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ISTRAŽIVANJE PODRIJETLA KAMENA I KONZERVATORSKO-RESTAURATORSKI RADOVI NA KAMENOJ PLASTICI IZ ZBIRKE DANIELI U ANTIČKOJ ZBIRCI ARHEOLOŠKOG MUZEJA ZADAR

Stalni postav antike Arheološkog muzeja Zadar izlaže građu rimske antike po principu tematskih cjelina, kao što su rimska vojska, arhitektura i urbanizam, umjetnost, religija i pokapanje. Veliki dio izložene građe čini kamena plastika, točnije 96 vrijednih primjeraka kojima je bila potrebna konzervatorsko-restauratorska obrada. U periodu od dvije godine na 50-ak kamenih spomenika izvršena je preventivna zaštita, dok je na 25 spomenika izvršen kompletan postupak zaštite. U ovom radu opisuje se konzervatorski postupak i petrografske analize provedene na mramornim skulpturama i portretima iz zbirke Danieli. Na temelju uzoraka kamene prašine, uzetih s eksponata, determinirana je vrsta i nastanak stijene. Petrografskom analizom određena je točnija provenijencija kamena i lokacija mogućih kamenoloma.

Ključne riječi: stalni postav, antika, konzervatorsko-restauratorski radovi, mramor, petrografska analiza

CONSERVATION AND RESTORATION WORK ON THE STONE SCULPTURES FROM THE DANIELI COLLECTION IN THE COLLECTION OF ROMAN ANTIQUITIES OF ARCHAEOLOGICAL MUSEUM ZADAR AND INQUIRY INTO THE ORIGIN OF ITS STONE

The permanent exhibition of Roman antiquities in Archaeological Museum Zadar is organized by themes, such as Roman military, architecture and urban planning, art, religion and burials. Stone sculptures account for large part of the exhibits – specifically, 96 valuable specimens that required conservation and restoration work. Over a period of two years, some 50 stone monuments underwent preventive protection measures and 25 of them underwent a full protection procedure. This paper describes the conservation treatment and petrographic analyses conducted on the marble sculptures and portraits from the Danieli Collection. Based on the stone dust samples collected from the exhibits, the type of the stone and its formation were determined. The petrographic analysis was used to establish a more accurate origin of the stone and the locations of the quarries it possibly came from.

Key words: Permanent exhibition, Roman period, conservation and restoration work, marble, petrographic analysis

UVOD

Arheološki muzej Zadar danas je smješten u središte povijesne jezgre rimske kolonije *Iadera*, u blizini rimskog foruma i kapitolija te glavne zadarske ulice Kalelarge, u zgradu izgrađenu 1972. god. po projektu Mladena Kauzlarića,[1] no njegov osnutak seže u davnu 1832. god.,[2] kada tadašnji austrijski namjesnik u Dalmaciji, general Vetter Vjenceslav von Lilienberg, izdaje proglas da se građa iz cijele Dalmacije prikuplja u Zadru kao sjedištu pokrajine.[3] Interes za starine i kolekcionarstvo u Zadru javlja se već krajem 14. i početkom 15. st., a kulminira iskopavanjima u Ninu, kada je pronađeno osam velikih kipova rimskih careva.[4] Muzej tijekom 18. i 19. stoljeća mijenja nekoliko lokacija. Prvo je 1877. god. smješten u napuštenu crkvu sv. Donata, uz trud tadašnjeg konzervatora za grad Ivana Smirića.[5] Nakon talijanske vladavine, tijekom koje je većina građe otuđena,[6] i nakon bombardiranja grada 1943. i 1944. god., sačuvana i spašena građa seli se 1954. god. u današnje prostorije Sveučilišta u Zadru gdje ostaje do 1974. god., kada se premješta u novu zgradu muzeja u sklopu samostana Sv. Marije. Stalne izložbe postavljene su od najstarijeg do najmlađeg razdoblja: na drugom je katu prapovijest, antička zbirka je na prvom katu, a srednji je vijek u prizemlju.[7] S početkom Domovinskog rata, 1991. god., sva arheološka građa sprema se u muzejske čuvaonice kako bi se eksponati zaštitili od ratnih razaranja. Sa završetkom rata vraćeni su prapovijesni i srednjovjekovni postav, dok se s antičkim postavom odlučilo pričekati jer se ukazala potreba za potpunom promjenom koncepcije. Pripremni radovi za novi postav antike započeli su 2005. god. izradom muzejskog koncepta i sinopsisa muzejske savjetnice Kornelije A. Gunio, zatim idejnim projektom arhitekata Ive Letilović i Igora Pedišića, koji sve eksponate smještaju unutar samonosive čelične strukture koja zapunjava središnji prostor etaže i svojom formom i ritmom asocira na arhitekturu rimskog hrama (sl. 1).

INTRODUCTION

Today, Archaeological Museum Zadar is located in the historical core of the Roman colony of *Iader*, in the vicinity of the Forum, Capitolium and the city's main street Kalelarga. It is housed in the building constructed in 1972 to the design of Mladen Kauzlarić,[1] but the Museum as such was founded back in 1832,[2] when the then Austrian governor of Dalmatia, General Vetter Vjenceslav von Lilienberg, issued a proclamation that the finds from whole Dalmatia be collected in Zadar as the provincial capital.[3] Antiquities and collecting activities first attracted interest way back in the late 14th and early 15th centuries. It culminated with the excavations in Nin, when eight massive statues of Roman emperors were found.[4] The Museum was relocated a few times in the 18th and 19th centuries. First, in 1877, it found its new home in the abandoned St. Donatus' Church, owing to the efforts of Ivan Smirić, the then inspector of ancient monuments in Zadar.[5] After the Italian rule, when most of the Museum's holdings were alienated,[6] and after the bombing of the city in 1943 and 1944, the holdings – what was saved of them – were moved to the premises of the present-day University of Zadar in 1954. They stayed there until 1974, when they were relocated once again to the new Museum building in the St. Mary's Monastery complex. The Museum's permanent exhibitions cover the represented periods in chronological order: Prehistory on the second floor, Roman Antiquities on the first floor and Middle Ages in the ground floor.[7] In 1991, early into the Homeland War, all the exhibits were stored in the Museum's depots in order to protect from ravages of war. After the war, the Prehistory and Middle Ages displays were restored while the Roman Antiquities display was put on hold because it was decided that it required a new concept. The reparations for the new Roman Antiquities display began in 2005, when the Museum advisor Kornelija A.

1 Mladen Kauzlarić (Gospić, 1896. – Zagreb, 1971.), hrvatski arhitekt.
2 Arheološki muzej osnovan je 30. studenog 1832. god. kao dio jednog sveopćeg muzeja koji je imao zadatak skupljati i čuvati sve spomenike, tragove, ostatke i dijelove života, kulture, prirode, tehnike, industrije i dr., od najranijih vremena do suvremenog doba, pod zajedničkim imenom Narodni ili Pokrajinski muzej.
3 Š. Batović 1982, 6.
4 U vrtu Josipa Đurovića u Ninu tijekom obrade zemlje pronađeno je nekoliko predimenzioniranih dijelova tijela za koje se pretpostavilo da pripadaju mramornim kipovima, što navodi zadarskog liječnika Antu Danielija Tommasonija da 1763. god. financira iskapanja, s ciljem otkupljivanja pronađene građe. M. Kolega 1989, 3–6.
5 Ivan Smirić (Zadar, 1842. – Zadar, 1928.) slikar, likovni pedagog, konzervator i restaurator starina.
6 U novije vrijeme tom se tematikom bavi profesorica Antonija Mlikota s Odjela za povijest umjetnosti Sveučilišta u Zadru koja je 2018. god. u Nacionalnoj arhivi u Washingtonu (NARA) pronašla dokument nazvan *Zara: Report on War damage on Monument and movable works of Art known to be stored in Italy*, a u kojem se donosi sadržaj četrnaest kutija iz zadarskog muzeja i drugih zbirki koje je Stefano Salvagno (asistent povjerenika Zavoda za zaštitu spomenika u Trstu) 1944. god. odnio iz Zadra. Nakon brojnih pregovora i pokušaja povratka umjetnina, 1961. god. potpisan je ugovor u kojem Jugoslavija i Italija razmjenjuju četiri kipa rimskih careva iz Nina (za koje je Italija tvrdila da nisu bili muzejsko vlasništvo, nego samo posuđeni za potrebe izložbe u Sv. Donatu, otvorene 1928. god.) za umjetnine odnesene iz Zadra.
7 Muzeološke koncepte izradili su Janko Belošević (srednji vijek), Šime Batović (prapovijest) te Julijan Medini i Boris Ilakovac (antika). Š. Batović 1982, 6.

1 Mladen Kauzlarić (Gospić, 1896 – Zagreb, 1971), Croatian architect.
2 Archaeological Museum was founded on 30 November 1832 as part of a general museum intended to collect and hold all monuments, traces, remains and fragments of life, culture, nature, technology, industry etc… from the earliest times to Modern Age. It was named National or Regional Museum.
3 Š. Batović 1982, 6.
4 While tilling land in his vegetable patch in Nin, Josip Đurović found a few parts of what was assumed to be oversized marble statues. This made the Zadar physician Ante Danieli Tommasoni finance excavations in 1763 in order to purchase the finds. M. Kolega 1989, 3–6.
5 Ivan Smirić (Zadar, 1842 – Zadar, 1928), painter, art educator and conservator and restorer of antiquities.
6 Recently, this has been an area of special interest of Professor Antonija Mlikota of the Department of History of the University of Zadar. In 2018, in the National Archives and Records Administration (NARA) in Washington D.C., she found a document entitled *Zara: Report on War damage on Monument and movable works of Art known to be stored in Italy*, listing the contents of the fourteen crates with the holdings of the Zadar Museum and other collections that Stefano Salvagno (the assistant commissioner of the Institute for the Protection of Cultural Monuments in Trieste) had taken away from Zadar in 1944. After a series of negotiations and attempts to restore the works of art, in 1961 Yugoslavia and Italy signed a contract stipulating that four statues of Roman emperors (the ones Italy claimed had not belonged to the Museum but had only been leased to it for the 1928 exhibition) be exchanged for the holdings taken away from Zadar.
7 The authors of the exhibition designs are Janko Belošević (Middle Ages), Šime Batović (Prehistory) and Julijan Medini and Boris Ilakovac (Roman antiquities). Š. Batović 1982, 6.

Slika 1. Antički postav Arheološkog muzeja Zadar, otvoren u lipnju 2014. god.
Figure 1. Roman Antiquities Exhibition in Archaeological Museum Zadar, opened in June 2014
foto / photo by: **I. Čondić**

Veliki dio izložene građe čini kamena plastika, točnije 96 vrijednih primjeraka[8] koji su zatečeni u lošem stanju, te im je bila potrebna konzervatorsko-restauratorska obrada. Neki od njih u pripremnoj su fazi poslani na konzervaciju-restauraciju u vanjske radionice,[9] dok su na ostalima

Giunio drafted the exhibition concept and synopsis and when architects Iva Letilović and Igor Pedišić completed their preliminary design, placing the exhibits on a self-supporting steel structure occupying the central area of the floor, thus reminding of the interior architecture of a Roman temple (Fig. 1).

Stone sculptures account for most of the exhibits – specifically, 96 valuable specimens.[8] They were in poor condition and required conservation and restoration work. In the preparatory phase, some of them were sent to specialized workshops elsewhere,[9] while the others were

8 Kameni eksponati izloženi u antičkom postavu potječu većinom s arheoloških nalazišta rimske provincije Dalmacije, pogotovo s područja južne Liburnije. Radi se o natpisima, nadgrobnim stelama, dijelovima arhitekture (frizovi, stupovi, grede), zavjetnim žrtvenicima, cipusima, ulomcima sarkofaga, skulpturama i portretima.

9 Na Umjetničkoj akademiji u Splitu, pod vodstvom red. prof. Ive Donelija i prof. Siniše Bizjaka, postupak konzervacije prošla je skulptura carice, inv. br. A10518; skulptura cara Augusta, inv. br. A7733; skulptura Cezara, inv. br. A7734. U restauratorskoj radionici Krševan (vlasnik Mile Mesić) konzervirani su sljedeći spomenici: ara Julije Kvijete, inv. br. A10211; počasni natpis L. V. Saturnina, inv. br. A7446; nadgrobna stela sa znamenjem centuriona, Ivoševci (*Burnum*), inv. br. A10578; ulomak vijenca, inv. br. A10585; ulomak pluteja s uklesanom ženskom tragičnom maskom, Podgrađe (*Asseria*), inv. br. A7674; kip umornog Herkula, Zadar, inv. br. A10603; reljef sjedećeg Jupitera, Zadar, inv. br. A10215; ulomak grede s posvetom božanskoj Faustini, Zadar, inv. br. A7398; žrtvenik, Podgrađe (*Asseria*), inv. br. A10201; natpisna ploča s posvetom Anzotici, Nin (*Aenona*), inv. br. A7284; zavjetni žrtvenik Latri, Nadin (*Nedinum*), inv. br. A7621; natpisne ploče s posvetom Latri, Podgrađe (*Asseria*), inv. br. A7288; ulomak zavjetnog natpisa, Zadar (*Iader*), inv. br. A10591; ulomak arhitravne grede, Podvršje kod Nina (*Aenona*), inv. br. A10208.

8 The stone monuments displayed in the Roman Antiquities exhibition mostly come from the archaeological sites on the territory of the Roman province of Dalmatia, particularly from South Liburnia. They include inscriptions, grave stelae, architectural elements (friezes, pillars, beams), votive altars, cipi, sarcophagus fragments, sculptures and portraits.

9 At Arts Academy in Split, the sculptures of an empress (inv. no. A10518), Emperor Augustus (inv. no. A7733) and Caesar (inv. no. A7734) underwent a conservation procedure led by Professor Ivo Doneli and Professor Siniša Bizjak. The following monuments were conserved in the Krševan restoration workshop (owned by Mile Mesić): ara of Iulia Quieta (inv. no. A10211), honorary inscription of L. V. Saturninus (inv. no. A7446), grave stela with centurion's insignia (Ivoševci/*Burnum*, inv. no. A10578), cornice fragment (inv. no. A10585), fragment of chancel-screen panel with female tragic mask carved in it (Podgrađe/*Asseria*, inv. no. A7674), statue of weary Hercules (Zadar, inv. no. A10603), relief depicting seated Jupiter (Zadar, inv. no. A10215), beam fragment with dedication to divine Faustina (Zadar, inv. no. A7398), altar (Podgrađe/*Asseria*, inv. no. A10201), inscription slab with dedication to Ansotica (Nin/*Aenona*, inv. no. A7284), Latra's votive altar, Nadin/*Nedinum*, (inv. no. A7621), inscription slabs with dedication to Latra (Podgrađe/*Asseria*, inv. no. A7288); fragment of votive inscription (Zadar/*Iader*, inv. no. A10591) and fragment of architrave beam (Podvršje near Nin/*Aenona*, inv. no. A10208).

