela za geologiju i Odjela za povijest umjetnosti Autonomnog sveučilišta u Barceloni, u specijaliziranim LEMLA laboratorijima provedeno snimanje i usporedba uzetih uzoraka.[7]

tiny grains of quartz of primary origin, very small in size (of a compact, fine-grained texture) and round in shape. For a comparative sample, we refer to previous reports in which sample of LEMLA 5097 was photographed, viz. material from the very quarries. With small variations in grain size and distribution, samples from fragments of Vis sculptures were undoubtedly identified as Pentelic marble (Figs. 4, 5).

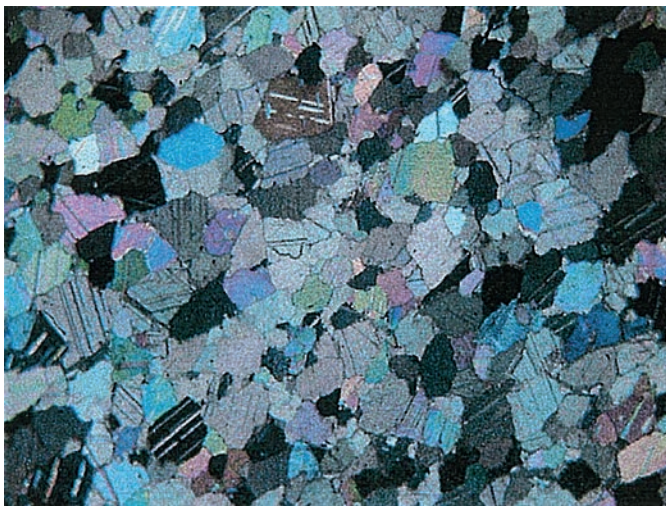
7 Tih je godina, naime, bio aktualan senzacionalan nalaz skupine carskih skulptura iz *Augusteuma* u Vidu kod Metkovića (antička *Narona*). Angažmanom ravnatelja Arheološkog muzeja u Splitu i voditelja arheoloških istraživanja u Vidu dr. sc. Emilija Marina te voditelja restauratorskih radova na carskoj skupini Ive Donellija, godine 2003. došlo je do suradnje s dr. sc. Aureliom Alvarezom i prof. dr. sc. Isabel Rodá de Llanza iz Laboratorija LEMLA Odjela za povijest umjetnosti Autonomnog sveučilišta u Barceloni. Na laboratorijsku analizu predani su uzorci većine skulptura iz carske skupine iz Vida te dva uzorka carskih skulptura iz Visa. Zahvaljujemo Ivi Donelliju na ustupljenoj dokumentaciji.

rhombohedral. It mainly forms sedimentary dolomite rocks, crystalline and granular aggregates of the mineral of the same name. Its hardness is 3.5 – 4, cleaves very well and has a conchoidal fracture. It can be transparent or translucent. It has a white streak and a vitreous and pearly lustre. Dolomite is a mineral of igneous, sedimentary and metamorphic origin.



*Slika 4.*
*Mikrofotografija uzorka iz gornjeg dijela skulpture, Issa 3019 Pentelic (foto: Laboratorij LEMLA)*

*Figure 4.*
*Microphotograph of a sample from the upper part of the sculpture, Issa 3019 Pentelic (photograph: LEMLA Laboratory)*



*Slika 5.*
*Mikrofotografija uzorka iz donjeg dijela skulpture, Issa 3020 Pentelic (foto: Laboratorij LEMLA)*

*Figure 5.*
*Microphotograph of a sample from the lower part of the sculpture, Issa 3020 Pentelic (photograph: LEMLA Laboratory)*

Analiza uzetih uzoraka s viših skulptura pokazala je da se radi o penteličkom mramoru.

U elaboratu analize uzoraka navodi se da je uzorak viškog mramora intenzivne bijele boje, sitnog zrna kristala, izuzetno kompaktan i srednje proziran. Mikroskopskim pregledom zamijećene su male pahuljaste tvorevine kristala muskovita.[8] Sastav ovog mramora je u velikom postotku vapnenački, s vrlo malo prisutnosti dolomita.[9] Zrna imaju poligonalne oblike. Ponekad se pojave sitna zrna kvarca primarnog podrijetla, vrlo malih dimenzija (kompaktne, sitnozrne teksture) i zaobljenih oblika. Za usporedni uzorak pozivamo se na prethodna izvješća u kojima se fotografira uzorak LEMLA 5097, materijala iz samih kamenoloma. Uz male varijacije u veličini i raspodjeli zrna, uzorci iz ulomaka viših skulptura nedvojbeno su određeni kao pentelički mramor (sl. 4, 5).

8 Mineral muskovit – $KAl_2(AlSi_3O_{10})(F,OH)_2$ – spada u skupinu tinjaca ili liskuna. Kristalizira u monoklinskom sustavu, a kristali imaju pločast habitus. Najčešći su listićasti i ljuskasti agregati. Proziran je ili djelomično proziran, ima bijel ogreb i najčešće sedefast sjaj, rjeđe staklast i svilenast.

9 Dolomit – $CaMg(CO_3)_2$ – može biti mineral i stijena. Dolomit kristalizira u trigonskom sustavu, a habitus mu je romboedarski. Uglavnom tvori sedimentne stijene dolomite koje su kristalasti i zrnasti agregati istoimenog minerala. Tvrdoće je 3,5 – 4, vrlo dobro se kala i ima školjkast lom. Može biti proziran i djelomično proziran. Ima bijel ogreb te staklast i sedefast sjaj. Dolomit je mineral magmatskog, sedimentnog i metamorfnog postanka.

**Radiographic imaging**

Other diagnostic procedures were also used to determine the current condition of the marble imperial sculpture fragments. We contacted the employees from the Laboratory of the *Brodosplit* company.[10] Shortly after the first contacts with Duje Vukičević, the head of the Laboratory, an expert team arrived in the restoration workshop with the field leader Siniša Repanić and the operator Miroslav Jaman, to arrange the imaging of the Vis sculptures. On 15 January 2020, radiographic imaging of parts of the imperial sculptures was performed in the restoration workshop of the Archaeological Museum in Split, viz. the lower fragments, where the iron joints in the marble block are located (Fig. 6). The aim was to determine the size of the iron joint and any possible cracks caused by the expansion of the metal oxide. These positions were radiologically imaged with the *Andrex Smart* RT device, 225 KV, 3 mA. The radiographs were made on the *Indux Fomapak* R5 film, measuring 100 x 480 mm. The film was chemically treated with *Fomadux* LT-P and *Fomadux Fix*. Various exposures were used, depending on the thickness of the stone to be imaged.

After the imaging of the mentioned areas on the sculptures and processing of films in the *Brodosplit* Laboratory, it turned out that the results were not satisfactory (Fig. 7). Ac-

10 The cooperation between the *Brodosplit* Laboratory and the Archaeological Museum in Split lasted continuously from 1996 to 2000 in terms of complex works in radiographic imaging of the large group of imperial marble sculptures from the *Augusteum* in Narona.

| Skulptura br.<br>Sculpture No. | Mjesto snimanja<br>Imaging area | Debljina (mm)<br>Thickness (mm) | Udaljenost FF (mm)<br>Distance FF (mm) | Vrijeme eksp. (min.)<br>Exp. time (min) | Struja mA<br>Current mA | Energija kV<br>Energy kV |
|---|---|---|---|---|---|---|
| A1 | lijevi kuk /<br>left hip | 270 – 300 | 520 | 20 | 4 | 200 |
| A1 | lijevi kuk /<br>left hip | 270 – 300 | 520 | 30 | 4 | 200 |

*Tablica 2.*
*Prikaz različitih ekspozicija radiografskog snimanja (izvor: Laboratorij Brodosplita, siječanj 2020.)*

*Table 2.*
*Various exposures of radiographic imaging (source: Brodosplit Laboratory, January 2020)*

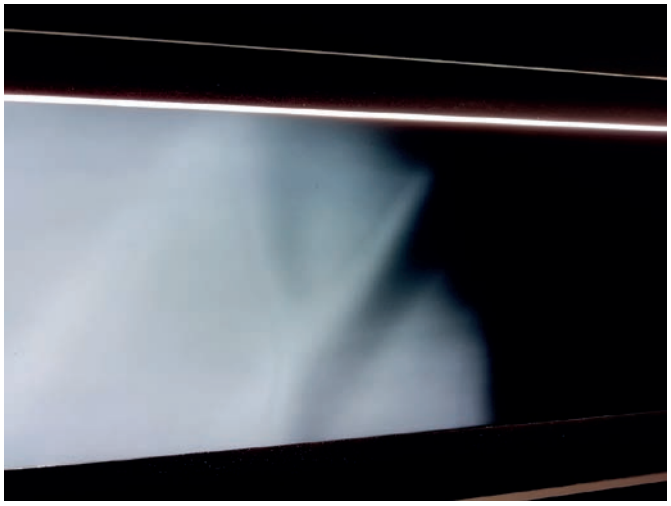
**Radiografsko snimanje**

Za utvrđivanje trenutnog stanja mramornih ulomaka carske skulpture korišteni su i drugi dijagnostički postupci. Kontaktirali smo djelatnike iz Laboratorija tvrtke *Brodosplit* .[10] Ubrzo nakon prvih kontakata s voditeljem Laboratorija Dujom Vukičevićem, u restauratorsku radionicu stigla je stručna ekipa, s terenskim voditeljem Sinišom Repanićem i operaterom Miroslavom Jamanom, radi dogovora o snimanju viših skulptura. Dana 15. siječnja 2020. u restauratorskoj je radionici Arheološkog muzeja u Splitu obavljeno radiografsko snimanje dijelova carskih skulptura, donjih ulomaka, u predjelu gdje se nalaze željezne spojnice u mramornom bloku (sl. 6). Cilj kontrole bio je utvrditi veličinu željezne spojnice i eventualnih pukotina nastalih zbog širenja metalnog oksida. Radiološko snimanje navedenih mjesta obavljeno je RT uređajem *Andrex Smart* 225 KV i 3 mA. Radiogrami su izrađeni na filmu *Indux Fomapak* R5 dimenzija 100 x 480 mm. Kemijska obrada filma obavljena je kemikalijama *Fomadux* LT-P i *Fomadux Fix*. Ovisno o debljini kamena koji je trebalo snimati, korištene su različite ekspozicije.

Nakon snimanja navedenih mjesta na skulpturama i obrade filmova u Laboratoriju *Brodosplita* pokazalo se da rezultati nisu zadovoljavajući (sl. 7). Razlozi nejasnih i nepotpunih rezultata prema tvrdnji stručnjaka za radiografska snimanja mogu se tražiti u gustoj strukturi mramornog materijala, zatim u neodgovarajućoj pokretnoj RTG opremi za tako zahtjevno snimanje te u filmovima i kemikalijama koji nisu bili dovoljno osjetljivi za takvu vrstu snimanja.[11]

*Slika 6.*
*Postavljanje filma u položaj za snimanje (foto: B. Vješnica)*

*Figure 6.*
*Setting the film for imaging (photograph: B. Vješnica)*



*Slika 7.*
*Nejasna snimka željezne spojnice na radiografskom filmu (foto: S. Repanić)*

*Figure 7.*
*Blurred image of an iron joint on radiographic film (photograph: S. Repanić)*

10 Suradnja Laboratorija *Brodosplita* i Arheološkog muzeja u Splitu kontinuirano je trajala u razdoblju od 1996. do 2000. godine s kompleksnim radovima na radiografskom snimanju velike skupine carskih mramornih skulptura iz *Augusteuma* u Naroni.

11 Zahvaljujemo stručnome timu na čelu s dipl. ing. Dujom Vukičevićem i članovima Sinišom Repanićem i Miroslavom Jamanom iz Laboratorija tvrtke *Brodosplit* d. o. o., Brodograđevna industrija Split d. d., na profesionalnome pristupu i korektno odrađenom poslu radiografskog snimanja te na analizi snimanja.

### 3D snimanje i izrada plastičnog modela

Kako bi se bolje razumjela skulptura, tj. način spajanja i pozicioniranje skulpture u prostoru, te kako bi se izradila dokumentacija zatečenog stanja, bilo je potrebno napraviti 3D skeniranje i izraditi 3D model.[12] Skeniranje je obavljeno aparatom *EinScan-Pro 2X Plus* u radionici Muzeja. Taj prijenosni skener kompaktnih dimenzija može se spojiti na prijenosno računalo. Snima 1.500.000 točaka u sekundi, što modelu daje veliku razlučivost. Objekte može spremati u STL, OBJ, PLY, ASC, 3MF i P3 formate te je tako kompatibilan s programima za daljnju softversku obradu i pripremu za 3D printer. Dobiveni modeli digitalizirani su u programima *Ex-Scan Pro*, *Siemens Solid Edge*, koji su sastavni dio skenera, a završna priprema za izradu 3D replike rađena je u programu *Autodesk Netfabb* (sl. 8, 9). Zbog dimenzija printera modele je nemoguće printati u potrebnom mjerilu te ih je programski trebalo dodatno obraditi i podijeliti u četiri modela. Kako bi printer prepoznao skenirani model, potrebno ga je prebaciti u G-kod te namjestiti parametre za printanje.[13] Svi ti parametri utječu i na kvalitetu ispisa. Modeli su printani u mjerilu 1 : 10 na printeru *Creality Ender3*[14] u PLA filamentu.[15] Dijelovi su zalijepljeni sekundarnim ljepilom, a spojevi retuširani epoksidnom masom. Tako dobiveni model pomogao je kod spajanja skulpture, te olakšao i ubrzao proces postavljanja iste u prostoru.

### Prijevoz spomenika

Prije prijevoza ulomci skulptura presloženi su na nove drvene palete, jer su dotadašnje tijekom godina dobrano istrunule. Radi dodatnog osiguranja od naglog pomicanja i mogućih oštećenja tijekom prijevoza, ulomci su učvršćeni za palete prozirnom industrijskom folijom za pakiranje. Uz desetke drugih kamenih spomenika koji će nakon restauratorskih zahvata biti izloženi na obljetničkoj izložbi u Arheološkome muzeju u Splitu, ulomci skulptura pomno su, s razmakom, složeni u kamion i dodatno osigurani kartonima i stiroporom da se tijekom vožnje ne bi dodirivali i oštetili. Nakon što je kamion trajektom stigao

12 3D skeniranje obavila je restauratorska tvrtka *ArtRestart*.

13 Prebacivanje modela u G-kod obavljeno je u programu *Ultimaker Cura*, u kojem je temperatura mlaznice postavljena na 200 °C, a temperatura podloge na kojoj se print nalazi na 50 °C.

14 Printer *Creality Ender 3* spada u kategoriju FDM printera, što znači da se koristi tehnologijom taloženog očvršćivanja. To je uređaj visoke preciznosti, jer koristi mlaznicu od 0,4 mm i filament od 1,75 mm, koji se zagrijava na temperaturu do 255 °C. Kompatibilan je s materijalima PLA, ABS, PETG i TPU te prepoznaje formate datoteka u STL, OBJ i G-kodu za 3D ispis. Jedini nedostatak printera je volumen ispisa, koji je skromnih dimenzija, 220 x 220 x 250 mm.