Slika 2. Postavljanje skulptura u montažni bazen
Figure 2. Sculptures being placed in assembly pool
foto / photo by: **K. A. Gunio**

radove obavili stručni djelatnici Arheološkog muzeja Zadar u periodu od listopada 2012. do veljače 2014. god.[10] Zbog prioriteta otvaranja Antičke zbirke radovi nisu provedeni do kraja. Na 55 spomenika izvršena je preventivna zaštita[11], dok je na 25 spomenika izvršen kompletan postupak zaštite. Stoga je nužno sada, kada je postav otvoren za javnost, stvoriti uvjete i omogućiti nastavak radova, što je djelomično uvršteno u plan i program javnih potreba u kulturi za 2020. god. U ovom radu donose se opisi i petrografske analize provedene na skulpturama i glavama portretima iz zbirke Danieli-Pellegrini.[12]

conserved and restored by the Museum's own experts in the period between October 2012 and February 2014.[10] As the opening of the new Roman Antiquities collection was a priority, the conservation and restoration work was not completed. A total of 55 monuments underwent preventive protection measures[11] and 25 monuments underwent full protection procedure. Now that the display is open for the public, the conditions for continuation of the work should be created – which is included in the program of public needs in culture for 2020. This paper presents the descriptions and petrographic analyses of the sculptures and portrait heads from the Danieli-Pellegrini Collection.[12]

10 Voditeljica radova bila je restauratorica i akademska kiparica Marija Zorica, sudjelovali su restauratorica Martina Rajzl, muzejski tehničar Frane Šunić, muzejski majstor Mario Duka i Vesna Paleka.
11 Otklonjena su površinska onečišćenja, tretirani su 3-postotnom i 5-postotnom otopinom biocidnog i fungicidnog sredstva *Asepsol Eco*.
12 Prema podatcima zadarskog bilježnika Ivana Sorrarija, sredinom 18. st. Ante Danieli Tommasoni posjeduje najveću privatnu zbirku u Dalmaciji, koja sadrži većinom otkupljenu arheološku građu s područja Nina, Zadra i drugih mjesta na obalnom području. Zbirka nešto kasnije dolazi u nasljedstvo zadarske obitelji Pellegrini-Danieli, od kada su poznati i prvi njezini popisi, da bi zatim završila u posjedu sjemeništa u Udinama, gdje građu kataloški obrađuju i publiciraju J. Banko i P. Sticotti. Prema njihovu kataloškom opisu, zbirka

10 The conservation and restoration work in the Museum was led by restorer and academic sculptor Marija Zorica. The Museum staff participating in it included restorer Martina Rajzl, museum technician Frane Šunić, museum repairman Mario Duka and Vesna Paleka.
11 Surface contaminants were removed; they were treated with 3-percent and 5-percent solutions of the biocide and fungicide *Asepsol Eco*.
12 According to the notes of Ivan Sorrari, the mid-18th-century notary public in Zadar, Ante Danieli Tommasoni owned the biggest private collection in Dalmatia, containing mostly the purchased archaeological finds from Nin, Zadar and other places in the coastal region. The collection was later inherited by the Pellegrini-Danieli family from Zadar, when it was inventoried for the first time. Subsequently, it ended up in the seminary in Udine, where it was catalogued and published by J. Banko and P. Sticotti. According to their catalogue, the Danieli-Pellegrini Collection contained 51 Roman sculptures. Soon afterwards, the seminary sold the collection at the auctions in 1900 and 1901. The Archaeological Institute in Vienna bought some 20 sculptures for Archaeological Museum Zadar, while the remaining items ended up in the museums in Venice, Aquileia, Milan, Copenhagen etc. The four massive statues of Roman empires from Nin that had

KONZERVATORSKO-RESTAURATORSKI RADOVI

Zbog samog broja, veličine i težine te vrsta oštećenja kamenih spomenika odlučeno je da se oformi privremena restauratorska radionica u sklopu samog prostora budućeg postava i da se radovi izvode *in situ*. Budući da su se svi radovi odvijali u neadekvatnim konzervatorsko-restauratorskim uvjetima, bilo je nužno postaviti četiri montažna bazena u kojima su se mogli nesmetano obavljati daljnji poslovi, bez ugrožavanja drugih skulptura i ostalih muzejskih predmeta (sl. 2).

Kod restauratorsko-konzervatorskog zahvata bitno je da ne dođe do novih oštećenja, a za to je potreban tehnički i estetski pristup restauratorsko-konzervatorskoj sanaciji, temeljen na iskustvu i naučenoj metodi, stoga su obavljani radovi, zbog složenosti i obujma posla, podijeljeni u više faza koje su se po potrebi odvijale paralelno.

1. faza:
a) demontaža, vađenje starih klinova
b) izrada bazena
c) izrada sondi i uzorkovanje
d) predkonsolidacija
f) desalinizacija.
2. faza:
g) mehaničko čišćenje
h) kemijsko čišćenje.
3. faza:
i) konsolidacija.
4. faza:
j) površinska zaštita
k) održavanje, klimatska zaštita.

1. FAZA

Demontaža, vađenje starih klinova

Kamene spomenike bilo je potrebno s udaljenih lokacija (muzejska čuvaonica, lapidarij, crkva sv. Donata) demontirati i transportirati u privremenu restauratorsku radionicu. Za te potrebe upotrijebljena je naoko jednostavna metoda, kombinacija drvenih valjaka, drvenih poluga i ručnog viličara, uz veći napor muzejskog tehničara i nekolicine studenata.[13]

U sve su portrete u predjelu vrata bile ugrađene željezne šipke, učvršćene olovom ili cementom (sl. 3). Željezo je korodiralo i na tim mjestima uzrokovalo pucanje kamena, te je šipke bilo nužno ukloniti. Uklonile su

Danieli-Pellegrini sadržavala je 51 komad antičke kamene plastike. Nedugo zatim, sjemenište zbirku rasprodaje na aukciji održanoj 1900. i 1901. god. Arheološki zavod u Beču otkupljuje 20-ak kiparskih djela za Arheološki muzej u Zadru, dok je ostala građa raznesena u muzeje u Veneciji, Akvileji, Milanu, Kopenhagenu i dr. Četiri velika kipa rimskih careva iz Nina, koji su završili u muzeju u Veneciji, talijanska vlada 1928. god. vraća Arheološkom muzeju u Zadru, prilikom preuređenja izložbe u Donatu. Kipovi su postavljeni na oslobođeni prostor oko crkve sv. Donata te su tamo stajali izloženi sve do preseljenja 1954. god. Vidi više u M. Kolega 1989, 3–6.

13 F. Šunić 2018, 6.

CONSERVATION AND RESTORATION WORK

Due to the number, size, weight and types of damage of the stone monuments, it was decided that a temporary restoration workshop be organized in the area of the future permanent exhibition and that the work should carried out *in situ*. As all the work was to take place in the conditions inadequate for conservation and restoration work, it was necessary to install four assembly "pools" where the work could be done without disturbance and without endangering other sculptures and other exhibits (Fig. 2).

When carrying out restoration and conservation work, it is important to avoid new damage. In order to do so, the technical and esthetical approach to restoration and conservation repair should be based on experience and methods learned. This is why the work – being complex and extensive – was divided into several phases which, as necessary, would sometimes be performed simultaneously.

Phase 1:
a) Dismantling and removal of old wedges
b) Installing assembly pools
c) Probing and sampling
d) Preconsolidation
f) Desalination
Phase 2:
g) Mechanical cleaning
h) Chemical cleaning
Phase 3:
i) Consolidation.
Phase 4:
j) Surface protection
k) Maintenance and protection from weathering factors

PHASE 1

Dismantling and removal of old wedges

The stone monuments had to be dismantled and transported from their distant locations (museum depot, stone monument collection, St. Donatus' Church) to the temporary restoration workshop. A seemingly simple method was used for the purpose: Combining wooden rollers, wooden shafts and a manual fork lift, the museum technician and a few students made great efforts to carry out this task.[13]

All the portrait heads had iron rods installed in their necks, fixed with lead or cement (Fig. 3). Corrosion of the iron cause the stone to crack on these places, so the rods had to be removed. Probes with diamond drill bits were used for their removal (Fig. 4). A plastic screw anchor was then inserted in every hole and a new stainless-steel rod

ended up in a museum in Venice were returned by the Italian government to Archaeological Museum Zadar in 1928, when the new display of the exhibition in St. Donatus' Church was inaugurated. The statues were exhibited in the area around St. Donatus' Church, where they remained until their removal in 1954. See more in M. Kolega 1989, 3–6.

13 F. Šunić 2018, 6.

Slika 3. Željezna šipka ugrađena u portret i učvršćena cementom, kamenjem i gipsom
Figure 3. Iron rod inserted in portrait and fixed with cement, rocks and gypsum
foto / photo by: **F. Šunić**

Slika 4. Uklanjanje željezne šipke bušenjem sondama s dijamantnom oštricom
Figure 4. Removal of iron rod by using probes with diamond drill bits
foto / photo by: **M. Zorica**

se bušenjem sondama s dijamantnom oštricom (sl. 4). U svaku je rupu zatim postavljena plastična tipla u koju se učvrstila vijcima nova šipka od prokroma koja izlazi iz portreta i s pomoću matice učvršćuje se za metalno postolje vitrine.[14] Nakon složenih konzervatorskih zahvata, mramorni portreti montirani su u vitrine stalnog postava.

Izrada montažnih bazena

Na podu zbirke improvizirana je izrada nepropusnih bazena od dasaka, linoleuma i folije, a u njih su se, na povišene grede, u ležećem položaju postavili spomenici kako bi se mogli izvesti svi daljnji konzervatorsko-restauratorski poslovi.

Uzorkovanje i sondiranje

Kako bi se izabrala najsigurnija i najefikasnija metoda rada, koja odgovara kemijsko-fizičkim osobinama kamenih spomenika, obavljeno je nekoliko predradnji: temeljiti pregled spomenika, pisana i fotodokumentacija zatečenog stanja,

was installed in it with screws. Using the rod protruding from the head and a screw nut, the head was then fixed to the metal shelf of the display case.[14] After complex conservation work, the marble portraits were installed in the display cases of the permanent exhibition.

Installing assembly pools

Makeshift impervious pools were assembled on the floor of the exhibition space using wooden planks, linoleum and foils. Beams were laid on the floor inside them and the monuments were laid on the beams so that all other conservation and restoration work could be carried out.

Sampling and probing

In order to opt for the safest and most efficient method of work that corresponds with the chemical and physical characteristics of the stone monuments, some preliminary work was done: the monuments were thoroughly examined; their condition was described and photographed; the stone types

14 F. Šunić 2018, 10.

14 F. Šunić 2018, 10

definiranje tipa kamena, analiza topljivih soli, vrste i stupanj oštećenja kamena, razne promjene koje su na njemu ostavili procesi starenja i klimatskih uvjeta te povijesni pregled prethodnih intervencija.[15] Svaki spomenik koji se nalazi u urbanoj sredini i koji je izložen atmosferskim utjecajima, s vremenom će biti prekriven raznim nečistoćama koje će manje ili više prionuti uz kamenu površinu. Prilikom temeljitog pregleda spomenika zatečena su razna onečišćenja[16] i oštećenja, npr. anorganska onečišćenja (crne, sive i smeđe kore[17] i inkrustacije[18]), organska onečišćenja, u što spadaju biološki obraštaji kao što su lišajevi, alge, a zatim razne bakterije, gljivice i plijesni, oštećenja nastala pod utjecajem vlage i topivih soli, oštećenja nastala pod utjecajem korozije metala.

Pretkonsolidacija

Kako ne bi došlo do gubitka osnovne kamene mase tijekom radova koji će uslijediti, obavljena je pretkonsolidacija na mjestima oštećene površine kamena. U tu svrhu korišten je konsolidant *Estel 1000*.[19] Tragovi boje vidljivi po draperiji skulptura površinski su zaštićeni i stabilizirani; u prvom sloju korišten je polivinil-alkohol (*Mowiol 4-98*),[20] a u drugom *Paraloid B-72*.[21]

Desalinizacija

Desalinizacija ili odsoljavanje proces je odstranjivanja štetnih topivih soli iz kamena. Određivanje štetnih topivih soli postiže se kvalitativnim i kvantitativnim kemijskim analizama, a uglavnom se određuju anioni: sulfati, kloridi, nitrati i karbonati. Kloridi, koji su i najčešći u obalnom pojasu, određivani su instrumentalno-potenciometrijskom titracijom.[22] Početna koncentracija natrijeva klorida (NaCl) određivana je analizom uzoraka vode iz prve kupke ili iz uzoraka vodenog ekstrakta prve pulpe. Temeljem provedenih analiza topivih soli prema Austrijskom standardu B 3355-1,[23] utvrđeno je da su u svim uzorcima detektirani kloridi u štetnoj koncetraciji te da je nužno provesti postupak desalinizacije. Početna koncentracija

were defined; soluble salts, types of stones and degrees of damage were defined; various consequences of ageing and weathering were determined; and history of earlier interventions was established.[15] Over time, every stone monument located in an urban area and exposed to weathering will be covered with various contaminants adhering to its surface more or less tightly. When the monuments were thoroughly examined, various contaminants[16] and types of damage were observed – for example, non-organic contaminants (black, gray and brown crusts[17] and incrustations[18]), organic contaminants (including biological layers such as lichens, algae, various bacteria, fungi and mold), damage caused by moisture and soluble salts and damage caused by metal corrosion.

Preconsolidation

In order to avoid the loss of basic stone mass during the work which was to follow, preconsolidation was carried out on damaged spots on the stone surface. To this end, the consolidant *Estel 1000* was used.[19] The traces of dye found on the drapery on the sculptures were protected and stabilized on the surface; polyvinyl alcohol (*Mowiol 4-98*) was used for the first layer[20] and *Paraloid B-72* for the second.[21]

Desalination

Desalination is a process of removal of harmful soluble salts from the stone. The harmful soluble salts are determined by using qualitative and quantitative chemical analyses. It is mostly anions that are determined: sulfates, chlorides, nitrates and carbonates. Chlorides – the most frequent in the coastal areas – were determined using instrumental potentiometric titration.[22] The initial concentration of sodium chloride (NaCl) was determined by analyzing the water samples from the first bath or the samples of the water extract of the first pulp. Based on the analyses of soluble salts conducted in accordance with the Austrian standard B 3355-1,[23] chlorides

15 Mikroanaliza kemijskog sastava sačuvanih pigmenata na pojedinim skulpturama nije obaviljena zbog prioriteta otvaranja antičkog postava. FTIR analiza, analize pokretnim svjetlosnim mikroskopom i snimanje UV lampom planiraju se obaviti u 2020. god. i prijavljeni su u program javnih potreba u kulturi.

16 Onečišćenje – tanka crna naslaga egzogenih čestica na kamenu koja ga prlja i može prerasti u „crnu koru", vidi više u K. Hraste 2015, 213.

17 Kora je naziv za koherentne nakupine materijala na površini kamena, vidljive debljine, koje, kad su nejednolike, otežavaju čitljivost površinskog reljefa; često su tamne boje i sastoje se od čestica atmosferskog onečišćenja uhvaćenog u gipsanu matricu, vidi više u K. Hraste 2015, 210.

18 Inkrustacija – naziv za koru u značenju mineralne kalcitne naslage; vidi više u K. Hraste 2015, 214.

19 *Estel 1000* (C. T. S.) – komercijalno ime proizvoda za konsolidaciju, sastavljenog od otopine etil-silikata u *White spirit* D40. Namijenjen je pretkonsolidaciji i konsolidaciji povijesnih žbuka i kamena silikatnog i karbonskog sastava. https://www.ctseurope.com/en/scheda-prodotto.php?id=220 (14. 9. 2019.)

20 *Polyvinyl alcohol* (PVAL) sintetski je vodotopiv i termoplastični polimer. Dobiva se potpunom ili djelomičnom hidrolizom polivinil-acetata.

21 *Paraloid B-72* trajna je nežuteća akrilna smola, po sastavu etil-metakrilat kopolimer. Topiv je u acetonu, etanolu, toluenu i ksilenu.

22 Analize je provela viša restauratorica Josipa Lovrić, a za tu svrhu korišten je aparat *Titrano plus*.

23 H. Malinar 2003, 50.

15 The chemical composition of the pigments preserved on some sculptures were not microanalyzed because the inauguration of the permanent exhibition of Roman Antiquities was a priority. Carrying out a FTIR analysis, mobile light microscope analyses and UV screening is planned for 2020. These activities have been submitted for inclusion in the program of public needs in culture for 2020.

16 Contaminant – a thin black deposit of exogenous particles on the stone. It stains the stone and can develop into a "black crust"; see more in K. Hraste 2015, 213.

17 Crust is the term for coherent accumulations of material on the stone's surface. They are of a visible thickness and, when uneven, they make the surface relief less legible. They are often of a dark color and consist of the particles of an atmospheric contaminant trapped in the gypsum matrix; see more in K. Hraste 2015, 210.

18 Incrustation – the term describing a crust in the form of mineral calcite deposit; see more in K. Hraste 2015, 214.

19 *Estel 1000* (C. T. S.) – The commercial name of the consolidation agent composed of an ethyl-silicate solution in *White spirit* D40. It is intended for preconsolidation and consolidation of historical plasters and stones composed of silicate and carbon, https://www.ctseurope.com/en/scheda-prodotto.php?id=220 (14 September 2019).

20 *Polyvinyl alcohol* (PVAL) is a synthetic hydrosoluble and thermoplastic polymer. It is obtained by a full or partial hydrolysis of polyvinyl acetate.