15 PLA ili polilaktična kiselina biorazgradivi je monomer koji se obično izrađuje od fermentiranoga biljnog škroba, poput kukuruza, manioke, šećerne trske ili pulpe šećerne repe. Dobiva se iz obnovljivih izvora te je materijal koji se najčešće koristi prilikom 3D ispisa.

cording to radiographic imaging specialists, the reasons for the vague and incomplete results can be found in the dense structure of the marble, inadequacy of the mobile X-ray equipment for such demanding imaging, and in the films and chemicals that were not sensitive enough for this type of imaging.[11]

### 3D imaging and plastic modelling

In order to better understand the sculpture, i.e. the jointing method and spatial positioning of the sculpture, and to prepare the documentation of the existing condition, it was necessary to make a 3D scan and a 3D model.[12] The scanning was performed with the *EinScan-Pro 2X Plus* device in the Museum's workshop. This compact-sized portable scanner can be connected to a laptop computer. It scans 1,500,000 points per second, which offers high-resolution modelling. Its output formats are STL, OBJ, PLY, ASC, 3MF, and P3, which makes it compatible with other software programmes for further processing and preparation for 3D printing. The models were digitised with the *Ex-Scan Pro* and *Siemens Solid Edge* software as integral parts of the scanner, while the final preparation for a 3D replica was made using *Autodesk Netfabb* (Figs. 8, 9). Due to the dimensions of the printer, the models could not be printed to the required scale, and they had to be further processed by software and divided into four models. In order for the printer to recognise the scanned model, it is necessary to use G-code and set the parameters for printing.[13] All such parameters also affect print quality. The models were printed at a scale of 1:10 on the *Creality Ender3*[14] printer in PLA filament material.[15] The parts were affixed with superglue, and the joints were retouched with epoxy. The rendered model aided in the joining of the sculpture and facilitated and accelerated the process of spatial positioning of the sculpture.

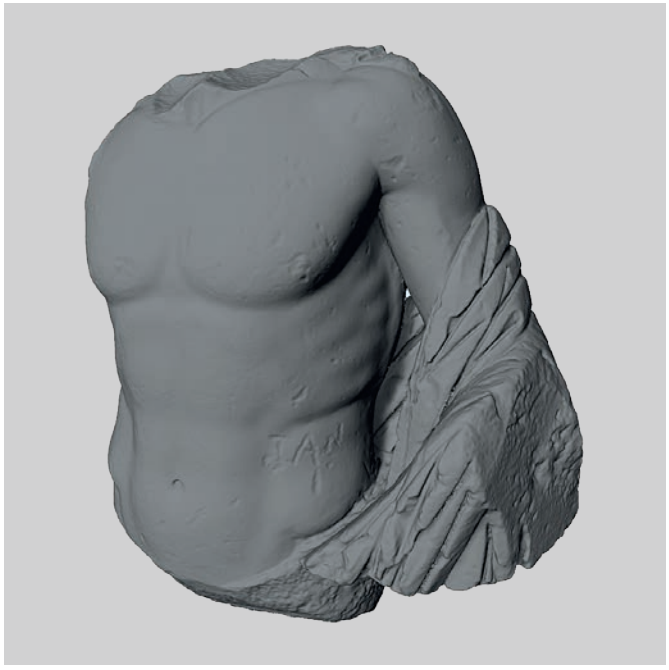
11 We would like to thank the expert team led by Duje Vukičević, B.Sc. Eng. and its members Siniša Repanić and Miroslav Jaman from the Laboratory of the *Brodosplit* d. o. o., Brodogradevna industrija Split d. d. company, for their professionalism and flawless radiographic imaging and analyses.

12 3D scanning was performed by the *ArtRestart* restoration company.

13 The model was converted to G-code by means of the *Ultimaker Cura* software. The temperature of the nozzle was set to 200 ° C, while the build plate temperature was set to 50 °C.

14 The *Creality Ender 3* printer belongs to the FDM category, which means that it utilises fused deposition modelling. It is a high-precision device, since it uses a 0.4 mm nozzle and 1.75 mm filament, heated to a temperature of up to 255 °C. It is compatible with the PLA, ABS, PETG and TPU materials, and can use files in the STL, OBJ and G-code formats. The only drawback of the printer is its modest build volume of 220 x 220 x 250 mm.

15 PLA or polylactic acid is a biodegradable monomer, typically made from fermented plant starch, e.g. from corn, cassava, sugar-cane or sugar beet pulp. It is produced from renewable resources and is mostly used in 3D printing.



*Slika 8.*
*Digitalizirani prikaz torza (foto: D. Ordulj)*

*Figure 8.*
*Digitised view of the torso (photograph: D. Ordulj)*

*Slika 10.*
*Oštećenje na skulpturi prouzročeno ljudskim djelovanjem (foto: B. Vješnica)*

*Figure 10.*
*Man-made damage to the sculpture (photograph: B. Vješnica)*

*Slika 9.*
*Digitalizirani prikaz donjeg dijela skulpture (foto: D. Ordulj)*

*Figure 9.*
*Digitised view of the lower part of the sculpture (photograph: D. Ordulj)*

iz Visa u Split te potom u AMS, spomenici su pomno izneseni na betonski plato muzejske restauratorske radionice. Uslijedio je vizualni pregled mramornih ulomaka skulpture te utvrđivanje njihovih dimenzija i težine. Utvrđena je ukupna visina od

**Transport of monuments**

Before the transport, the fragments of the sculptures were placed on new wooden pallets, because the previous ones had rotted over the years. To provide additional protection against sudden movements and possible damage during transport, the fragments were fastened to the pallets with transparent industrial packaging foil. Together with dozens of other stone monuments that will be displayed at the anniversary exhibition at the Archaeological Museum in Split following their restoration, the fragments of the sculptures were carefully spaced and stacked in a truck and additionally secured with cardboard and polystyrene to prevent contact and damage. After the truck arrived by ferry from Vis to Split and then in the AMS, the monuments were carefully placed on the concrete plateau of the Museum's restoration workshop. The marble fragments of the sculpture were then visually inspected, and their dimensions and weight were measured. The following was determined: a total height of 176 cm, width of 72 cm, thickness of 48 cm and weight of 510 kg. Further examination determined the dimensions of the man-made damages (Fig. 10): carved signatures, scratches, remains of cement plaster. In order to gain a better insight, the marble fragments were cleaned with a hot-steam high-pressure washer (Fig. 11). This procedure thoroughly removed a perennial layer of dirt, grease, traces of animal-made shelters, moss, and microbiological residues from the marble surface. Removal of the first layer of deposits on the surface of the marble

176 cm, širina od 72 cm, debljina od 48 cm i težina od 510 kg. Daljnjim pregledom utvrđene su dimenzije oštećenja nastalih ljudskom rukom (sl. 10): uklesani potpisi, ogrebotine, ostaci cementne žbuke. Radi još boljeg uvida u stanje, mramorni ulomci podvrgnuti su metodi čišćenja visokotlačnim strojem na vrelu paru (sl. 11). Tim je postupkom s površine mramora pomno uklonjen višegodišnji sloj nečistoće, masnoće, tragova životinjskih nastambi, mahovine i mikrobioloških ostataka. Uklanjanjem prvog sloja naslaga na površini mramornih ulomaka mjestimično se ukazuju tvrdokornije kalcitne naslage. U cjelini, mramor je kompaktan, uz površinsku degradaciju nastalu zbog izloženosti atmosferilijama; nema tragova osoljavanja te još uvijek ima finu teksturu, ne računajući pritom na oštećenja nastala ljudskim djelovanjem. Relativno mekše kalcitne naslage uklanjaju se postupnim mehaničkim čišćenjem uz pomoć ultrazvučne igle ili ručno, skalpelima raznih profila. Svi preostali kalcifikati uklanjaju se s pomoću finih abraziva (stakleni ili kameni prah) metodom suhog pjeskarenja (sl. 12). Kako bi se različiti restauratorski postupci uopće mogli primijeniti, potrebna su posebna pomagala i alati, bez kojih rad ne bi bio moguć, a to su: automehaničarska dizalica, pomična stropna kolica za lančanu dizalicu, lančana dizalica, laserska libela, ručna auto-dizalica. Uz pomoć kliznih stropnih kolica i lančane dizalice skulptura je uspješno postavljena. Kad je donji ulomak skulpture uspravljen u izvorni položaj, na njega se više puta tijekom ukupnih radova montirao i demontirao torzo (sl. 13).

**Izrada rekonstrukcija**

Proučavanjem ikonografije skulpture zapaženo je nekoliko zanimljivih detalja, koji su pomogli prilikom atribucije, tj. odredili na koji način pristupiti rekonstrukcijama. Proučavanjem torza u predjelu vrata i ramena uočeni su završeci tenije;[16] izgled desnog leđnog mišića[17] ukazuje da je desna ruka bila uzdignuta, dok položaj lakta lijeve ruke ukazuje da je bila ispružena. Proučavanjem anatomije prsnih mišića i položaja sačuvane desne noge možemo odrediti središnju liniju kontraposta. Svi ti elementi pomogli su u pronalaženju sličnih primjera skulptura u literaturi, kako bi se po uzoru na njih pristupilo izradi rekonstrukcija. Jedan takav primjer je i skulptura diviniziranog cara Augusta ili Tiberija iz *Museo Nacional del Prado* u Madridu,[18] koja je bila glavna vodilja pri restauratorskom zahvatu. Po uzo-

16 Tenija, lat. *taenia*, grč. ταινία: vrpca, traka. Ukazuje da je glava imala krunu od lišća hrasta crnike, koja je na potiljku vezana vrpcom; Schroder 1993, str. 142.

17 Najširi mišić leđa (lat. *musculus latissimus dorsi*) je veliki plosnati leđni mišić.

18 Skulptura je izrađena za vladavine cara Klaudija (41. – 54. g.). Pretpostavlja se da prikazuje diviniziranog cara, Augusta ili Tiberija. Skulptura je doživjela mnoge rekonstrukcije, poput ruku i stopala u antici, a glava Augusta dodana je u 17. st. Izrađena je od sitnozrnog bijelog mramora; Schroder, 1993, str. 142.

fragments revealed sporadic more persistent calcite deposits. On the whole, the marble is compact, with surface degradation caused by exposure to weather conditions. There are no traces of efflorescence, and the texture is still fine, excluding the man-made damages. Relatively softer calcite deposits are removed by gradual mechanical cleaning with an ultrasonic needle or manually, with scalpels of various profiles. All other remaining calcifications are removed with fine abrasives (glass or stone powder) by dry sandblasting (Fig. 12). In order to make various restoration procedures possible, special appliances and tools are required, without which work would not be possible, such as: a garage lift, travelling ceiling trolleys for chain hoists, a chain hoist, a laser line level, and a manual car jack. The sculpture was successfully set with the help of the travelling ceiling trolleys and the chain hoist. When the lower fragment of the sculpture was erected in its original position, the torso was mounted and dismounted several times during the works (Fig. 13).

**Making of reconstructions**

By studying the iconography of the sculpture, several interesting details were observed, which facilitated the attribution, i.e. helped determine how to approach the reconstructions. Examination of the torso in the neck and shoulder areas revealed the ends of a taenia;[16] the appearance of the right back muscle[17] implies that the right arm was raised, while the position of the left elbow indicates that the left arm was extended. By studying the anatomy of the pectoral muscles and the position of the preserved right leg, it is possible to determine the axis of the contrapposto. All these elements helped to find similar examples of sculptures in the literature, in order to follow their example for reconstructions. One such example is the sculpture of the divinised Emperor Augustus or Tiberius from the *Museo Nacional del Prado* in Madrid,[18] which served as the main landmark for the restoration works. The left leg with the base was reconstructed after it, while the drapery was reconstructed based on its original lines. Further reconstruction was not performed due to insufficient information on the anatomy, appearance and modelling of the missing

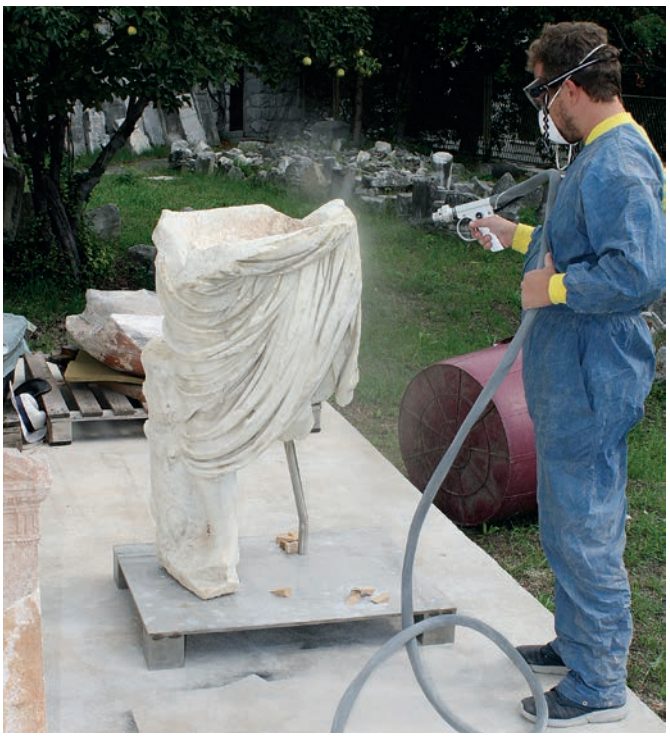
16 Taenia, L. *tænia*, Gr. *ταινία*: a band, fillet, ribbon. It indicates that the head had a crown of oak leaves, tied with a ribbon behind the head. Schroder 1993, p. 142.

17 The broadest muscle of the back (L. *musculus latissimus dorsi*) is the large, roughly triangular muscle covering the lower part of the back.

18 The sculpture was made during the reign of Emperor Claudius (AD 41–54). It is assumed to depict a divinised emperor, either Augustus or Tiberius. The sculpture has been reconstructed a number of times, e.g. its hands and feet in antiquity, while the head of Augustus was added in the 17th century. It is made of fine-grained white marble. Schroder, 1993, p. 142.

*Slika 11.*
*Dubinsko pranje mramorne površine parom (foto: B. Vješnica)*

*Figure 11.*
*Deep steam washing of the marble surface (photograph: B. Vješnica)*



*Slika 12.*
*Uklanjanje tvrđih naslaga kalcitne kore metodom suhog pjeskarenja finim abrazivima (foto: B. Vješnica)*

*Figure 12.*
*Removal of thick calcite crust layers by dry sandblasting with fine abrasives (photograph: B. Vješnica)*

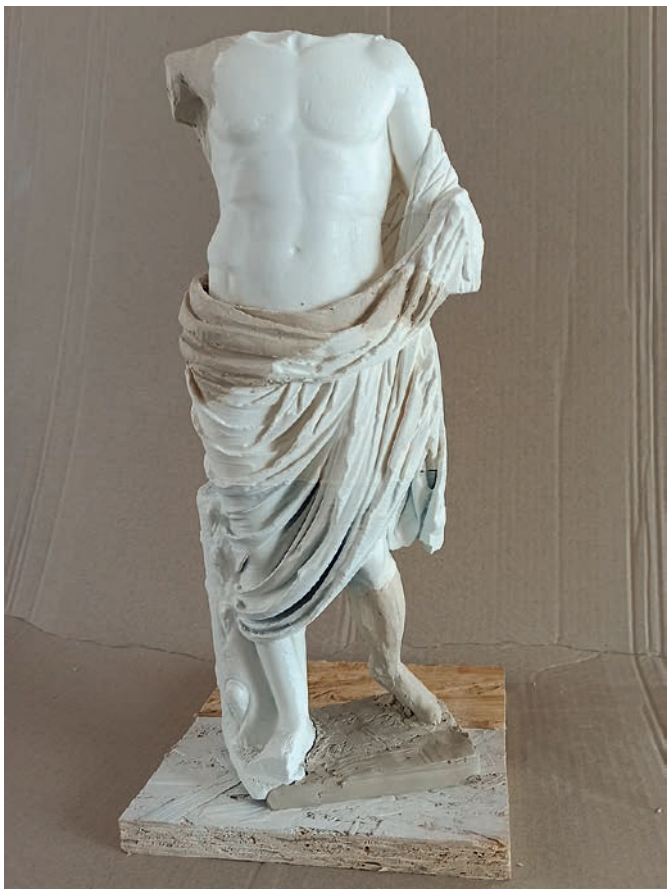
ru na nju izrađena je rekonstrukcija lijeve noge s bazom, dok je izrada rekonstrukcije draperije pratila izvorne linije draperije. U daljnju rekonstrukciju nismo se upuštali zbog nedostatnih informacija o anatomiji, izgledu i modeliranju nedostajućih dijelova, premda se oni ikonografski mogu rekonstruirati. Nedostajući dijelovi najprije su modelirani na umanjenom plastičnom modelu te su poslužili prilikom modeliranja originala (sl. 14). Rekonstrukcije su izrađene u glini te je načinjen silikonski kalup. Materijal korišten za izradu kalupa je dvokomponentna silikonska guma *Alpa Sil MF3*,[19] koja je aplicirana na glinu. Zbog velikih dimenzija rekonstrukcije bilo je potrebno izraditi gipsanu kapu kako bi se ukrutio gumeni kalup. Kalup je razdvojen i pripremljen za izradu odljeva u umjetnom materijalu *Acrystal Decor Carrara*[20] (sl. 15, 16). Odljev je naknadno obrađen tradicionalnim klesarskim tehnikama i estetski prilagođen skulpturi, uz decentno naglašenu razliku između rekonstrukcije i originala, koja je izvedena uz pomoć razlike u boji.