21 *Paraloid B-72* is a durable non-yellowing acrylic resin. It is an ethyl methacrylate copolymer by its composition. It is soluble in acetone, ethanol, toluene and xylene.

22 The analyses were carried out by senior restorer Josipa Lovrić, using the *Titrino plus* instrument.

23 H. Malinar 2003, 50.

Inventarni broj	Početna konc. klorida mg/L
A10216	251,36
A7301	238,12
A7744	192,6
A7740	188,32
A7305	184,2
A7746	181
A7743	177,1
A7745	176,3
A7739	173
A7732	171,92

Slika 5. Rezultati analize početne koncentracije klorida
Figure 5. Results of initial chloride concentration analysis
izradila/ prepared by: **M. Rajzl**

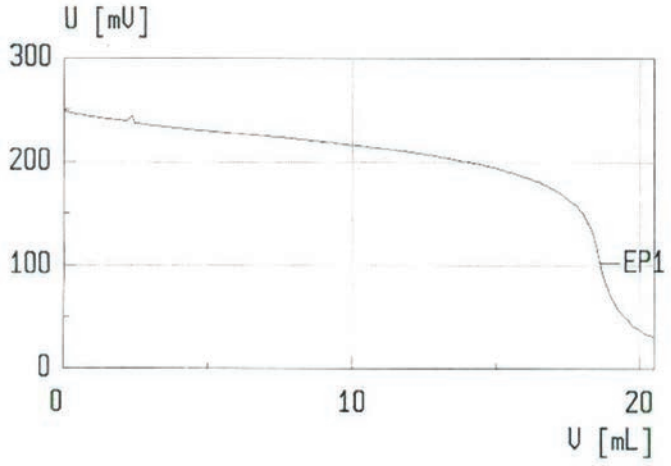
```
877 Titrino plus          06124   5.877.0020

RESULT REPORT
Method                  MET U      KONCklorida

Duration of determination                539.9 s
Sample number                              2
Sample size                             10 mL

EP1     102.1 mV                     18.6377 mL
         432.6 s                       ERC 52.2
Manual stop
KONCENTRAC.                          251.36 mg/L

CURVE
Method                  MET U      KONCklorida
```



Slika 5a. Rezultati analize početne koncentracije klorida na primjeru akefalne skulpture A10216
Figure 5a. Results of initial chloride concentration analysis for acephalous sculpture A10216
foto / photo by: **M. Rajzl**

klorida u uzorcima bila je u rasponu od 251,36 mg/L do 171,92 mg/L (sl. 5, 5a). Proces desalinizacije se, ovisno o stanju kamenog spomenika, obavljao paralelno na nekoliko načina: pranjem, vodenom kupkom, vodenom parom[24] i tretiranjem oblozima. Metoda uranjanja kamenog spomenika u posudu od plastike (PVC-a) s vodom vršila se uz dodatak biocidnog i fungicidnog sredstva *Asepsola Eco*,[25] osim u slučaju kada se voda uzimala za analizu (sl. 6). Upotrebljavala se vodovodna voda, dok je zadnja izmjena obavljena s destiliranom vodom. Također se upotrebljavala metoda oblaganja kamena oblozima od celulozne pulpe, namočenim u destiliranu vodu.[26] Prije izmjene vode ili pulpe mjerena je količina izlučenih soli iz predmeta, a proces je trajao sve dok se količina soli iz

in harmful concentrations were detected in all samples and it was necessary to carry out a desalination procedure. The initial concentration of chlorides in the samples ranged from 251.36mg/L to 171.92mg/L (Figs. 5, 5a). Depending on the condition of a particular monument, the desalination process was carried out simultaneously in several ways: by washing, by using water bath, by using water vapor[24] and by using compresses. When the method of submerging a stone monument into a plastic (PVC) container filled with water was used, the biocide and fungicide *Asepsol Eco* was added[25], except in the cases when water was used for an analysis (Fig. 6). Tap water was used in such occasions, but distilled water was used for the last bath. The method of applying cellulose-pulp compresses soaked in distilled water on the stone was also used.[26] Before water or pulp was changed, the quantity of the salts

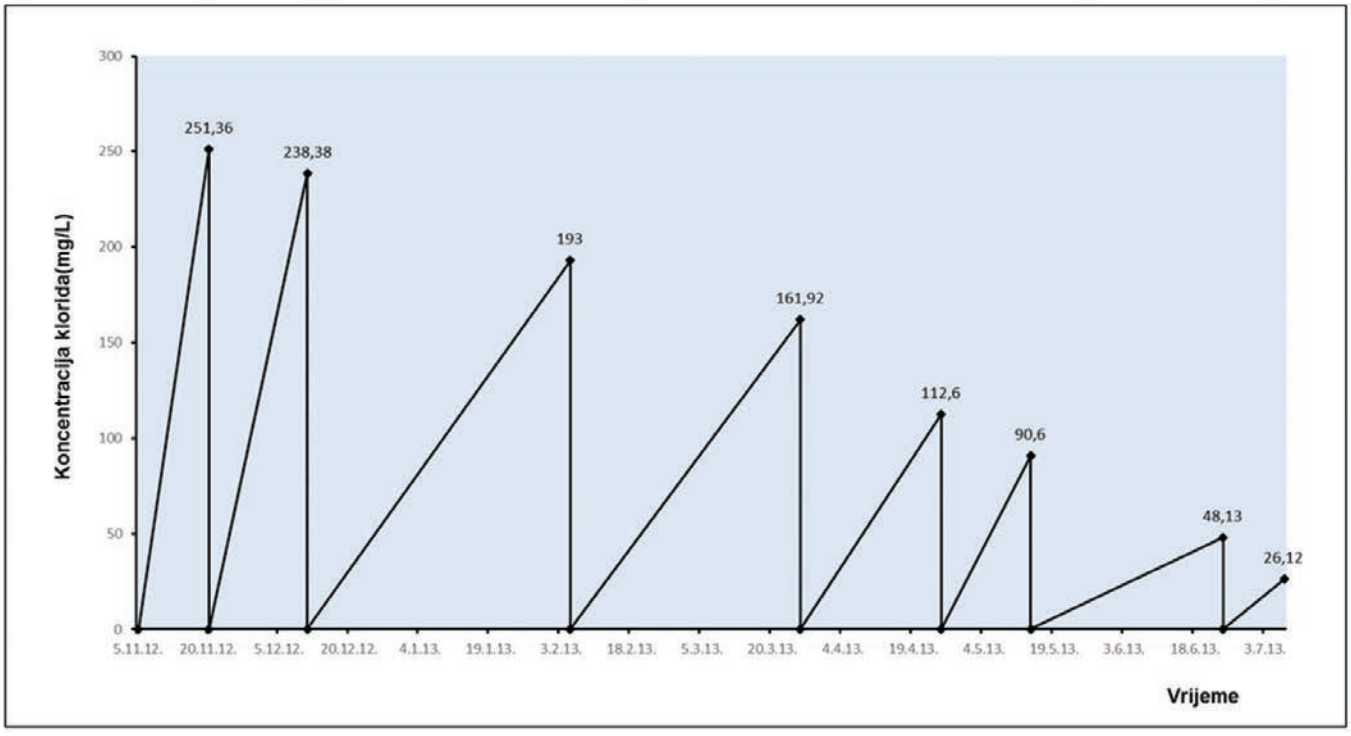
24 Vodena para pod povišenom temperaturom poboljšava proces otapanja klorida i postupak odsoljavanja.
25 ASEPSOL® eko (Pliva d. o. o.) je biodegradibilni, djelotvorni kationski dezinficijens, ugodna mirisa, čiju osnovu čine kvarterne amonijeve soli s dodatkom alkohola, http://www.pliva-sept.hr/proizvodi/Asepsol-EKO.html (14. 9. 2019.).
26 Kamen će apsorbirati vodu koja će otopiti štetne topive soli i prilikom isparavanja povući soli koje nastoje izaći na površinu, formirajući inkrustacije u samoj pulpi. Pulpa se ostavlja oko tjedan dana kada se odstranjuje i zamjenjuje svježom, a postupak se ponavlja po potrebi.

24 When the temperature increases, water vapor improves the chloride dissolution process and desalination process.
25 ASEPSOL® eko (Pliva d. o. o.) is an efficient biodegradable cationic disinfectant of pleasant odor, based on quaternary ammonium salts with an addition of alcohol, http://www.pliva-sept.hr/proizvodi/Asepsol-EKO.html (14 September 2019).
26 The stone will absorb the water that will dissolve the harmful soluble salts and, when evaporating, will bind the salts trying to reach the surface, thus forming incrustations in the pulp. The pulp is left to rest for about a week. Then it is replaced with a fresh one and the procedure is repeated if necessary.

Slika 6. Desalinizacija glave u PVC posudi, uz dodatak biocidnog i fungicidnog sredstva
Figure 6. Desalination of a head in PVC container, with addition of biocidal and fungicidal agent
foto / photo by: **M. Zorica**

kamena nije spustila na neštetni minimum, što znači da su mjerenja na svim uzorcima na kraju pokazivala kocentraciju klorida u rasponu od 30 mg/L do 26 mg/L. Proces je trajao od šest do osam mjeseci (graf. 1).

extracted from the object was measured; the process lasted until the quantity of the salt from the stone reached a non-harmful minimum – in other words, until the measurements on all samples showed chloride concentrations ranging from 30mg/L to 26mg/L. The process took from six to eight months (Chart 1).



Grafikon 1. Shematski prikaz procesa opadanja koncentracije klorida na primjeru akefalne skulpture A10216
Chart 1. Chloride concentration drop for acephalous sculpture A10216
izradila / prepared by: **M. Rajzl**

Slika 7. Čišćenje mramornih glava vodom
Figure 7. Cleaning marble heads with water
foto / photo by: **M. Rajzl**

2. FAZA
Mehaničko i kemijsko čišćenje

Proces čišćenja predstavlja estetski i tehnički problem koji se mora pažljivo odabrati. Iskustvo je pokazalo da su mnogi kameni spomenici oštećeni prilikom čišćenja i da su se prilikom procesa izgubili vrijedni podatci poput sačuvanih tragova pigmenata, originalne patine, a ponekad i sitnih fragmenata nestabilne površine. No proces čišćenja svakako treba eliminirati sve što bi moglo oštetiti kamenu strukturu. Tijekom procesa uklonjene su štetne topive soli, djelomične inkrustacije i crne kore, naslage materijala upotrebljenog pri prethodnoj restauraciji i sve rekonstrukcije nosova, mikroorganizmi, parazitska vegetacija, nečistoće od ptica i drugih životinja. Izbor odgovarajuće metode prilagođen je za svaki specifični slučaj na temelju analize stupnja i vrsta onečišćenja, karakteristika i tipa kamena.

Čišćenje vodom

Nečistoće s kamenih spomenika, naslage od zemlje, masnoće i čađe uklonile su se pranjem vodom, vodenom parom, mekim četkama i pH neutralnim deterdžentom *Contradom 2000*.[27] Pazilo se na oštećeni kamen, kako voda ne bi uzrokovala gubitak nestabilne površine (sl. 7). Čišćenje vodenom parom pokazalo se učinkovito kod uklanjanja organskih onečišćenja, bioloških obraštaja (kolonija mikroskopskih algi, lišajeva, mahovine i trave) i voska zasićenog gljivicama.

Paste i oblozi

Za omekšavanje tvrdokornih naslaga korišteni su oblozi od celulozne pulpe[28] s dodatkom dviju vrsta mineralnih glina, sepiolite i atapulgite,[29] koje su po svom sastavu vrlo slične i, osim što omekšavaju površinske tvrdokorne naslage, daju dobre rezultate upijanja nečistoća iz kamena, uključujući i topive soli. Kao solvent, ovisno o stupnju oštećenja i vrsti onečišćenja, koristile su se paste zasićene otopinom amonijeva karbonata[30]

27 *Contrad 2000* vodena je emulzija na bazi anionskih i neionskih aktivnih tvari, upotrebljava se kao sredstvo za čišćenje i dekontaminaciju, https://www.restauro-online.com/Contrad-2000-Cleaning-concentrate (6. 11. 2019.).
28 Celulozna vata – 100 % bijeljena celuloza u listovima.
29 Sepiolita i atapulgita vrste su mineralnih glina, bogate hidratnim magnezij-silikatnim mineralom, koje imaju veliko svojstvo apsorpcije.
30 Otopina amonijeva karbonata pretvara slabo topljivi kalcijev sulfat u topljivi amonijev sulfat koji prelazi u pulpu i na taj se način uklanja, što pospješuje proces desalinizacije, dok reakcijom amonijeva karbonata s kalcijevim

PHASE 2
Mechanical and chemical cleaning

The cleaning process is an esthetical and technical problem that has to be selected carefully. Experience tells us that many stone monuments were damaged during cleaning, losing valuable data in the process – the data like preserved traces of pigments, original patina and, sometimes, tiny fragments of unstable surfaces. Everything that could damage the stone structure must be eliminated from the cleaning process. During the process, the following was removed: harmful soluble salts, partial incrustations and black crusts, deposits of the material used in earlier restorations, all nose reconstructions, microorganisms, parasite vegetation, excrements of birds and other animals. A suitable method is to be selected for every individual case based on an analysis of the degree and types of contaminants and the characteristics and type of stone.

Cleaning with water

The contaminants from the stone monuments, deposits of dirt, grease and soot were removed by washing with water, water vapor, soft brushes and the pH neutral detergent *Contrad 2000*.[27] Precautions were taken to prevent water from causing a loss of unstable surface on damaged stones (Fig. 7). Cleaning with water vapor turned out to efficient in removing organic contaminants, biological layers (microscopic algae colonies, lichens, moss and grass) and wax saturated with fungi.

Pastes and compresses

For softening persistent deposits, cellulose-pulp compresses [28] with an addition of two mineral clays – sepiolite and attapulgite[29] – were used. These clays are very similar by their composition and, besides softening persistent surface deposits, they are also efficient in absorbing contaminants from the stone, including soluble salts. Depending on the degree of damage and the type of contaminants, pastes saturated with ammonium carbonate solution[30] or those saturated with a hydrogen peroxide solution were used as solvents. They fully or partially remove the contaminants (Figs. 8, 8a).

27 *Contrad 2000* is a water emulsion based on anionic and non-ionic surfactants. It is used as a cleaning and decontamination agent, https://www.restauro-online.com/Contrad-2000-Cleaning-concentrate (6 November 2019).
28 Cellulose cotton – 100 % bleached cellulose in sheets.
29 Sepiolite and attapulgite are types of mineral clays rich in a hydrate magnesium-silicate mineral with large absorption capacity.
30 Ammonium carbonate solution turns poorly soluble calcium sulfate into soluble ammonium sulfate which turns into pulp and is thus eliminated. This expedites the desalination process. Ammonium carbonate reacts with calcium sulfate to form the unsolvable calcium carbonate – therefore no basic stone mass is lost.

Slika 8. Nanošenje obloga od celulozne pulpe i sepiolite
Figure 8. Applying cellulose-pulp compresses soaked in sepiolite
foto / photo by: **M. Zorica**

Slika 8a. Oblozi od celulozne pulpe zasićene otopinom amonijeva karbonata
Figure 8a. Cellulose-pulp compresses saturated with ammonium carbonate solution
foto / photo by: **M. Rajzl**

ili otopinom vodikova peroksida, čiji je učinak potpuno ili djelomično uklanjanje nečistoća (sl. 8, 8a).

Mehaničko čišćenje

Štetne naslage i tvrde kore, nakon što su omekšale djelovanjem odgovarajućih pasta, uklonjene su mehanički, kirurškim skalpelima, dlijetima, električnim mikromotorom i ultrazvučnom iglom (sl. 9, 9a). Pri čišćenju se pazilo na razliku između štetnih naslaga i plemenite patine[31] koja je rezultat prirodnih procesa na površini kamena i kao takvu ju treba sačuvati. Od čišćenja mikropjeskarnikom se odustalo nakon nekoliko probnih sondi zbog listanja i osipanja površine kamena.