*Slika 13.*
*Uspravljena skulptura (foto: B. Vješnica)*

*Figure 13.*
*Upright sculpture (photograph: B. Vješnica)*

19 *Alpa Sil MF3* je adicijski dvokomponentni silikon iznimno dobrih mehaničkih svojstava bez toplinske reakcije, koji se koristi za izradu modela i kalupa.

20 *Acrystal Decor Carrara* je kompozitni materijal bez otapala, koji se vrlo lako upotrebljava. Dostupan je u obliku tekućine (akrilna smola na vodenoj bazi) i bijelog praha (mineralni kristali sa sitnim kamenim dijelovima).



*Slika 14.*
*Nedostajući dijelovi na printanom modelu (foto: D. Ordulj)*

*Figure 14.*
*Missing parts on the printed model (photograph: D. Ordulj)*

*Slika 15.*
*Modeliranje noge u glini (foto: B. Vješnica)*

*Figure 15.*
*Leg modelling in clay (photograph: B. Vješnica)*

*Slika 16.*
*Skidanje gipsane kape s gumenog kalupa (foto: B. Vješnica)*

*Figure 16.*
*Removal of the plaster cap from the rubber mould (photograph: B. Vješnica)*

**Izrada metalne konstrukcije**

Prije zamjene dosadašnje drvene podloge novom nosivom podlogom od nehrđajućeg čelika, preostalo je snimanje položaja planirane proteze za sidrenje unutar sačuvane glinene rekonstrukcije lijeve noge i postolja skulpture. U dijelu rekonstrukcije pete i lista lijeve noge zarezana je glina i otvorena sonda do središnje drvene armature, čije su se mjere dalje koristile za izradu trajne proteze za statiku cijele skulpture. Uslijedili su radovi na zamjeni privremene drvene podloge novom stalnom nosivom podlogom. Drvena podloga (paleta na koju je prvi put postavljena skulptura) zamijenjena je novom metalnom nosivom podlogom od nehrđajućeg čelika, inoksa. Nova nosiva podloga od inoksa sastoji se od nosive ploče (dužina 900 mm, širina 700 mm, debljina stijenke 12 mm) i od četiri pravokutna

parts, although they can be reconstructed iconographically. The missing parts were first modelled on a scaled-down plastic model, and then served to model the original (Fig. 14). The reconstructions were formed of clay, and a silicone mould was made. The mould was made of two-component silicone rubber *Alpa Sil MF3*,[19] which was applied to the clay. Due to the large dimensions of the reconstruction, it was necessary to make a plaster cap in order to harden the rubber mould. The mould was separated and prepared for casting in the composite ma-

19 *Alpa Sil MF3* is an addition two-component silicone with extremely good mechanical properties without thermal reaction, used to make models and moulds.

*Slika 17.*
*Izrada nosive metalne palete (foto: D. Ordulj)*

*Figure 17.*
*Making of the load-bearing metal pallet (photograph: D. Ordulj)*

*Slika 18.*
*Pozicioniranje linije laserske libele na desnom boku skulpture (foto: B. Vješnica)*

*Figure 18.*
*Positioning of the laser line level on the right side of the sculpture (photograph: B. Vješnica)*

profilna nosača ploče (dužina 100 mm, širina 100 mm, visina 100 mm, debljina stijenke 3 mm). Nosači su zavareni u kutove nosive ploče s donje strane (sl. 17), a na dno nosača podloge montirani su prianjajući gumeni čepovi. Na pripremljenu novu nosivu podlogu od inoksa zadnji put se provizorno montira skulptura kako bi se označila mjesta i smjer bušenja donjeg ulomka u predjelu sačuvanog dijela dna postolja i desne noge te za bušenje izvornika u dijelu lijeve potkoljenice.

**Pripreme za bušenje ulomka**

Kako je ova faza radova zahtijevala širi radni prostor, skulptura je prenesena na betonski plato na ulazu u restauratorsku radionicu. Od velike pomoći bila je drvena greda nadstrešnice ulaznog prostora, koja je poslužila kao nosač za manju lančanu

terial *Acrystal Decor Carrara*[20] (Figs. 15, 16). The cast was subsequently processed with traditional stonemasonry techniques and aesthetically adapted to the sculpture, with an appropriately emphasised difference between the reconstruction and the original, made by means of a difference in colours.

**Making of metallic construction**

Before replacing the previous wooden support with a new stainless-steel support, the position of the planned anchoring prosthesis within the preserved clay reconstruction of the left leg and the base of the sculpture had to be imaged. The clay reconstruction of the left heel and calf was cut and a probe was opened to the central wooden armature. Its dimensions were further used to make a permanent structural prosthesis for the whole sculpture. This was followed by replacement of the temporary wooden support with a new permanent one. The wooden support (the pallet on which the sculpture was first placed) was replaced by a new metal one made of stainless steel (inox). The new inox support consists of a support plate (900 mm long, 700 mm wide, 12 mm thick wall) and four rectangular profiled plate supports (100 mm long, 100 mm wide, 100 mm high, 3 mm thick wall). The supports were welded to the underside corners of the support plate (Fig. 17), and self-adhesive rubber stoppers were mounted on the bottom of the support holder. The sculpture was provisionally mounted on the prepared new inox support for the last time to mark the positions and directions of drilling the preserved part of the pedestal bottom and the right leg of the lower fragment, and for the drilling of the left lower leg of the original.

**Preparations for the drilling of the fragment**

Since this phase of works required a wider workspace, the sculpture was transferred to the concrete plateau at the entrance to the restoration workshop. The wooden beam of the eaves above the entrance was quite useful, since it served as the holder for the smaller hoist. With the help of two chain hoists, the lower part of the sculpture was laid from the new inox support in a temporary lying position on a specially customised wooden pallet made of waterproof plywood, for the purpose of the intended drilling. The already drawn lines on the marble surface were used as an aid in levelling the fragment in a horizontal position with a laser line level to centre the drilling direction (Fig. 18). The position was precisely adjusted to a height suitable for a way-type drill[21] with a drill

20 *Acrystal Decor Carrara* is a solvent-free composite material that is very easy to use. It is available as liquid (based on aqueous acrylic resin) and white powder (mineral crystals with stone particles).

21 The *Eibenstock* wet core drill with rig, model: END 130/3, power: 1800 W.

*Slika 19.*
*Mokro bušenje dna baze (foto: B. Vješnica)*

*Figure 19.*
*Wet drilling of the base bottom (photograph: B. Vješnica)*

*Slika 20.*
*Mramorni uložak, detalj (foto: B. Vješnica)*

*Figure 20.*
*Marble insert, detail (photograph: B. Vješnica)*

dizalicu. Uz pomoć dviju lančanih dizalica donji dio skulpture polegnut je s nove nosive podloge od inoksa u privremeni ležeći položaj na za to prilagođenu drvenu paletu od vodootporne šperploče, radi predviđenog bušenja. Kao pomoć pri niveliranju ulomka u vodoravnom položaju laserskom libelom radi centriranja smjera bušenja (sl. 18) korištene su već ucrtane linije na površini mramora. Položaj se precizno namještao na visinu koja je pogodna za bušilicu[21] na vodilicama s krunastim svrdlom promjera 30 mm i vodenim hlađenjem. Kad je nakon dužeg namještanja dobivena ista razina za bušenje, započelo se s provjerom smjera bušenja rupa uz pomoć laserske libele. Prije početka bušenja dna baze na vrh krunastog svrdla zalijepljena je traka kao oznaka za dubinu bušenja, što je ujedno i dužina spojnice (trn) od inoksa, koji će naknadno po zadanom planu biti fiksiran u pripremljenu perforaciju. Nakon što je na glavu bušilice i svrdlo priključena voda,[22] gumenim crijevom, iz mrežne opskrbe, započelo se s bušenjem označenog područja dna baze skulpture. Zbog relativno male zadane dubine bušenja od 160 mm postupak nije trajao više od nekoliko minuta. Po završetku postupka kruna je bez zastoja izvučena iz bušenog dijela dna baze, a mramorni uložak koji je već u dubini bio napuknuo, bez poteškoća je izvađen (sl. 19). Mramorni je uložak izvađen iz prve perforacije nakon mokrog bušenja djelovao čisto i pravilno, no na njegovu kraju primijećena je smeđa nakupina, najsličnija mrlji prouzročenoj širenjem korozije (sl. 20). Naknadnim

bit with a diameter of 30 mm and water cooling. When the lines for the drilling were levelled after a long adjustment, the check-up of the drilling direction for the holes was initiated with the laser line level. Before drilling the bottom of the base, a piece of tape was glued to the top of the drill bit to mark the drilling depth, corresponding to the length of an inox steel joint (tang), which would subsequently be fixed in a prepared perforation according to the plan. When water was fed to the drill head and bit[22] through a rubber hose from the mains supply, drilling of the marked area of the bottom of the sculpture base was initiated. Due to the relatively small predefined drilling depth of 160 mm, the procedure did not take more than a few minutes. Following the end of the procedure, the bit was smoothly pulled out of the drilled part of the bottom of the base, and the marble insert, which had already cracked in depth, was removed without difficulty (Fig. 19). The marble insert removed from the first perforation after wet drilling seemed clean and regular, but a brown patch was observed at its end, most closely resembling stains caused by the spread of corrosion (Fig. 20). A follow-up examination of the surface of the sculpture led to the conclusion that the finding from the marble insert is not unique, but rather manifest in the form of efflorescence on the surface of the entire sculpture. All the described phases of the drilling procedure were repeated at the second marked position, in the middle of the lower left leg fracture. Since the original lower leg is missing, it will be structurally replaced by the inox prosthesis. The pro-

21 Bušilica za mokro bušenje sa stalkom *Eibenstock*, model: END 130/3, snaga: 1800 W.

22 Općenito, mokro bušenje ili hlađenje vodom pomaže kruni ili krunastom svrdlu da se ne pregrijava i tako ne mijenja svojstva materijala za bušenje. Vodeno hlađenje istodobno pomaže i materijalu koji se buši, u ovom slučaju mramoru, jer se djelovanjem bušenja ne mijenja mrežna struktura kristala, smjer bušenja je pravilan te je na kraju i perforacija pravilna, što je i cilj ovog postupka.

22 In general, wet drilling or water cooling prevents the drill bit from overheating and thus does not alter the properties of drilling material. Water cooling also helps the material to be drilled, in this case, marble, since the drilling does not alter the network structure of crystals, the drilling direction is regular as well as the resultant perforation, which is the objective of this procedure.

pregledom površine skulpture došlo se do zaključka da nalaz s mramornog uloška nije jedinstven, nego se ponavlja u vidu izboja na površini cijele skulpture. Sve već opisane faze postupka bušenja, ponovljene su na drugom označenom mjestu u sredini loma potkoljenice lijeve noge. Kako izvorna potkoljenica skulpture nedostaje u statičkom smislu će je zamijeniti proteza od inoksa. Postupak bi trebao biti lakši jer se ponavlja, no uvijek iskrsne nova prepreka; tako je u pripremi za drugo bušenje cijeli ulomak bilo potrebno namjestiti da se linije laserske libele poklope sa smjerom bušenja. Druga poteškoća bio je kosi lom mramora u točki predviđenoj za bušenje, što je prilagođeno poravnavanjem površine uz pomoć finog dlijeta. Treća prilagodba bila je remontiranje bušilice i krunastog svrdla bliže lomu, radi što preciznijeg bušenja. Nakon završetka istog postupka za drugo spojno mjesto, cijeli je ulomak detaljno ispran mlazom vode, a osobito nove perforacije.

**Pokusna montaža usadaka/spojnica *u suho***

Sigurnosti radi, te kako bi se uklonile nedoumice, provjerava se kvaliteta novih perforacija na način da se u njih, *u suho* (bez ljepila), pokusno montiraju već pripremljeni usadci od inoksa i kositrene bronce.[23] Dakle, ovdje se radi o metalnim spojevima koji će biti ugrađeni (fiksirani ljepilom) u pripremljene mramorne džepove. Kad se ugrade u mramor, služit će kao čvrsta spona između izvornika i nove nosive podloge od inoksa. Razlika je djelomično u funkciji i svakako u materijalu. U desnu nogu u dno baze izvornika umeće se usadak od inoksa dužine 150 mm i promjera 30 mm, koji je fino uzdužno unutarnje tokaren (ima tokarene navoje za maticu M16 dužine 55 mm) tako da se prilagođenom maticom (sl. 21) s donje strane nosive podloge od inoksa čvrsto priljubi i zategne. Za razliku od toga, usadak koji se planira fiksirati u mramorni džep (perforaciju) potkoljenice lijeve noge, s razlogom je izrađen od kositrene bronce, tj. od mekšeg materijala u odnosu na planiranu protezu (inoks), kako s vremenom ne bi došlo do kemijske reakcije koja bi prouzročila čvrsti spoj i samim time otežanu manipulaciju kod montaže i demontaže. Ovakav postupak osigurava i dugoročnu reverzibilnost zahvata.[24] Usadak od kositrene bronce gotovo je istih dimenzija kao prethodni, dužine 150 mm i promjera 31 mm, i također je fino uzdužno unutarnje tokaren, ali nema navoja, i

23 Kositrena bronca ili tzv. prava bronca ili bakrena slitina s kositrom najstarija je bakrena slitina; u pravilu sadržava 80 % bakra, ili više, te do 20 % kositra, uz neznatne dodatke drugih kovina. Kositrena bronca usatka (spojke) koja je ovdje korištena, ima oznaku slitine: CuSn12. Kemijski sastav: Cu 85,0 – 88,5 %, Sn 10,8 – 12,8 %. Opis i namjena: slitina je otporna na trošenje, koroziju i utjecaj morske vode. Preporučuje se za spojke i dijelove spojke, matice, vretena opterećena okretanjem, za vijence pužnih kotača, za obruče i konstrukcijske dijelove u obliku cijevi, za uloške cilindara, za visoko opterećene stojeće i klizne letve.

24 Donelli 1997, str. 285–338.

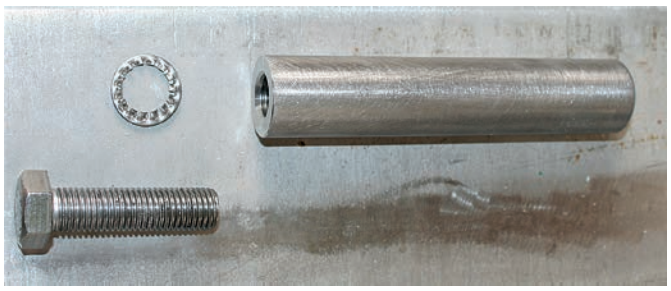
cess should have been easier because it was a repetition, but a new obstacle arose, as always. Thus, while preparing for the second drilling, the entire fragment had to be adjusted so that the lines of the laser level coincided with the drilling direction. Another difficulty was the oblique fracture of the marble at the point intended for drilling, which was adjusted by levelling the surface with a fine chisel. The third adjustment regarded repositioning the drill and the drill bit closer to the fracture, in order to drill as precisely as possible. After completion of the same procedure for the second junction, the whole fragment was thoroughly washed with a jet of water, particularly its new perforations.