Slika 9. Mehaničko čišćenje površine kamena mikromotorom
Figure 9. Mechanical cleaning of stone surface (with micromotor)
foto / photo by: **M. Zorica**

Slika 9a. Mehaničko čišćenje površine kamena kirurškim skalpelom
Figure 9a. Mechanical cleaning of stone surface (with surgical scalpel)
foto / photo by: **M. Rajzl**

Mechanical cleaning

Having been softened with suitable pastes, the harmful deposits and hard crusts were removed mechanically, using surgical scalpels, chisels, electric micromotor and ultrasound needle (Figs. 9, 9a). During the cleaning, the difference between the harmful deposits and noble patina[31] was kept in mind. This patina is a result of natural processes taking place on a stone surface and should be preserved as such. After a few trial probings, the idea of using a micro-sandblaster for the cleaning was given up because the stone surface started exfoliating and crumbling.

sulfatom nastaje netopljivi kalcijev karbonat pa nema gubljenja osnovne kamene mase.

31 Plemenita patina nastaje tijekom godina neposredno ispod površine kamena otapanjem kalcita i njegovom pretvorbom u minerale vevelit i vedelit, varijetete kalcijeva oksalata, te predstavlja prirodan proces starenja kamena. Vidi više u I. Donelli, H. Malinar 2015, 128.

31 The "noble" patina accumulates over the years immediately underneath the stone surface by dissolution of calcite and its turning into the minerals whewellite and weddellite, varieties of calcium oxalate. It is a natural stone-ageing process. See more in I. Donelli, H. Malinar 2015, 128.

3. FAZA
Konsolidacija

U postupku konsolidacije podrazumijevamo upotrebu raznih konsolidanata koji duboko penetriraju u kamen i poboljšavaju njegovu koheziju, njegove mehaničke karakteristike. Dubina penetracije ovisi o oštećenju i poroznosti kamena te o vrsti konsolidanta koji se primjenjuje i njegovoj aplikaciji. Ako se radi o kamenu niske poroznosti, tada je dubina penetracije sporija, ako se radi o kamenu veće poroznosti, tada penetracija ima brže djelovanje. Konsolidant se nanosi premazivanjem kistom, prskanjem, potapanjem i vakuumskom impregnacijom.[32] Postupak konsolidacije primjenjuje se u slučajevima kada je kamen u lošem stanju ili kada mu prijeti opasnost od daljnjeg raspadanja. Konsolidaciju i premazivanje zaštitnim premazom nije bilo moguće izvesti na gotovim predmetima zbog prekida radova i otvorenja antičke zbirke. No danas, četiri godine kasnije, redovitim praćenjem i nadzorom primjećuju se na nekim skulpturama nove površinske mrlje nastale prilikom dodirivanja brojnih posjetitelja. Stoga se izvođenje navedene faze uvrstilo u plan i program za 2020. god.[33] Preporučljivi su konsolidanti: etil-silikati, akrilne smole i barijev hidroksid.

Adhezivi i ispunjači

Ako u kamenu postoje jača oštećenja i veće pukotine, upotrebljavaju se adhezivi[34] i ispunjači kojima se postiže stabilnost.[35] Kao ispunjač upotrebljavala se epoksi-smola, koja je pogodna kao vezivo i kao ispunjač zbog svoje velike snage adhezije, elastičnosti i mehaničkih karakteristika.[36] Epoksi-smole reagiraju na svjetlo i zrak, te nakon nekog vremena promijene boju (požute) i slabije su čvrstoće. Upotrebljavaju se unutar kamena, u pukotinama koje nisu izložene atmosferskim utjecajima i mehaničkim udarcima, a ako se ipak upotrebljavaju na površini, mora ih se prekriti drugim proizvodom koji je čvršći (sl. 10, 10a). U prošlosti se često kao ispunjač upotrebljavao portland cement, ali danas znamo da se njime nikako ne smije služiti jer je bogat supstancijama alkala i sulfata. Tijekom hidratacije cementa, topivi alkali koncentriraju se u otopini i migriraju difuzijom prema površini. Reakcijom s ugljičnim dioksidom iz zraka, na površini kamena ili neposredno

PHASE 3
Consolidation

The consolidation process implies the use of various consolidants that penetrate deep into the stone, thus improving its cohesion and its mechanical characteristics. The depth of penetration depends on the degree of damage and stone porosity and on the type and application of the consolidant being used. If the stone is of low porosity, penetration is slower; if it is of high porosity, penetration is faster. The consolidant is applied by a paintbrush, by sprinkling, by submerging and by vacuum impregnation.[32] The consolidation procedure is used in the cases when a stone is in poor condition or when it is exposed to the danger of further degradation. The consolidation and application of a protective coating on the objects was not possible because the work had to be stopped for the inauguration of the Roman Antiquities exhibition. Today, however, four years later, regular monitoring and control have revealed some new surface stains on some sculptures. They emerged as a result of touching by numerous visitors. This is why this phase was included in the 2020 program.[33] The following consolidants are recommended: ethyl-silicates, acrylic resins and barium hydroxide.

Adhesives and fillers

If there are major damages and cracks in a stone, adhesives[34] and fillers are used in order to achieve stability.[35] Epoxy resin was used as a filler. It is suitable both as a binder and as a filler due to its high adhesion capacity, elasticity and mechanical characteristics.[36] Epoxy resins react to light and air and change their color after a while (they become yellow). Their strength is not so high. They are applied inside the stone, in the cracks which are not exposed to weathering and mechanical blows. If they are used on the surface nevertheless, they have to be covered with another, stronger product (Figs. 10, 10a). Portland cement was often used as a filler in the past but now we know we cannot use it because it is rich in alkalis and sulfates. During hydration of cement, the soluble alkalis concentrate in the solution and migrate by diffusion towards the surface. Upon reaching the surface, they react with carbon dioxide in the air to form the soda (sodium carbonate with a 10 water molecula) crystals on the stone's surface or

32 U metodi konsolidacije kamena s pomoću vakuuma koriste se niskotlačni uvjeti u zatvorenom okružju. Naime, vakuumiranjem se dobiva podtlak. Predmeti se omotavaju u dvostruki sloj pamučnog flanela i *rubber latex* pod određenim stupnjem vakuuma kako bi se konsolidant ravnomjerno distribuirao u dio između predmeta i vanjskog omotača. Konsolidant se polako pušta i prati se njegova penetracija. Željeni konsolidant prodire u sve pore kamena gdje se prije nalazio zrak, na taj način učvršćenje je maksimalno. Postupak se ponavlja sve dok kamen upija sredstvo. Prednost je te metode što se može primijeniti *in situ*.

33 Troškovi izvođenja konzervatorsko-restauratorskog zahvata potražuju se od Ministarstva kulture i prijavljeni su na program javnih potreba u kulturi za 2020. god.

34 Adheziv – ljepilo.

35 Ispunjači se obično pripremaju miješajući veziva s materijalima kao što su silicijev dioksid, stakleni prah, kamen u prahu i dodatci pigmenta.

36 Kao vezivo može se upotrijebiti *Paraloid 72 B*, zasićen mramornom prašinom, koji se može lako obrađivati dok je mekan, a ako sjaji, trlja se staklenim vlaknima.

32 The vacuum consolidation method is used in low-pressure conditions in a closed environment. When vacuum is created, underpressure is also created. The objects are wrapped in a double layer of cotton flannel and *rubber latex* at a certain degree of vacuum so that the consolidant could distribute evenly into the part between the object and the outer layer. The consolidant oozes slowly and its penetration is monitored. The desired consolidant penetrates into all pores in the stone where air once was. Maximum consolidation is thus achieved. The procedure is repeated as long as the stone can absorb the agent. The advantage of this method is that it can be used *in situ*.

33 The request for compensation of the costs of the conservation and restoration work has been submitted to the Ministry of Culture for inclusion in the program of public needs in culture for 2020.

34 Adhesive – a glue.

35 Fillers are usually made by mixing binders with materials like silica dioxide, glass powder, stone powder and pigment admixtures.

36 *Paraloid 72 B*, saturated with marble dust, can be used as a binder. It is easily worked while it is soft; if shining, it rubs against glass fibers.

Slika 10. Popunjavanje rupa nastalih u prijašnjoj restauraciji
Figure 10. Filling holes created in earlier restoration
foto / photo by: **M. Rajzl**

Slika 10a. Popunjavanje rupa nastalih probijanjem originalnog sloja
Figure 10a. Filling holes created by penetration of original layer
foto / photo by: **M. Rajzl**

ispod nje nastaju kristalići sode, natrijeva karbonata, sa 10 molekula vode. Tijekom vremena taj karbonat gubi vlagu i prelazi u termonatrit, natrijev karbonat s jednom molekulom vode. Taj proces očituje se kristalizacijom i tvar prelazi u fini prah.[37] S obzirom na to da je cement obično manje porozan nego mnoge vrste kamena, stvaranje vode unutar same strukture, isparavanje vode i kristalizacija soli upravo se događaju na materijalu koji je porozniji, tj. u ovom slučaju na kamenu, a ne cementu, što znači da razlike u rastezljivosti između cementa i kamena pri promjeni temperature mogu uzrokovati pucanje i mehaničko oštećenje kamena. Zato su stare rekonstrukcije od cementa mehanički i kemijski odstranjene.

Petrografska analiza uzoraka

Pažljivo se, iz već postojećih rupa, izvukla kamena prašina za petrografsku analizu. Uzorci su poslani u vanjski laboratorij na Geološko-paleontološki zavod PMF-a.[38]

Stijene su opisane makroskopski i mikroskopski.[39] Dobiveni mikroskopski preparat promatra se u prolaznom svjetlu, prvo bez uključenog analizatora, a poslije s analizatorom, kako bi se prepoznali različiti minerali. Radi dokumentacije mikroskopski se preparati fotografiraju bez uključenog analizatora i s uključenim analizatorom.

immediately underneath it. Over time, this carbonate loses its moisture and turns into thermonatrite, a sodium carbonate with a single water molecule. This process takes place in the form of crystallization. The substance turns into a fine dust.[37] Since cement is usually less porous than many sorts of stones, the forming of water within the structure, evaporation of water and crystallization of salts take place on the more porous material – in this case, it is stone, not cement. This means that, when temperature changes, the differences in elasticity between cement and stone can cause cracking of the stone and mechanical damage to it. This is why the earlier cement-based reconstructions were mechanically and chemically removed.

Petrographic analysis of the samples

Stone dust was carefully extracted from the existing holes in order to be analyzed. The samples were sent to the laboratory of the Geological and Paleontological Institute of the Faculty of Science.[38]

The rocks were described macroscopically and microscopically.[39] The thin sections (microscope preparations) were observed under polarized optical microscope, first without crossed polars and then with them, so that various minerals could be recognized. For documentation purposes, the thin sections were photographed – both in cross polarized and plane light.

37 https://korak.com.hr/korak-052-prosinac-2015-iscvjetavanja-na-kamenim-povrsinama (13. 11. 2019.).
38 Petrografsko-mineraloškу analizu iz mikroskopskih preparata izradila je dr. sc. Vlasta Ćosović, mikroskopske preparate izradio je dipl. ing. Željko Ištuk.
39 Makroskopski opis obuhvaća boju (ili raspon boja), veličinu zrna (krupno, srednje, sitno) te otvorene ili mineralnom tvari ispunjene pukotine. Mikroskopski opis sadrži: teksturne i strukturne osobine, minerale, dimenzije sastojaka, stupanj sortiranja u klastima, međuzrnate kontakte ili dodire te opise fosilnog sadržaja. Analizirani uzorci veličine su od 0,5 mm do oko 2 cm. Napravljeni su mikroskopski preparati, izbrusci. Mikroskopski se preparat radi tako da se uzorak izreže u pločicu debljine nekoliko milimetara. Pločica se ispolira samo s jedne strane, opere i osuši. Tako priređena pločica lijepi se na predmetno stakalce, slijedi brušenje dok pločica ne postane potpuno prozirna (debljine oko 30 µm).

37 https://korak.com.hr/korak-052-prosinac-2015-iscvjetavanja-na-kamenim-povrsinama (13 November 2019).
38 The petrographic and mineralogical analysis of the microscope preparations was conducted by Vlasta Ćosović, PhD. The thin-sections were made by Željko Ištuk, BA.
39 The macroscopic description refers to color (or range of colors), grain size (coarse, medium-sized, fine) and fractures (empty or cemented). The microscopic description refers to textural and structural characteristics, minerals, size of components, degree of sorting in clasts, intergranular contacts and fossil contents. The size of the analyzed samples ranged between 0.5mm to approx. 2cm. Thin sections (microscope preparations) were made. Thin sections are done in such way that a rock-sample is cut into a rock slice a few millimeters thick. The slice is grinding and polished only on one side and then washed and dried. It is then glued to the glass slide and polished until fully transparent (approx. 30µm thick).

POPIS KAMENIH PREDMETA NA KOJIMA SU OBAVLJENI KONZERVATORSKO-RESTAURATORSKI RADOVI

1. Glava mladića s dugom kosom

Mjesto čuvanja: Stalni postav antike, Arheološki muzej Zadar, inv. br. A7745
Mjesto nalaza: Nepoznato (zbirka Danieli)
Dimenzije: Ukupna visina 28 cm
Materijal: Mramor
Opis
Portret prikazuje mladića izrazito lijepe fizionomije, s bujnom i kovrčavom kosom. Debeli se pramenovi preklapaju što stvara dojam bujnosti i lepršavosti. Izuzetno je kvalitetno kiparsko djelo koje odlikuje viši stupanj estetske i klesarske obrade i pripada u skupinu individualnog porteta koji se ne može povezati uz određenu carsku osobu. Datira se u kraj 2. / poč. 3. st.[40]
Zatečeno stanje
Cijela glava prekrivena je sivo-smeđom patinom, dok su u uvojcima kose mjestimično vidljive i deblje naslage u vidu crne kore. Na obrazima se primjećuje nagrižen originalni sloj, vidljivo je listanje kamena te ljuskanje i šećerasto osipanje. Nos je u prijašnjem restauratorskom zahvatu rekonstruiran, a zalijepljen je donji dio uha i dio pramena kose. U trenutku kad je portret zaprimljen na konzervaciju, rekonstrukcija nosa već je bila uklonjena (sl. 11).
Petrografska analiza (sl. 11a, 11b)
Makroskopski opis: Homogene teksture, bijele boje.
Mikroskopski opis: Granoblastični srednjozrnati mramor. Poligonalna zrna kalcita (veličine dominante skupine kristala između 500 i 800 mikrona) u mozaičkom su kontaktu.

40 N. Cambi, M. Kolega 1990, 38.

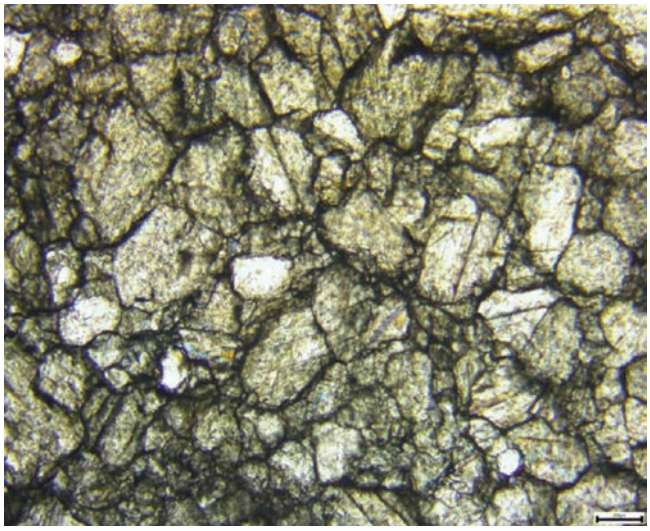
THE LIST OF STONE OBJECTS THAT UNDERWENT CONSERVATION AND RESTORATION WORK

1. Young man's head with long hair

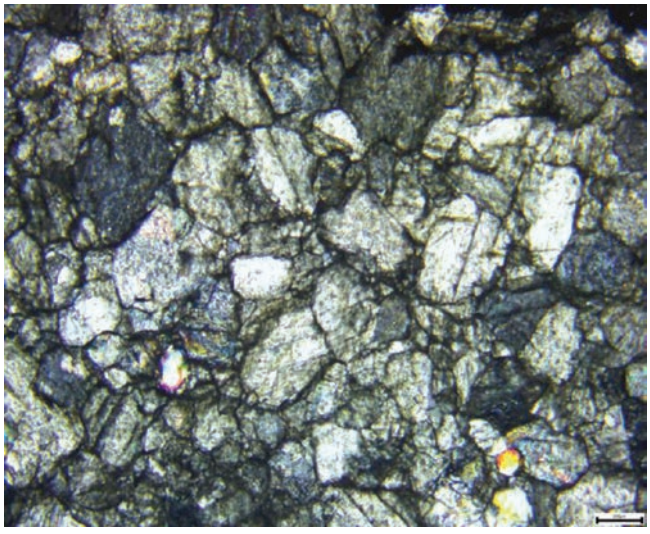
Kept in: Permanent Exhibition of Roman Antiquities, Archaeological Museum Zadar, Inv. No. A7745
Found at: Unknown (Danieli Collection)
Dimensions: Total height 28cm
Material: Marble
Description
It is a portrait of a particularly handsome young man, with luxuriant and curly hair. Thick overlapping locks give it the air of rich, fluttering hair. This excellent work of art has achieved a high esthetical level and workmanship. This sculpture belongs to a group of individual portraits that cannot be associated with a specific emperor. Dated to the late 2nd and early 3rd century AD.[40]
Condition
The entire head was covered with gray and brown patina; thick deposits of black crust could be seen in places on the curls of his hair. An eroded original layer could be seen on the cheeks. Exfoliation, imbrication and sugar-like crumbling of the stone were also visible. The nose had been reconstructed during an earlier restoration work; the lower part of an ear and some locks of hair had been glued. When the portrait was handed over for the conservation, the reconstructed nose had already been removed (Fig. 11).
Petrographic analysis (Figs. 11a, 11b)
Macroscopic description: Homogenous texture, white color.
Microscopic description: Granoblastic medium-grained marble. The polygonal calcite grains (the size of the predominant crystal group: between 500 and 800 microns) are arranged in a mosaic pattern.