**Dry trial installation of pins/joints**

To be on the safe side, and in order to remove any confusion, the quality of new perforations is checked by experimental dry installation of prepared inox and tin bronze pins into them (without glue).[23] To wit, these are metal joints that will be built into (cemented with glue) the prepared marble pockets. When installed in marble, they will serve as a solid link between the original and the new inox support. The difference is partly in the function, and definitely in the material. An inox pin, 150 mm long and 30 mm in diameter, is inserted into the right leg and the bottom of the original base. It is finely longitudinally internally turned (with turned threads for 55 mm long M16 nuts) so that it can be firmly pressed and tightened with an adjusted nut (Fig. 21) on the underside of the inox support. In contrast, the pin to be fixed in the marble pocket (perforation) of the lower left leg, is purposefully made of tin bronze, i.e. a softer material compared to the planned prosthesis (inox), to prevent chemical reactions over time, which would cause a tight joint and consequently make assembly and disassembly difficult. Such a procedure also ensures long-term reversibility of the process.[24] The tin bronze pin is almost the same size as the previous one, 150 mm long and 31 mm in diameter, and is also finely longitudinally internally turned, but has no threads, because this sculpture will be repeatedly assembled and disassembled in the future for various presentations and exhibitions by fitting onto the reconstruction of the left leg and base, which requires a sliding joint is required.

23 Tin bronze is the oldest copper alloy. In general, it contains at least 80 % copper, and up to 20% tin, with slight additions of other metals. The tin bronze of the pin (joint) used here has the following alloy designation: CuSn12. Chemical composition: Cu 85.0 – 88.5 %, Sn 10.8 – 12.8 %. Description and intended use: the alloy is resistant to wear, corrosion and impact of sea-water. It is recommended for couplings and parts of ball-and-screw couples, worm wheel rims, hoops and pipe-shaped structural parts, cylinder inserts, heavy-duty load-bearing pedestal and rail strips.

24 Donelli 1997, pp. 285–338.



*Slika 21.*
*Detalj nosive konstrukcije koji se ugrađuje u bazu (foto: B. Vješnica)*

*Figure 21.*
*Detail of the load-bearing structure to be inserted in the base (photograph: B. Vješnica)*

*Slika 22.*
*Bušenje ucrtanih položaja na nosivoj podlozi za fiksiranje skulpture (foto: D. Ordulj)*

*Figure 22.*
*Drilling of marked positions on the support for the fixing of the sculpture (photograph: D. Ordulj)*

to zato što će se u budućnosti kod raznih prezentacija i izložaba ova skulptura više puta montirati i demontirati nasađivanjem na rekonstrukciju lijeve noge i baze te je stoga potreban klizni spoj.

**Preslika položaja baze i rupa na novu nosivu podlogu od inoksa**

Dok je donji dio skulpture položen na karton, preslikavaju se rubne linije izvorne baze i mjesto perforacije. Predložak izvorne baze preslikava se na površinu nosive ploče od inoksa, uz dodatnu presliku zadane perforacije. Potom se označeno mjesto na nosivoj ploči buši uz pomoć svrdala za inoks i glodala (sl. 22).

**Fiksiranje usadaka (spojnica)**

Nakon probne montaže *u suho* opet se demontiraju svi dijelovi, te se na nosivoj podlozi oko perforacije izolira površina ljepljivom trakom kako bi se izbjegla mogućnost fiksiranja izvorne baze za nosivu podlogu. Za fiksiranje usadaka ili spojnica u mramorne perforacije (džepove) korišteno je dvokomponentno epoksidno ljepilo *Megapoxy*[25] u omjeru 1 : 1. Nakon miješanja

25 *Megapoxy* PM je višenamjenska dvokomponentna epoksidna pasta pogodna za primjenu u građevinarstvu. Kremaste strukture, jednostavna za miješanje, u omjeru 1 : 1, prikladna je za sljedeće primjene: lijepljenje i ugradnja betonskih proizvoda, kamena, mramora i granita te drva i metala, kitanje i popravak betonskih cijevi i spremnika, betonskih podova i stubišta te proizvoda od stakloplastike. Svojstva proizvoda: omjer miješanja 1 : 1, boja smole i katalizatora: bijela neutralna, čvrstoća na tlak: 80 MPa, vlačna čvrstoća prionjivosti

**Marking of the positions of the base and holes on the new inox support**

While the lower part of the sculpture is laid on cardboard, the outlines of the original base and the place of perforation are marked. The original base template is copied to the surface of the inox support, with an additional counterpart of the predefined perforation. The marked spot on the support plate is then drilled with drill bits for inox and a milling tool (Fig. 22).

**Fixing of pins (joints)**

After a trial dry installation, all parts are disassembled again, and the surface of the support around the perforation is insulated with adhesive tape in order to prevent affixing of the original base to the support. The *Megapoxy*[25] two-component epoxy adhesive mixed at a ratio of 1:1 was used to fix the pins or joints into marble perforations (pockets). After mixing, the adhesive is applied into the perforations with a spatula while a part of the sculpture is suspended on the chain hoist. A thin

25 *Megapoxy* PM is a multi-purpose two-component epoxy paste suitable for civil engineering applications. It has a creamy texture, and blends easily in a 1:1 mix ratio. It is suitable for the following applications: bonding and installation of concrete articles, stone, marble and granite, as well as wood and metal, filling and repair of concrete pipes and tanks, concrete floors and stairs, and fibreglass articles. Product specifications: 1:1 mixing ratio; resin and hardener colour: white neutral; compressive strength: 80 MPa; tensile bond strength (steel/steel): 10 MPa; flexural strength: 15 MPa; tensile strength: 25 MPa; flash point: 100 °C; minimum application temperature: 10 °C; minimum cure time: 12 h at 25 °C. www.saxumtec.com (19/11/2020).

*Slika 23.*
*Spuštanje baze skulpture na usadak od inoksa s ljepilom, detalj (foto: B. Vješnica)*

*Figure 23.*
*Lowering of the base of the sculpture onto an inox pin with glue, detail (photograph: B. Vješnica)*

*Slika 24.*
*Korištenje male hidrauličnе dizalice kod fiksiranja usadka od kositrene bronce (foto: B. Vješnica)*

*Figure 24.*
*Use of a small hydraulic jack while fixing a tin bronze pin (photograph: B. Vješnica)*

ljepilo se špahtlom nanosi u perforaciju dok je dio skulpture ovješen na lančanu dizalicu. Na usadak od inoksa također se nanosi ljepilo u tankome sloju i ubacuje u perforaciju, te se spuštanjem skulpture preko lančane dizalice i pritiskom na nosivu ploču usadak od inoksa umeće u ispunu baze (sl. 23); višak ljepila klizi niz stijenku. Potrebna su 24 sata da ljepilo postigne maksimalnu čvrstoću.

Za uspješno fiksiranje usatka (spojnice) od kositrene bronce bilo je potrebno malo tehničko pomagalo. Naime, za razliku od izvorne baze, koja je težinom cijelog ulomka o nosivu podlogu pritisnula usadak u perforaciju, na strani potkoljeničnog loma bilo je potrebno izgraditi drveno postolje i na vrhu postaviti malu hidrauličnu dizalicu kojom se usadak od kositrene bronce potiskivao, a višak ljepila istiskivao (sl. 24).

**Izrada proteze od inoksa i sidrenje skulpture**

Nakon postupaka modeliranja (nepostojeće) lijeve noge i većeg dijela baze u glini te izrade odljeva rekonstrukcije u umjetnom kamenu, zatim fiksiranja usadaka (spojnica) u izvornik, uslijedila je izrada proteze od nehrđajućeg materijala, inoksa, koja bi kroz šupljinu rekonstrukcije trebala sidriti izvorni rub lijeve noge s nosivom podlogom. Da bi se to postiglo, morala se već gotova rekonstrukcija lijeve noge okomicom otvoriti u dijelu od pete do trbušastog mišića lista, kako bi se omogućio slobodan pristup za lociranje dviju točaka nagiba buduće proteze i

layer of adhesive is also applied to the inox pin, which is then inserted into the perforation, and placed into the base filling (Fig. 23) by lowering the sculpture with the chain hoist and exerting pressure on the support. Excess adhesive slides down the wall. It takes 24 hours for the adhesive to reach maximum strength.

A small technical aid was needed to fix the tin bronze pin (joint) successfully. Namely, in contrast to the original base, which pushed the pin into the perforation with the weight of the whole fragment on the support, the side of the lower leg fracture required building a wooden pedestal with a small hydraulic jack on top to push the tin bronze pin, and squeeze out excess adhesive (Fig. 24).

Making of inox prosthesis and anchoring the sculpture

After the modelling of the (non-existent) left leg and most of the base in clay and making the cast of the reconstruction in artificial stone, followed by fixing the pins (joints) in the original, a prosthesis was made of stainless material, inox, intended to anchor the original edge of the left leg through the reconstruction cavity onto the support. To achieve this, the completed reconstruction of the left leg had to be opened vertically from the heel to the gastrocnemius muscle to facilitate free access for locating two angle points of the future prosthesis and the third point for the prosthesis anchor on the inox support. Certain preliminaries were necessary to define these points. They included mounting of a part of the sculpture (fastened with a nut on the inox support for the pin [joint] fitted into the original base) on the support. Then the open reconstruction of the left leg and base was mounted, and the anchor point of the prosthesis was located in the narrow zone of the open heel on the support. This marked anchor point on the support was perforated in the same way as the previous one, for the connection with the original base

(čelik/čelik): 10 MPa, savojna čvrstoća: 15 MPa, vlačna čvrstoća: 25 MPa, točka paljenja: 100 °C, najniža temperatura upotrebe: 10 °C, minimalno vrijeme sušenja: 12 h na 25 °C. www.saxumtec.com (19. 11. 2020.).

*Slika 25.*
*Nakon otvaranja rekonstrukcije, detalj (foto: B. Vješnica)*

*Figure 25.*
*After the opening of the reconstruction, detail (photograph: B. Vješnica)*

*Slika 26.*
*Zavarivanje spojnih točaka proteze (foto: B. Vješnica)*

*Figure 26.*
*Welding of prosthesis attachment points (photograph: B. Vješnica)*

lociranje treće točke – sidrišta proteze za nosivu podlogu od inoksa. Za definiranje tih točaka neophodne su bile predradnje, koje su uključivale montažu dijela skulpture (pričvršćenog maticom preko nosive podloge za usadak od inoksa [spojnicu] ugrađenu u bazu izvornika) na nosivu podlogu, s jedne strane. S druge strane montirana je otvorena rekonstrukcija lijeve noge i baze, gdje je u uskom pojasu otvorene pete na nosivoj ploči locirana točka sidrenja proteze. Tako označena točka sidrenja na nosivoj ploči perforirana je na isti način kao i prethodna za spoj s izvornom bazom skulpture. Nakon definiranja dviju krajnjih točaka spajanja, umetka od kositrene bronce i perforacije na nosivoj podlozi, moguće je izraditi protezu koja će ih povezivati. Proteza je od punog profila inoksa promjera 30 mm i sastavljena je od tri dijela, koja su na licu mjesta spojena zavarivanjem (sl. 25, sl. 26, sl. 27):

a) tokareni cilindrični umetak, dužine 145 mm; od toga je 125 mm fino uzdužno tokareno na promjer 18 mm (ovaj dio ulazi u već fiksirani umetak od kositrene bronce),

of the sculpture. When the two end connecting points, the tin bronze pin and the perforation on the support are all set, it is possible to make a prosthesis as their coupling. The prosthesis is made of solid inox with a diameter of 30 mm and consists of three parts, attached by welding in situ (Fig. 25, Fig. 26, Fig. 27):

a) turned cylindrical pin, 145 mm long, of which 125 mm is finely longitudinally turned to a diameter of 18 mm (this part is to be inserted into the already fixed tin bronze insert),
b) prosthesis shaft, 370 mm long,
c) the end of the prosthesis is 110 mm long, and has a turned thread for M 16 nuts, 55 mm long.

The making of the inox prosthesis and its mounting on the support was the final step which made it possible for the entire sculpture to stand independently and securely (Fig. 28).

*Slika 27.*
*Konačan oblik proteze od inoksa (foto: B. Vješnica)*

*Figure 27.*
*Final form of the inox prosthesis (photograph: B. Vješnica)*

*Slika 28.*
*Digitalni crtež metalne konstrukcije (izradio: D. Ordulj)*

*Figure 28.*
*Digital drawing of the metal structure (made by D. Ordulj)*

b) osovina proteze, dužine 370 mm,
c) završetak proteze je dužine 110 mm koji ima urezan navoj za maticu M 16, dužine 55 mm.

Izradom proteze od inoksa te njezinom montažom na nosivu podlogu uklonjena je i posljednja prepreka da cijela skulptura samostalno i sigurno stoji (sl. 28).

## Zaključak

Iako je ovdje riječ o skulpturi čije umjetničko-stilske značajke upućuju na diviniziranog cara (Augusta?), u pozadini ove teme stoji širi kontekst, tj. cijela skupina carskih skulptura, koja podsjeća na skupinu iz Vida kod Metkovića, antičke Narone. Upravo nam je način rada i prezentiranja skupine carskih skulptura iz Narone bio najprihvatljiviji primjer, koji nam je dao smjernice na koji način restauratorskim radovima prezentirati skulpturu,

## Conclusion

Although this is a sculpture whose artistic and stylistic features point to a divinised emperor (Augustus?), the background of this topic includes a broader context, i.e. a whole group of imperial sculptures, reminiscent of the group from Vid near Metković, viz. ancient Narona. The mode of operation and presenting the group of imperial sculptures from Narona was the example we found most acceptable. It provided us with guidelines on how to present the sculpture by way of restoration works, without overdoing the very restoration.[26] While paying attention to the structure of the marble, we tried to preserve the patina of time. With a minimum of interventions on the material, we adapted the metal construc-

26 Marinković 2014, pp. 9–22

*Slika 29.*
*Skulptura bez rekonstrukcije (foto: T. Seser)*

*Figure 29.*
*Sculpture without reconstruction (photograph: T. Seser)*

*Slika 30.*
*Skulptura s rekonstrukcijama (foto: D. Ordulj)*

*Figure 30.*
*Sculpture with reconstructions (photograph: D. Ordulj)*

a da pritom ne pretjeramo s restauratorskim zahvatom.[26] Pazeći na strukturu mramora, nastojali smo sačuvati vremensku patinu. Minimalnim intervencijama u materijal, prilagodili smo tome metalnu konstrukciju, bez koje ne bismo uspjeli uspraviti skulpturu. Analizirajući studiozno slične primjere restauriranja carskih skulptura u svijetu, minimalno smo intervenirali na mjestu draperije srednjeg desnog dijela skulpture i kod položaja lijeve noge od koljena naniže s dijelom baze. Intencija je bila djelomičnom rekonstrukcijom skulpture ponuditi posjetitelju izložbe više didaktički negoli estetski doživljaj (sl. 29 i sl. 30).

tion, without which we would not have been able to raise the sculpture to an upright position. Having meticulously analysed similar examples in restoration of imperial sculptures from around the world, our work on the drapery of the middle right section of the sculpture and on the left leg from the knee down with a part of the base was kept to a minimum. The partial reconstruction of the sculpture was intended to offer the visitors of the exhibition an experience that would be more didactic than aesthetic (Fig. 29 and Fig. 30).

***Prijevod** / **Translation:*** Denis Gracin

26 Marinković 2014, str. 9–22

**Literatura / Bibliography**

**Brunšmid 1901**
J. Brunšmid, *Arheološke bilješke iz Dalmacije i Panonije IV,* Vjesnik Arheološkog muzeja u Zagrebu V, Zagreb 1901, 89-92.

**Ivčević 1998**
S. Ivčević, *Carske statue s Visa*, Histria Antiqua 4, Pula 1998, 75-84.

**S. Schroder 1993**
S. Schroder, *Katalog klasične skulpture muzeja Prado, svezak I: portreti*, Madrid 1993, 140-143.

**Donelli 1997**
I. Donelli, *Konzervacija i restauracija mramornih skulptura iz Augusteuma Narone,* VAHD 97, Split 2004, 285-338.

**Marinković 2014**
V. Marinković, *Mramorne skulpture iz Narone – problem muzejske prezentacije.* Portal 5, Zagreb 2014, 9-22.