40 N. Cambi, M. Kolega 1990, 38.

Slika 11. Zatečeno stanje glave prije konzervatorskih radova, inv. br. A7745, AMZd
Figure 11. Head before conservation work, Inv. No. A7745, AMZd
foto / photo by: **M. Zorica**

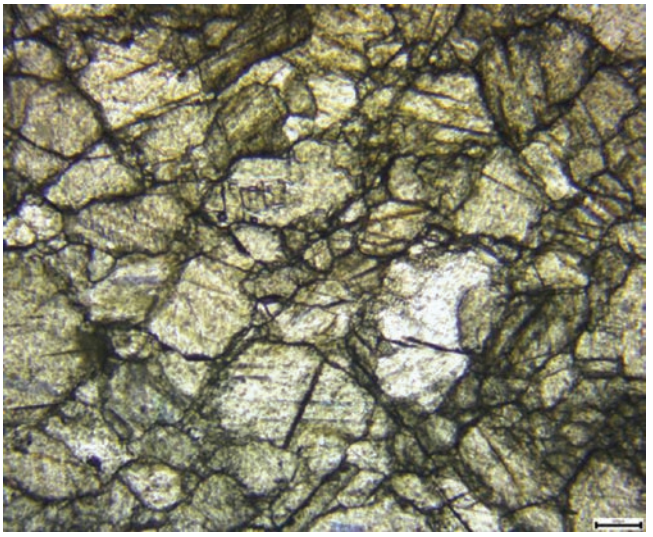


Slika 11a. Fotografija mikroskopskog preparata bez uključenog analizatora
Figure 11a. Photomicrograph in plane polarized light
foto / photo by: **V. Ćosović**

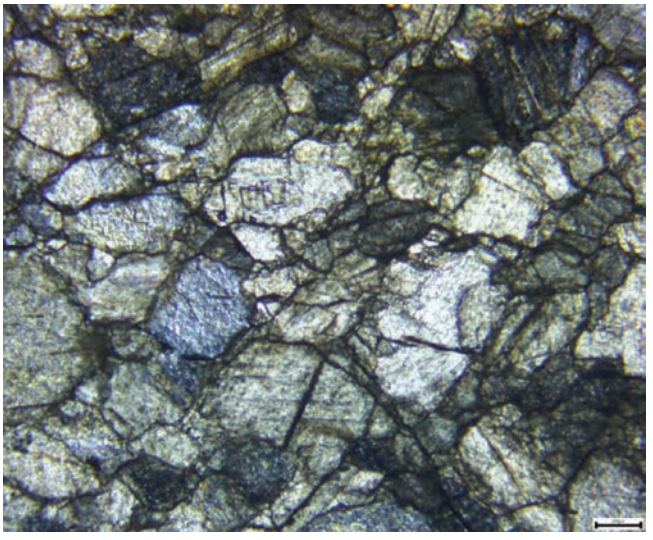


Slika 11b. Fotografija mikroskopskog preparata s uključenim analizatorom
Figure 11b. Photomicrograph in cross polarized light
foto / photo by: **V. Ćosović**

Slika 12. Zatečeno stanje glave prije konzervatorskih radova, inv. br. A7743, AMZd
Figure 12. Head before conservation work, Inv. No. A7743, AMZd
foto / photo by: **M. Zorica**



Slika 12a. Fotografija mikroskopskog preparata bez uključenog analizatora
Figure 12a. Photomicrograph in plane polarized light
foto / photo by: **V. Ćosović**



Slika 12b. Fotografija mikroskopskog preparata s uključenim analizatorom
Figure 12b. Photomicrograph in cross polarized light
foto / photo by: **V. Ćosović**

2. Glava bradatog muškarca

Mjesto čuvanja: Stalni postav antike, Arheološki muzej Zadar, inv. br. A7743

Mjesto nalaza: Nepoznato (zbirka Danieli)

Dimenzije: Ukupna visina 43 cm

Materijal: Mramor

Opis

Portret prikazuje bradatog muškarca s gustom kovrčavom kosom i vijencem od lovorova lišća na glavi. Datira se u polovinu 2. st. Prednji dio glave detaljno je obrađen, dok stražnji djeluje nedovršeno, što navodi na zaključak da je glava bila dio nekog kipa.[41]

Zatečeno stanje

Prilikom temeljitog pregleda glave ustanovljena su organska i anorganska onečišćenja. Cijela glava prekrivena je sivo-smeđom patinom, dok se na kosi i vratu nalaze deblje kalcificirane naslage i gljivice, mjestimično su vidljive mrlje cementa i vapna. Nos mu je otučen, a na lijevom obrazu primjećuje se listanje kamena te ljuskanje i šećerasto osipanje (sl. 12).

Petrografska analiza (sl. 12a, 12b)

Makroskopski opis: Svijetla (žućkastobijela) stijena homogene strukture.

Mikroskopski opis: Srednjozrnati granoblastični mramor. Kristali kalcita, poligonalnog oblika i dobro definiranih ploha, do 800 velikih mikrona, dodiruju se. S obzirom na odnos mineralnih zrna vidljiva je mozaična struktura stijene.

2. Head of bearded man

Kept in: Permanent Exhibition of Roman Antiquities, Archaeological Museum Zadar, Inv. No. A7743

Found at: Unknown (Danieli Collection)

Dimensions: Total height 43cm

Material: Marble

Description

The portrait depicts a bearded man with thick, curly hair and a laurel wreath on his head. Dated to mid-2nd century AD. The front part of the head is finely executed, while the rear part seems unfinished. This indicates that the head was part of a statue.[41]

Condition

The head was thoroughly examined and organic and non-organic contaminants were found. The entire head was covered with a gray and brown patina, while rather thick calcified deposits and fungi, together with occasional stains of cement and lime, could be seen on the hair and neck. The nose was chiseled off; exfoliation, imbrication and sugar-like crumbling could be seen on the left cheek (Fig. 12).

Petrographic analysis (Figs. 12a, 12b)

Macroscopic description: Bright-colored (yellowish-white) rock of homogenous structure.

Microscopic description: Medium-grained granoblastic marble. Polygonal calcite crystals, up to 800 microns in diameters, with well-defined surfaces, are in contact with each other. In terms of the interrelation between mineral grains, the mosaic structure of the rock can be seen.

41 M. Kolega 2003, 104.

41 M. Kolega 2003, 104.

3. Glava mladića s vijencem na glavi

Mjesto čuvanja: Stalni postav antike, Arheološki muzej Zadar, inv. br. A7746

Mjesto nalaza: Nepoznato (zbirka Danieli)

Dimenzije: Ukupna visina 28 cm

Materijal: Mramor

Opis

Portret prikazuje mladića s blagim i sjetnim izgledom lica, s gustim pramenovima kose. Datira se u poč. 3. st. Oštećena su usta i vrh brade, a pri vrhu i rekonstruirani nos. Na glavi dominira izdignuti vijenac dvaput omotan oko glave. Na temelju tog atributa, glava mladića pripada skupini ovjenčanih portreta koji se povezuju sa svećeničkom službom, i to carskog kulta.[42]

Zatečeno stanje

Cijela glava prekrivena je sivo-smeđom patinom i voskom zasićenim raznim onečišćenjima, u kojem su se tijekom vremena razvile gljivice. Mjestimično je vidljiva deblja crna i smeđa kora, ispod koje se nazire oštećeni i ispucani kamen. Vidljiva su i oštećenja od štetnih topivih soli, nagrižena usta, brada i obrazi. Glava je popucala preko čela i zalijepljena u prijašnjim restauratorskim postupcima, dok je nos rekonstruiran u gipsu (sl. 13).

Petrografska analiza (sl. 13a, 13b)

Makroskopski opis: Svijetla stijena homogene teksture, krhotina pokazuje izrazito oštre rubove.

Mikroskopski opis: Granoblastični kalcitno-dolomitni mramor. Kristali kalcita dominiraju (poligonalna do nepravilna zrna veličine od 200 do 400 mikrona), kristali dolomita pravilnih su oblika i dodiruju se poput saća, stijena ima mozaičnu strukturu.

3. Wreathed head of young man

Kept in: Permanent Exhibition of Roman Antiquities, Archaeological Museum Zadar, Inv. No. A7746

Found at: Unknown (Danieli Collection)

Dimensions: Total height 28cm

Material: Marble

Description

A portrait of a young man with a gentle, melancholic face, with thick locks of hair. Dated to the early 3rd century AD. The mouth, tip of chin and tip of reconstructed nose damaged. Prominent, double-wrapped wreath dominating the head. Based on this attribute, the young man's head was classified in a group of wreathed portraits associated with priesthood of an Imperial cult.[42]

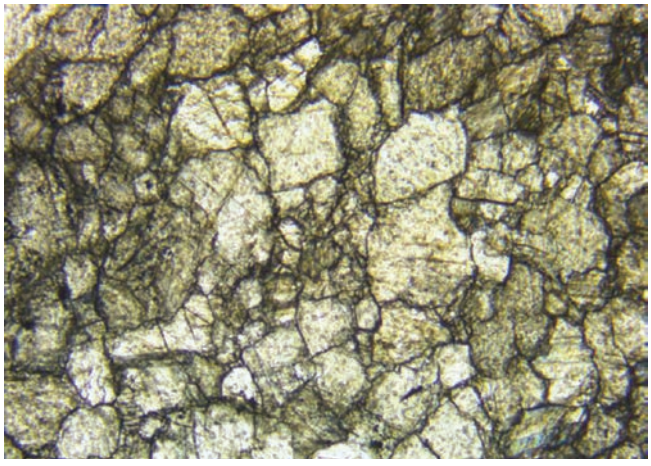
Condition

The entire head was covered with gray and brown patina and wax saturated with various contaminants, in which fungi had developed. A rather thick black and brown crust could be seen in places. Damaged and cracked stone showed through underneath. Damage from harmful soluble salts could be seen; the mouth, chin and cheeks were eroded. During an earlier restoration, a crack across the forehead had been glued and the nose had been reconstructed with gypsum (Fig. 13).

Petrographic analysis (Figs. 13a, 13b)

Macroscopic description: Bright-colored rock of homogenous texture; very sharp edges of the break.

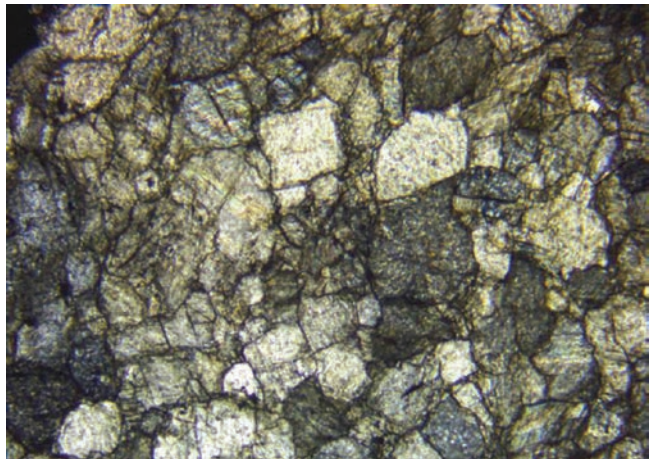
Microscopic description: Granoblastic calcite-dolomitic marble. Calcite crystals are predominant (polygonal to asymmetrical grains ranging from 200 to 400 microns). The dolomite crystals are symmetrical and are interconnected in a honeycombed pattern. The rock has a mosaic-shaped structure.



Slika 13a. Fotografija mikroskopskog preparata bez uključenog analizatora

Figure 13a. Photomicrograph in plane polarized light

foto / photo by: **V. Ćosović**



Slika 13b. Fotografija mikroskopskog preparata s uključenim analizatorom

Figure 13b. Photomicrograph in cross polarized light

foto / photo by: **V. Ćosović**

42 M. Kolega 2003, 114.

42 M. Kolega 2003, 114.

Slika 13. Zatečeno stanje glave prije konzervatorskih radova, inv. br. A7746, AMZd
Figure 13. Head before conservation work, Inv. No. A7746, AMZd
foto / photo by: **M. Rajzl**

Slika 14. Zatečeno stanje glave prije konzervatorskih radova, inv. br. A7305, AMZd
Figure 14. Head before conservation work, Inv. No. A7305, AMZd
foto / photo by: **M. Zorica**

4. Glava mlađeg muškarca

Mjesto čuvanja: Stalni postav antike, Arheološki muzej Zadar, inv. br. A7305

Mjesto nalaza: Nepoznato (zbirka Danieli)

Dimenzije: Ukupna visina s vratom 32 cm

Materijal: Vapnenac, petrografska analiza pokazala je da je glava izrađena iz klastičnog, srednje zrnatog vapnenca, a ne iz bijelog mramora, kako se do sada navodilo u literaturi.[43]

Opis

Glava je sačuvana s većim dijelom vrata koji je sa stražnje strane koso odlomljen, vjerojatno zbog usađivanja u kip ili torzo. Portret prikazuje mladića ovalna lica, kratke guste kose, s velikim očima usmjerenim na promatrača. Oči su obrađene do detalja s urezanim šarenicama, polukružnim i udubljenim zjenicama. Glava je izvanredno kvalitetno kiparsko djelo rimske portretne umjetnosti, u posljednje vrijeme atribuira se jednom od Konstantinovih sinova i datira se u poč. 4. st.[44]

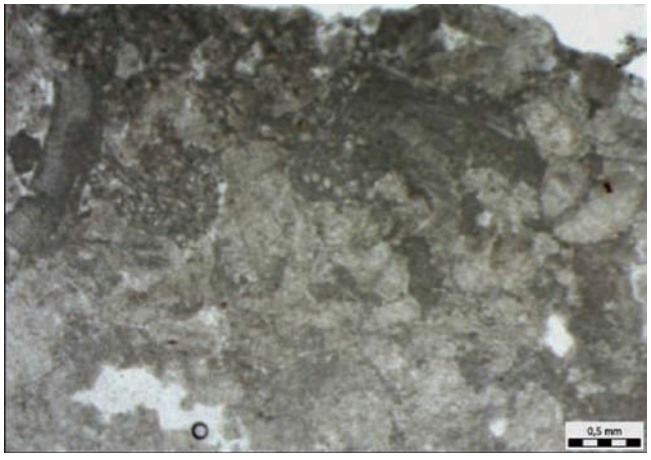
Zatečeno stanje

Cijela glava prekrivena je sivo-crnom patinom, dok su mjestimično vidljive i deblje crne inkrustacije[45], vidljivi su tragovi cementa i vapna. U pramenovima kose primjećuje se šećerasto osipanje površinskog sloja što je posljedica štetnih topivih soli (sl. 14).

Petrografska analiza (sl. 14a)

Makroskopski opis: Vapnenac, klastičan, srednjozrnati ili kalkarenit. Reagira burno sa 10-postotnom solnom kiselinom. Bijele boje.

Mikroskopski opis: Vezivo mikritno. Klasti su različitog sastava: dolomitna zrna, ulomci mikritnog vapnenca, rekristalizirani ostatci organizama. Brojne pukotine zaostale nakon djelovanja atmosferilija.



Slika 14a. Fotografija mikroskopskog preparata bez uključenog analizatora

Figure 14a. Photomicrograph in plane polarized light

foto / photo by: **V. Ćosović**

43 N. Cambi, M. Kolega 1990, 43; M. Kolega 2003, 119–120.
44 M. Kolega 2003, 120.
45 Kalcificirane naslage.

4. Young man's head

Kept in: Permanent Exhibition of Roman Antiquities, Archaeological Museum Zadar, Inv. No. A7305

Found at: Unknown (Danieli Collection)

Dimensions: Total height with neck 32cm

Material: Limestone. A petrographic analysis showed that the head was made of a classical, medium-grained limestone and not of white marble, as had been mentioned in literature.[43]

Description

The head and most of the neck have been preserved. The back of the neck is broken off in a slanting break, probably to be mounted on a statue or torso. It is a portrait of a young man with an oval face, short thick hair and big eyes gazing at the beholder. The eyes are minutely depicted, with irises marked and with semicircular and recessed pupils. The head is an extraordinary specimen of the Roman portrait sculpture of the highest quality. Recently it was attributed to one of Constantine's sons and dated to the early 4th century AD.[44]

Condition

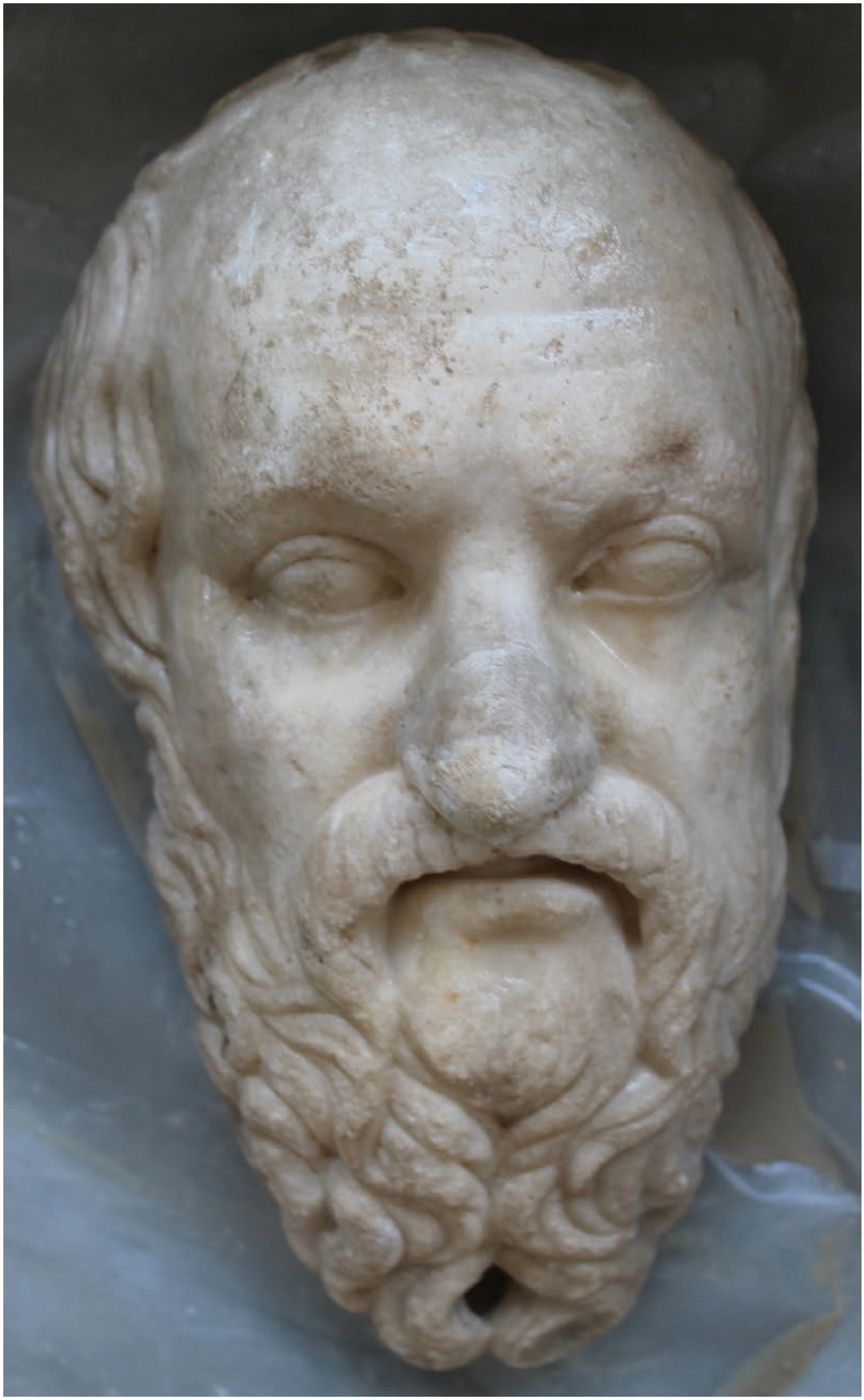
The entire head was covered with gray and black patina and rather thick black incrustations[45] and traces of cement and lime could be seen in places. Sugar-like crumbling of the surface layer could be seen in the hair – a result of the effect of harmful soluble salts (Fig. 14).

Petrographic analysis (Fig. 14a)

Macroscopic description: Limestone – clastic, medium-grained or calcarenite. Reacts strongly when in contact with 10-percent hydrochloric acid. White color.

Microscopic description: Micritic binder. Clasts of varied composition: dolomite grains, fragments of micritic limestone, recrystallized remains of organisms. Numerous cracks due to weathering.

43 N. Cambi, M. Kolega 1990, 43; M. Kolega 2003, 119–120.
44 M. Kolega 2003, 120.
45 Calcified deposits.



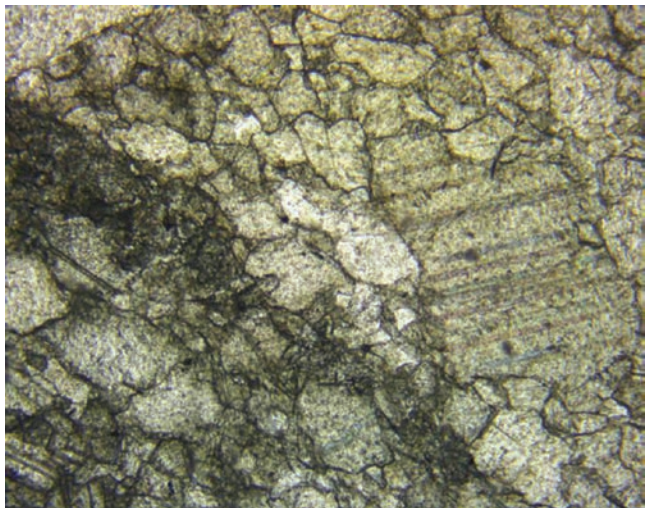
Slika 15. Zatečeno stanje glave prije konzervatorskih radova, inv. br. A7740, AMZd
Figure 15. Head before conservation work, Inv. No. A7740, AMZd
foto / photo by: **M. Rajzl**

5. Glava Sokrata

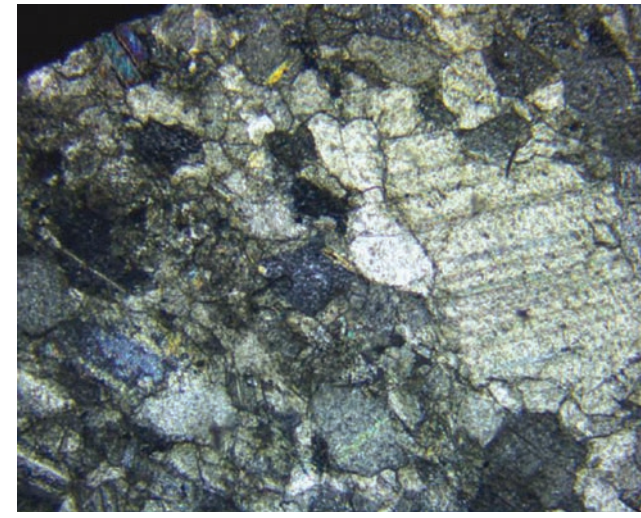
Mjesto čuvanja: Stalni postav antike, Arheološki muzej Zadar, inv. br. A7740
Mjesto nalaza: Nepoznato (zbirka Danieli)
Dimenzije: Ukupna visina s vratom 31 cm
Materijal: Mramor
Opis
Portret prikazuje starijeg bradatog muškarca, silenskih crta lica, visoka i izbočena čela. Datira se u prvu polovinu 2. st. Kosa prekriva samo uši, dok je gornji dio ćelav. Na temelju fizionomijskih osobina portret se sa sigurnošću može pripisati filozofu Sokratu. Glava je sačuvana samo u prednjoj polovici i nedostaje joj vrh nosa koji je naknadno rekonstruiran.[46]
Zatečeno stanje
Cijela glava prekrivena je sivo-smeđom patinom i smeđom kalcifikacijom ispod koje je vidljivo osipanje kamena. Mjestimično su vidljive mrlje cementa i vapna. Vrh nosa u prijašnjoj je restauraciji rekonstruiran u kamenu sličnom originalu (sl. 15).
Petrografska analiza (sl. 15a, 15b)
Makroskopski opis: svijetla (sivkastobijela) stijena (krhotina pokazuje oštre rubove).
Mikroskopski opis: granoblastični mramor. Kristali kalcita veličine su od 100 mikrona do 1,5 mm. U stijeni je prisutan poneki kristal dolomita. Dominira dodirni kontakt među zrnima, dajući mozaičnu strukturu, iako ima i utiskivanja kristala (to se osobito vidi među sitnijim kristalima kalcita). Prisutni su akcesorni minerali koji otkrivaju mineralno „onečišćenje" protolita ili primarne stijene.

5. Socrates' head

Kept in: Permanent Exhibition of Roman Antiquities, Archaeological Museum Zadar, Inv. No. A7740
Found at: Unknown (Danieli Collection)
Dimensions: Total height with neck 31cm
Material: Marble
Description
It is a portrait of an elderly bearded man with Silenian features and a high bulging forehead. Dated to the first half of the 2nd century AD. The hair covers the ears but the top of the head is bald. Based on the facial features, we can positively say that the portrait depicts the philosopher Socrates. Only the front half of the head has been preserved. The tip of the nose, reconstructed earlier, is missing.[46]
Condition
The entire head was covered with gray and brown patina and brown calcification; crumbling of the stone visible underneath. Cement and lime stains could be seen in places. The tip of the nose had been reconstructed in an earlier restoration, using a stone similar to the original (Fig. 15).
Petrographic analysis (Figs. 15a, 15b)
Macroscopic description: Bright-colored (grayish and white) rock (sharp edges of the break).
Microscopic description: Granoblastic marble. Calcite crystals ranging from 100 microns to 1.5mm. Occasional dolomite crystals can be seen in the rock. The grains are mostly separated by linear or gently sutured boundaries within the mosaic structure, although interlocking of the crystals are present (particularly between tiny calcite crystals). Accessory minerals are found, indicating mineral "pollution" of the protolith (primary rock).



Slika 15a. Fotografija mikroskopskog preparata bez uključenog analizatora
Figure 15a. Photomicrograph in plane polarized light
foto / photo by: **V. Ćosović**



Slika 15b. Fotografija mikroskopskog preparata s uključenim analizatorom
Figure 15b. Photomicrograph in cross polarized light
foto / photo by: **V. Ćosović**

46 M. Kolega 2003, 100–103.

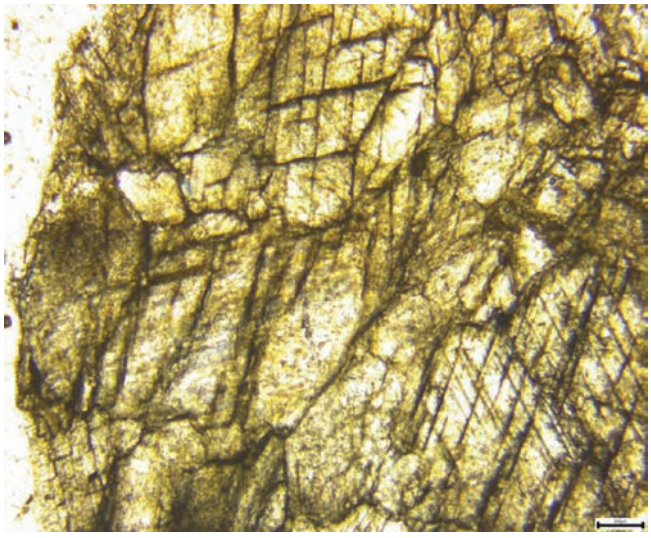
46 M. Kolega 2003, 100–103.

6. Glava starije žene

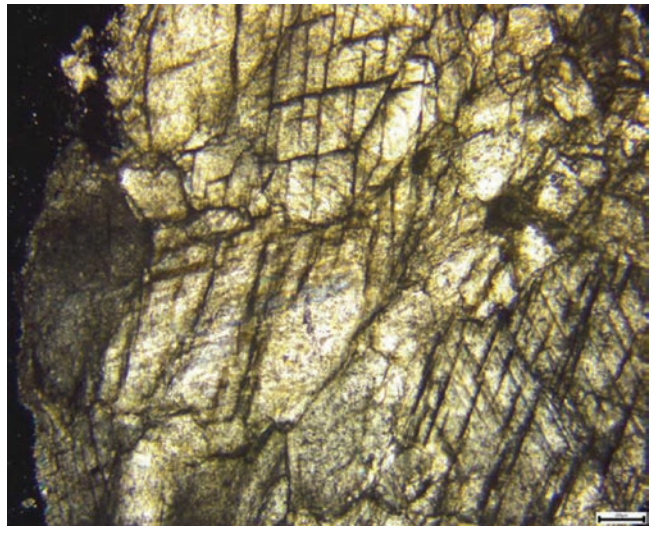
Mjesto čuvanja: Stalni postav antike, Arheološki muzej Zadar, inv. br. A7744
Mjesto nalaza: Nepoznato (zbirka Danieli)
Dimenzije: Ukupna visina 30 cm
Materijal: Mramor
Opis
Portret prikazuje stariju ženu s izduženim licem, naglašenim podočnjacima te naknadno rekonstruiranim nosom. Na portretu dominira frizura s tanjim i debljim pletenicama koje prate oblik glave i prema stražnjem se dijelu skupljaju u široku punđu koja, gledajući iz profila, podsjeća na turban. Glava predstavlja individualni portret koji se ne može povezati s određenom osobom. Datira se u sredinu 2. st.[47]
Zatečeno stanje
Glava je u cijelosti prekrivena smeđom patinom, na nekim mjestima vidljive su deblje kalcifikacije nastale taloženjem raznih štetnih naslaga na kamenu i izmjenjivanjem ciklusa vlaženja i sušenja. Oko usnica, na desnom obrazu i na vratu oštećen je površinski sloj, što je posljedica štetnih topivih soli. U prijašnjoj restauraciji dio pri dnu vrata premazan je slojem cementa. Na usnicama je sačuvana polikromija crvene boje. Nos je rekonstruiran u gipsu (sl. 16).
Petrografska analiza (sl. 16a, 16b)
Makroskopski opis: Šećerasta tekstura bijele, s malo primjesa oker boje.
Mikroskopski opis: Krupnozrati granoblstični mramor. Mozaična struktura, poligonalni kristali promjera zrna od 1 mm do 1,4 mm dodiruju se poput saća.

6. Elderly woman's head

Kept in: Permanent Exhibition of Roman Antiquities, Archaeological Museum Zadar, Inv. No. A7744
Found at: Unknown (Danieli Collection)
Dimensions: Total height 30cm
Material: Marble
Description
It is a portrait of an elderly woman with a long face, marked rings around the eyes and a subsequently reconstructed nose. The prominent hair features thin and thick braids that follow the shape of head, forming a wide bun at the back of the head. In profile, the bun reminds of a turban. It is an individual portrait that cannot be associated with any specific person. Dated to the mid-2nd century AD.[47]
Condition
The entire head was covered with brown patina. Rather thick calcification could be seen in places. It was a result of sedimentation of various harmful deposits and alteration of moistening and drying cycles. Harmful soluble salts had damaged the surface layer around the lips, on the right cheek and on the neck. The lower part of the neck had been coated with a cement layer during an earlier restoration. Red polychromy preserved on lips. Nose reconstructed using gypsum (Fig. 16).
Petrographic analysis (Figs. 16a, 16b)
Macroscopic description: White sugar-like texture with some admixture of ocher color.
Microscopic description: Coarse-grained granoblastic marble. Mosaic structure; polygonal crystals with grains ranging from 1mm to 1.4mm interconnected in honeycombed pattern.



Slika 16a. Fotografija mikroskopskog preparata bez uključenog analizatora
Figure 16a. Photomicrograph in plane polarized light
foto / photo by: **V. Ćosović**



Slika 16b. Fotografija mikroskopskog preparata s uključenim analizatorom
Figure 16b. Photomicrograph in cross polarized light
foto / photo by: **V. Ćosović**

47 M. Kolega 2003, 106.

47 M. Kolega 2003, 106.

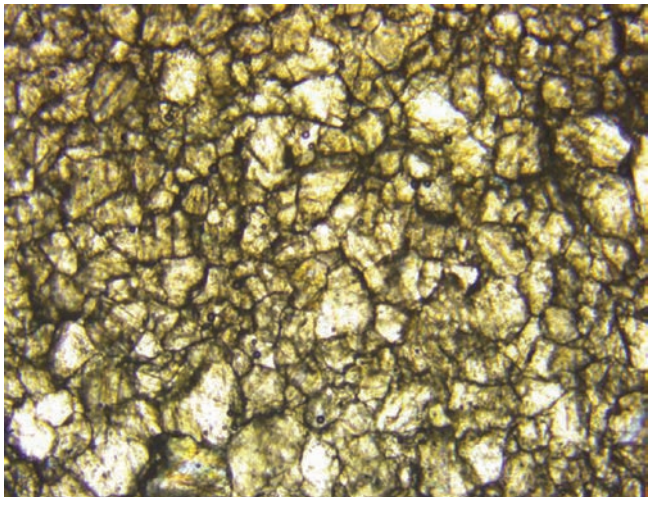
Slika 16. Zatečeno stanje glave prije konzervatorskih radova, inv. br. A7744, AMZd
Figure 16. Head before conservation work, Inv. No. A7744, AMZd
foto / photo by: **M. Zorica**

7. Glava mlade žene

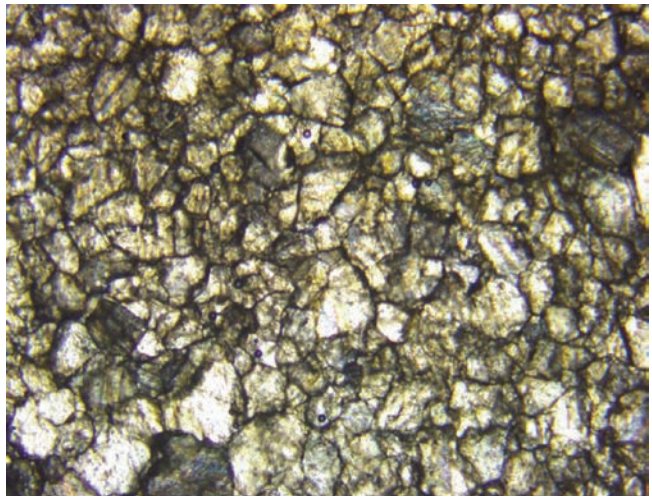
Mjesto čuvanja: Stalni postav antike, Arheološki muzej Zadar, inv. br. A7739
Mjesto nalaza: Nepoznato (zbirka Danieli)
Dimenzije: Ukupna visina 29 cm
Materijal: Mramor
Opis
Portret prikazuje mladu ženu s okruglim i punim licem, naglašenim podbratkom i jakim vratom. Na glavi dominira visoko počešljana kosa koja je izvedena u sitnim kružnim uvojcima. Stražnji dio glave prekriven je velom ispod kojeg je kosa skupljena u punđu. U sredini se nalazi veća rupa koja je vjerojatno nastala prilikom izlaganja glave u prostoru. Stilskom i ikonografskom analizom glava se datira u kraj 1. st., pripada individualnom građanskom portretu i ne može se povezati s određenom osobom.[48]
Zatečeno stanje
Glava je u cijelosti prekrivena žuto-smeđom kalcificiranom naslagom u tankom sloju, koja nastaje taloženjem raznih nečistoća na kamenu i izmjenjivanjem ciklusa vlaženja i sušenja. Kalcifikacije nisu dobre za kamen jer sadrže znatnu količinu štetnih tvari koje ubrzavaju proces razaranja. Na bradi i obrazima oštećen je površinski sloj, što je posljedica štetnih topivih soli. Mjestimično su po glavi vidljive mrlje cementa (sl. 17).
Petrografska analiza (sl. 17a, 17b)
Makroskopski opis: Homogena stijena, bijela, s malim primjesama sivkaste nijanse.
Mikroskopski opis: Sitnozrnati granoblastični mramor. Kristali se kalcita dodiruju, mozaična struktura stijene karakteristična je za taj uzorak. U strukturi se uočava poneki kristal dolomita. Mineralna zrna – kristali – podjednakih su veličina, od 200 do 400 mikrona u prosjeku.

7. Young woman's head

Kept in: Permanent Exhibition of Roman Antiquities, Archaeological Museum Zadar, Inv. No. A7739
Found at: Unknown (Danieli Collection)
Dimensions: Total height 29cm
Material: Marble
Description
It is a portrait of a young woman with a round face, marked double chin and strong neck. The dominant swept-up hairstyle features tiny circular curls. The back of the head is veiled; there is a bun under the veil. A big hole can be seen in the center; it was probably made when the head was displayed at an exhibition. Based on the style and iconography, the head was dated to the late 1st century AD. It is an individual portrait that cannot be associated with any specific person.[48]
Condition
The entire head was covered with a thin yellow and brown calcified deposit of various contaminants that had been exposed to alteration of moistening and drying cycles. Calcification is harmful to the stone because it contains many harmful substances that can accelerate the decomposition process. Harmful soluble salts had damaged the surface layer on the chin and cheeks. Cement stains can be seen on the head in places (Fig. 17).
Petrographic analysis (Figs. 17a, 17b)
Macroscopic description: Homogenous rock, white, with occasional grayish shades.
Microscopic description: Fine-grained granoblastic marble. Calcite crystals are interconnected, forming a mosaic structure typical of this pattern. Occasional dolomite crystals can be seen in the structure. Mineral grains – crystals – are of very similar size, ranging from 200 to 400 microns on average.



Slika 17a. Fotografija mikroskopskog preparata bez uključenog analizatora
Figure 17a. Photomicrograph in plane polarized light
foto / photo by: **V. Ćosović**



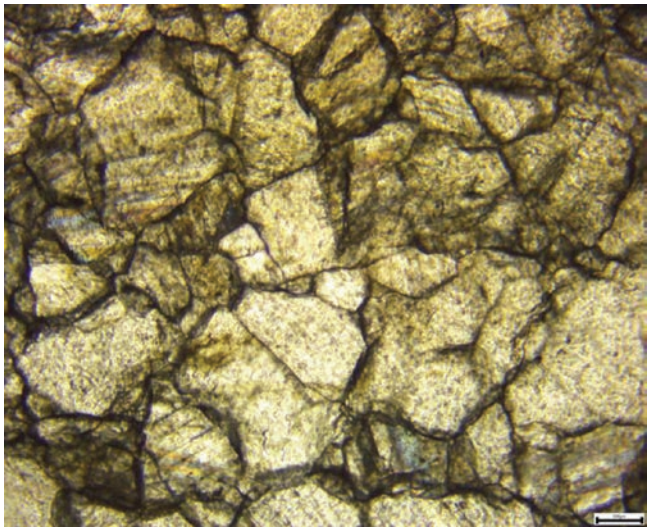
Slika 17b. Fotografija mikroskopskog preparata s uključenim analizatorom
Figure 17b. Photomicrograph in cross polarized light
foto / photo by: **V. Ćosović**

48 M. Kolega 2003, 94.

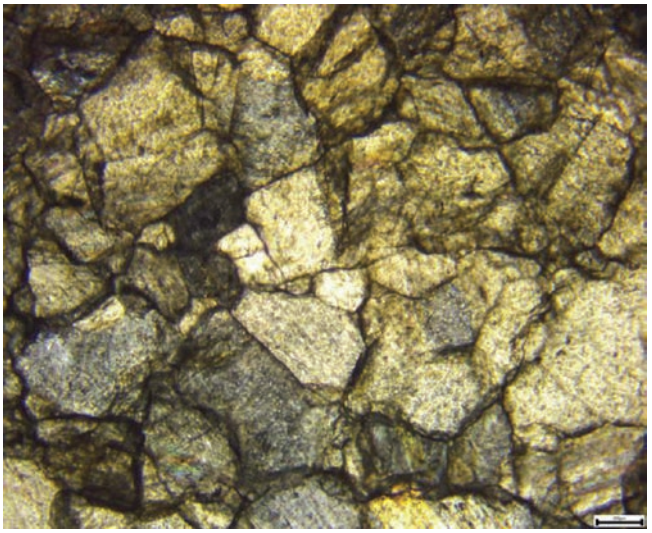
48 M. Kolega 2003, 94.

Slika 17. Zatečeno stanje glave prije konzervatorskih radova, inv. br. A7739, AMZd
Figure 17. Head before conservation work, Inv. No. A7739, AMZd
foto / photo by: **M. Rajzl**

Slika 18. Zatečeno stanje glave prije konzervatorskih radova, inv. br. A7732, AMZd
Figure 18. Head before conservation work, Inv. No. A7732, AMZd
foto / photo by: **M. Zorica**



Slika 18a. Fotografija mikroskopskog preparata bez uključenog analizatora
Figure 18a. Photomicrograph in plane polarized light
foto / photo by: **V. Ćosović**



Slika 18b. Fotografija mikroskopskog preparata s uključenim analizatorom
Figure 18b. Photomicrograph in cross polarized light
foto / photo by: **V. Ćosović**

8. Glava žene

Mjesto čuvanja: Stalni postav antike, Arheološki muzej Zadar, inv. br. A7732
Mjesto nalaza: Nepoznato (zbirka Danieli)
Dimenzije: Ukupna visina 27 cm
Materijal: Mramor
Opis
Portret prikazuje ženu mlađe dobi, izrazito lijepe fizionomije, stilizirane frizure skupljene u punđu, s tankom pletenicom oko glave. Portret je bez individualnih oznaka, a po načinu češljanja i obliku frizure ona svoje mjesto nalazi u julijevsko-klaudijskoj umjetnosti. Datira se u prvu polovinu 1. st.[49]
Zatečeno stanje
Cijela glava prekrivena je sivo-smeđom patinom, dok se mjestimično nazire i deblja kalcifikacija. Primjećuje se ljuskanje i šećerasto osipanje oko usana, brade, čela i nosa. Nos je u prijašnjoj restauraciji rekonstruiran u gipsu (sl. 18).
Petrografska analiza (sl. 18a, 18b)
Makroskopski opis: Šećerasta struktura, svijetla, bijela stijena s primjesom plavkastih nijansi.
Mikroskopski opis: Srednje do krupnozrnati granoblastični mramor. Kristali kalcita između 800 mikrona i 1 mm se dodiruju, karakteristična mozaična struktura stijene s obzirom na odnos mineralnih zrna.

8. Woman's head

Kept in: Permanent Exhibition of Roman Antiquities, Archaeological Museum Zadar, Inv. No. A7732
Found at: Unknown (Danieli Collection)
Dimensions: Total height 27cm
Material: Marble
Description
It is a portrait of a very beautiful young woman, with a stylized hairdo with a bun and with a thin braid wrapped around the head. The portrait has no individual specifics. Based on the combing style and shape of the hairdo, it belongs to the art of the Julio-Claudian period. Dated to the first half of the 1st century AD.[49]
Condition
The entire head was covered with gray and brown patina; rather thick calcification can be seen in places. Imbrication and sugar-like crumbling could be seen around the lips, chin, forehead and nose. In an earlier restoration, the nose had been reconstructed using gypsum (Fig. 18).
Petrographic analysis (Figs. 18a, 18b)
Macroscopic description: Sugar-like structure; bright-colored white rock with occasional bluish shades.
Microscopic description: Medium-to coarse-grained granoblastic marble. Calcite crystals ranging from 800 microns and 1mm are interconnected, forming a mosaic structure typical of this rock in terms of the interrelation between mineral grains.

Slika 19. Uklanjanje rekonstrukcije nosa izvedene u prijašnjoj restauraciji
Figure 19. Removal of nose reconstruction made in earlier restoration
foto / photo by: **M. Rajzl**

Obavljeni radovi:

- Na glavi žene (A7732), glavi starije žene (A7744), glavi Sokrata (A7740), glavi mladića s vijencem (A7746) uklonjene su stare neadekvatne rekonstrukcije nosova. Rekonstrukcije su bile izvedene u gipsu, osim na glavi Sokrata koja je bila izvedena u kamenu, te su s pomoću drvenih klinova fiksirane za portrete. Rekonstrukcije su zatečene u lošem stanju, osipale se, a neke su bile pričvršćene i cementom. Postavilo se pitanje treba li ih konzervirati i vratiti na mjesto, no s obzirom na to da nikako nisu estetski odgovarale portretima, odlučilo ih se ne vratiti.[50] Klinovi i cement su uklonjeni, a rupice su zapunjene epoksi-smolom i kamenom prašinom koja je po površini premazana tankim slojem MAR-gripa 411 Z5B (sl. 19).

- Na svih osam glava izvađeni su stari željezni korodirani klinovi koji su zamijenjeni novim od nehrđajućeg (inoks) materijala. Rupe oko klinova su zapunjene epoksi-smolom i kamenom prašinom te premazane tankim površinskim slojem MAR-gripa 411 Z5B (sl. 20).

- Pretkonsolidacija. Kako ne bi došlo do gubitka osnovne kamene mase tijekom radova koji će uslijediti, na glavi mladića s vijencem na glavi (A7746), glavi starije žene (A7744), glavi mlađe žene (A7732) i glavi mladića s dugom kosom (A7745) učinjena je djelomična pretkonsolidacija po oštećenim zonama. U tu se svrhu konsolidant *Estel 1000*

Restoration work carried out so far:

- Inadequate nose reconstructions, made during earlier restorations, were removed from a woman's head (A7732), an elderly woman's head (A7744), Socrates' head (A7740) and the wreathed head of a young man (A7746). The reconstructions had been made using gypsum, except on Socrates' head, where stone had been used. They had been affixed to the portraits by means of wooden wedges. The reconstructions were in poor condition; they were crumbling and some of them were affixed with cement. The question arose whether they should be conserved and returned. As they did not fit the portraits esthetically, it was decided not to return them.[50] The wedges and cement were removed and epoxy resin and stone dust were injected in the holes. A thin layer of MAR-grip 411 Z5B was then applied on the surface (Fig. 19).

- The old corroded iron wedges were removed from all eight heads and were replaced with new stainless (inox) material. Epoxy resin and stone dust was injected in the holes around the wedges and a thin layer of MAR-grip 411 Z5B was then applied on the surface (Fig. 20).

- Preconsolidation. In order to avoid a loss of basic stone weight during the work to follow, partial preconsolidation was done on the damaged areas on the wreathed head of a young man (A7746), elderly woman's head (A7744), young

50 Nos odražava karakter čovjeka tako da se po etičkim principima ne rekonstruira, međutim prijašnji, pogotovo talijanski i austrijski restauratori upuštali su se u te poslove u dogovoru s kustosima koji bi im davali smjernice po analogijama sličnih skulptura ili portreta.

50 As the nose reflects a person's character, reconstructing it is considered unethical. However, earlier restorers, particularly Italian and Austrian ones, performed such reconstructions nevertheless, after consulting curators who would give them guidelines based on analogies with similar sculptures and portraits.

Slika 20. Novi klin od inoks materijala
Figure 20. New stainless wedge
foto / photo by: **M. Zorica**

nanosio kistom. Konsolidanti na bazi silicija primarno se upotrebljavaju za konsolidaciju kamena i žbuka oslabljene kohezije. Etil-silikat, poznat još pod skraćenicom TEOS (tetraetil-ortosilikat), pod utjecajem vlage iz zraka prilikom dodira s kamenom, razgrađuje se hidrolizom u silicijevu kiselinu i etilni alkohol koji isparava. Silicijeva kiselina zatim se razlaže u silicijev dioksid (kremen ili kvarc) koji nadomješta izgubljeno vezivo u strukturi kamene površine.[51]

- Desalinizacija je izvršena potapanjem svih glava u PVC posude. U početku se upotrebljavala vodovodna voda uz dodatak fungicidnog i baktericidnog sredstva *Asepsol Eco*,[52] osim u slučaju kada se voda uzimala za analizu. Zadnje se ispiranje obavilo čistom destiliranom vodom.

- Ostatci polikromije vidljivi na usnicama starije žene (A7744) premazani su u prvom sloju 2,5-postotnom otopinom polivinil-alkohola (*Mowiol 4-98*), a zatim 5-postotnom otopinom *Paraloida B72* u acetonu.

- Čišćenje i pranje vodom s pomoću mekanih četki, uz dodatak pH neutralnog deterdženta *Contrad 2000*,[53] izvedeno je u početku radova na svim glavama radi uklanjanja

woman's head (A7732) and long-haired young man's head (A7745). To this end, the consolidant *Estel 1000* was applied with a paintbrush. The silicon-based consolidants are primarily used for consolidation of the stones and plasters of impaired cohesion. When moisture from the air gets in contact with the stone, a hydrolysis takes place: ethyl-silicate (also known under its abbreviation TEOS – tetraethyl-orthosilicate) decomposes itself into silicic acid and volatile ethyl alcohol. The silicic acid than breaks down into silicon dioxide (flint stone or quartz), which compensates for the lost binder in the structure of the stone surface.[51]

- Desalination was carried out by submerging all heads in PVC containers. In the beginning, tap water with added fungicide and bactericide agent *Asepsol Eco*[52] was used, except when the water was to be used for an analysis. Clean distilled water would be used for the final rinsing.

- The traces of polychromy on the lips of the elderly woman (A7744) were first coated with a 2.5-percent solution of polyvinyl alcohol (*Mowiol 4-98*) and then with a 5-percent solution of *Paraloida B72* in acetone.

- At the very beginning, all the heads were cleaned and washed with water and soft brushes, with an addition of pH

51 I. Donelli, H. Malinar 2015, 151.
52 Upotrebljavala se 3-postotna a zatim i 5-postotna otopina *Asepsol Eco* u vodi.
53 Prvo se upotrebljavala 2,5-postotna, a zatim i 5-postotna otopina *Contad 2000* u vodi.

51 I. Donelli, H. Malinar 2015, 151.
52 A 3-percent, and then a 5-percent solution of *Asepsol Eco* in water was used.

površinskih nečistoća, nakupina prljavštine, masnoće i zemlje, dok se čišćenje vodenom parom izvodilo paralelno cijelo vrijeme tijekom procesa čišćenja. Osim što je uklonila ostatke mikroorganizama, prljavštine i zemlje, para je na glavi mladića s vijencem (A7746) otapala i vosak, što je omogućilo njegovo lakše uklanjanje mehaničkim putem.[54]

- Za omekšavanje naslaga i djelomičnu desalinizaciju na svim glavama upotrijebljeni su oblozi od celulozne pulpe u kombinaciji s apsorcijskom glinom sepiolitom i destiliranom vodom. Prah gline ručno se miješa s vodom da se dobije mekana smjesa koja se onda špatulama u sloju od 10 mm nanosi na kamen i oblaže celuloznom pulpom. Oblozi su ostavljani da djeluju tri tjedna, a zatim su zamjenjivani novim, sve dok se nije dobio željeni rezultat.[55]

- Mehaničko čišćenje. Omekšane naslage uklonjene su kirurškim skalpelima različitih dimenzija i profila, ultrazvučnom iglom i električnim motorom. Pri čišćenju se pazilo na razliku između nečistoća i tzv. plemenite patine koja je rezultat prirodnih procesa na površini kamena i kao takvu treba ju sačuvati. Glava mladića s vijencem na glavi (A7746), zasićena voskom, čistila se vodenom parom i kirurškim skalpelom, upotrebljavali su se nožići različitih veličina. Sloj voska prvo bi se otopio, a zatim sastrugao, sve dok se nije došlo do originalne patine.

- Injektiranje. Rupice nastale probijanjem originalnog sloja, vidljive na glavi starije žene (A7744) i na glavi mlađe žene (A7739), zapunjene su epoksi-smolom i kamenom prašinom te su premazane tankim površinskim slojem MAR-gripa 411 Z5B.

9. Akefalni ženski kip

Mjesto čuvanja: Stalni postav antike, Arheološki muzej Zadar, inv. br. A10216

Mjesto nalaza: Nepoznato (zbirka Danieli)

Dimenzije: Ukupna visina kipa bez baze 142 cm, najveća širina 52 cm

Materijal: Mramor

Opis

Prikazuje žensku osobu odjevenu u rimsku odjeću. Od jednog bloka mramora nastali su kip, baza i potporanj, dok je glava nastala od posebnog bloka, s obzirom na to da je na vratu pripremljeno udubljenje za njezino postavljanje. Nedostaje desna ruka od kraja nadlaktice prema dolje te zapešće i šaka lijeve ruke. Na kipu je vidljivo naknadno preklesavanje izvorno muškog lika u ženski, u donjem prednjem dijelu dio muške toge preklesan je u žensku tuniku. Muški je lik u tehničkom smislu ipak bio kvalitetniji i kiparski dotjeraniji, a datira se u julijevsko-klaudijevsko doba.[56]

Zatečeno stanje:

neutral detergent *Contrad 2000*,[53] in order to remove surface contaminants and deposits of dirt, grease and soil. Cleaning with water vapor was carried out simultaneously. Besides removing the remaining microorganisms, dirt and soil, the vapor also melted the wax on the wreathed head of a young man (A7746), thus enabling its easier removal by mechanical means.[54]

- For softening of deposits and partial desalination on all the heads, cellulose-pulp compresses were used in combination with absorptive clay (sepiolite) and distilled water. The powdered clay was manually mixed with water in order to obtain a soft mixture which would then be applied to the stone with spatulas as a 10-mm-thick layer; cellulose pulp would then be wrapped around the stone. The compresses were left around the stone for three weeks and were then successively replaced until the desired result was achieved.[55]

- Mechanical cleaning. The softened deposits were removed with surgical scalpels of different dimensions and profiles, an ultrasound needle and an electric motor. During the cleaning, precaution was taken that difference be made between contaminants and the so-called noble patina (the latter is a result of natural processes on a stone's surface and should therefore be preserved). The wreathed head of a young man (A7746), saturated with wax, was cleaned with water vapor and surgical scalpel. Knives of various size were used. The layer of wax would first be melted and then scraped off, until the original patina would be reached.

- Injection. Epoxy resin and stone dust were injected in the holes created when the original layer was penetrated (visible on the elderly woman's head (A7744) and young woman's head (A7739)). A thin layer of MAR-grip 411 Z5B was then applied on the surface.

9. Acephalous woman's statue

Kept in: Permanent Exhibition of Roman Antiquities, Archaeological Museum Zadar, Inv. No. A10216

Found at: Unknown (Danieli Collection)

Dimensions: Total height of state without base 142cm; max. width 52cm

Material: Marble

Description

It is a statue of a woman dressed in Roman clothing. The statue, base and support were all made of a single block of marble. The head was made of a separate block, as we can tell from the recess on the neck, intended for affixing it to the statue. The lower part of the right upper arm and the whole right lower arm are missing and so are the left wrist and hand.

54 Upotrebljavao se parni čistač marke *Kärcher SC 2*.

55 Ovim postupkom dolazi do dubinskog i površinskog izvlačenja raznih onečišćenja u masu obloga i omekšavanja tvrdokornih naslaga.

56 M. Kolega 2003, 87.

53 A 2.5-percent, and then a 5-percent solution of *Contad 2000* in water was used.

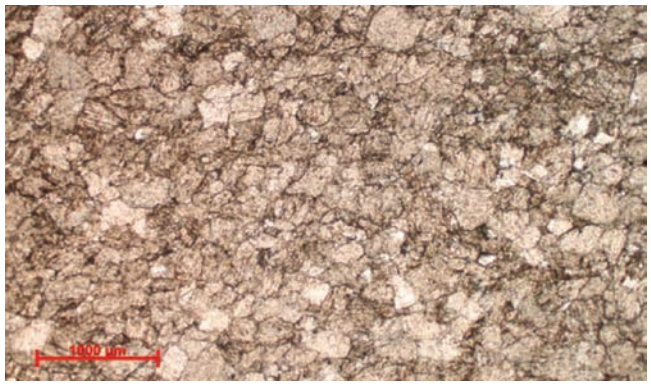
54 The steam cleaner model *Kärcher SC 2* was used.

55 This procedure enables both the in-depth and surface extraction of various contaminants and their absorption into the compresses, as well as softening of the persistent deposits.

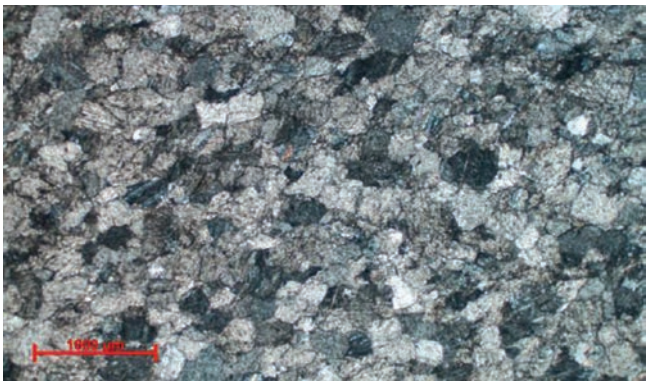
Slika 21. Debele kore na stražnjoj strani skulpture prije čišćenja
Figure 21. Thick crusts on rear side of sculpture before cleaning
foto / photo by: **M. Rajzl**

Cijela skulptura prekrivena je smeđom patinom, dok se na leđima nalaze deblje naslage sive i smeđe inkrustacije. Oko rupa u kojima su bile postavljene ruke, vidljiva je korozija. Na području donjeg dijela vidljive su crne crte, tragovi gljivica. Po cijeloj skulpturi također su vidljivi tragovi cementa i žbuke. Ostatci pompejansko crvene boje sačuvani su po draperiji s prednje strane skulpture (sl. 21).
Petrografska analiza (sl. 21a, 21b)
Makroskopski opis: Mramor homogene teksture, bijele boje.
Mikroskopski opis: Sitnozrnati granoblastični mramor mozaične strukture.

Traces of re-dressing of an originally male statue into a female one can be seen. Part of a man's toga was re-dressed into a woman's tunic. Dated to the Julio-Claudian period.[56]
Condition:
The entire sculpture was covered with brown patina, with thick deposits of gray and brown incrustation on the back. Corrosion was visible around the holes into which the arms had been fixed. Black lines – traces of fungi – were visible in the lower part. Traces of cement and plaster were also seen on the entire sculpture. Remains of the Pompeian red were preserved on the drapery on the sculpture's front side (Fig. 21).
Petrographic analysis (Figs. 21a, 21b)
Macroscopic description: Marble of homogenous texture, white color.
Microscopic description: Fine-grained granoblastic marble with mosaic structure.



Slika 21a. Fotografija mikroskopskog preparata bez uključenog analizatora
Figure 21a. Photomicrograph in plane polarized light
foto / photo by: **V. Ćosović**



Slika 21b. Fotografija mikroskopskog preparata s uključenim analizatorom
Figure 21b. Photomicrograph in cross polarized light
foto / photo by: **V. Ćosović**

56 M. Kolega 2003, 87.

Obavljeni radovi:

- Skulptura je postavljena na drvene grede unutar montažnog bazena.

- Kako bi se tijekom radova koji slijede sačuvali tragovi boje vidljivi na draperiji, ta su mjesta zaštićena i stabilizirana u prvom sloju 2,5-postotnom otopinom polivinilalkohola (*Mowiol 4-98*), a zatim u drugom sloju 5-postotnom otopinom *Paraloid B-72* u acetonu.

- Radovi su započeli pranjem skulpture mekanim četkama uz dodatak pH neutralnog deterdženta *Contrad 2000*.[57] Uklonjene su površinske nečistoće te naslaga prljavštine i zemlje, dok se čišćenje vodenom parom izvodilo paralelno cijelo vrijeme tijekom procesa čišćenja.

- Desalinizacija i omekšavanje naslaga izvodilo se paralelno, s pomoću nekoliko metoda: skulptura se tretirala oblozima od celulozne pulpe, sepiolite i destilirane vode tri puta, a oblozi su ostavljani da djeluju u prosjeku tri tjedna, te oblozima od celulozne pulpe i destilirane vode sedam puta, a djelovali su u prosjeku tjedan dana. S pomoću tog vodenog ekstrakta radila se analiza i pratilo otapanje soli. Čišćenje vodenom parom pod povišenom temperaturom također je utjecalo na proces otapanja klorida i postupak odsoljavanja.

- Postupak desalinizacije proveden je i kemijskim putem, upotrebljavani su oblozi od celulozne pulpe i *Arbocela 200*,[58] zasićeni 9-postotnom otopinom amonijeva karbonata. Dobila bi se mekana smjesa koja se nanosila na površinu kamena u sloju od 20 mm. Smjesa bi se pokrila polietilenskom folijom te bi se ostavila da djeluje 24 sata. Nakon toga skulptura bi se temeljito isprala vodom i u dva bi se navrata oblagala oblozima od čiste demineralizirane vode i celulozne pulpe kako bi se iz kamena estrahirali tragovi eventualno zaostalog amonijeva karbonata. Amonijev karbonat ujedno je omekšao i tvrdokorne naslage.

- Uklanjanje organskih onečišćenja. Na donjem djelu skulpture vidljive su gljivice i alge koje su više puta prskane 10-postotnom otopinom vodikova peroksida, nakon čega se skulptura temeljito ispirala vodom. Cijela je skulptura u nekoliko navrata tretirana i 5-postotnom otopinom *Asepsol Eco*.

- Mehaničko čišćenje. Omekšana inkrustacija uklonjena je kirurškim skalpelima, dok su deblja kalcifikacija na stražnjoj strani skulpture i korozija nastala oko utora za ruku uklonjene ultrazvučnom iglom. Prilikom čišćenja pazilo se na razliku između nečistoće i plemenite patine te na sačuvane ostatke boje.

Restoration work carried out so far:

- The sculpture was laid on the wooden beams within the assembly pool.

- In order to protect the traces of dye on the drapery during the work that was to follow, these spots were protected and stabilized. A 5-percent solution of polyvinyl alcohol (*Mowiol 4-98*) was used for the first layer and a 5-percent solution of *Paraloid B-72* in acetone was used for the second layer.

- The sculpture was first washed using soft brushes and with an addition of the pH neutral detergent *Contrad 2000*.[57] Surface contaminants and deposits of dirt and soil were removed. Cleaning with water vapor was carried out simultaneously throughout the cleaning process.

- Desalination and softening of the deposits was carried out simultaneously. A couple of methods were used: a) the sculpture was treated three times with the compresses soaked in cellulose pulp, sepiolite and distilled water and the compresses would be left wrapped around it for three weeks on average; b) the sculpture was treated seven times with the compresses soaked in cellulose pulp and distilled water and the compresses would be left wrapped around it for a week on average. This water extract was used for the analysis and dissolution of salts was monitored. Cleaning with water steam at a high temperature also had effect on the chloride dissolution process and desalination procedure.

- Desalination procedure was also carried out chemically; compresses of cellulose-pulp and *Arbocel 200*[58] were used, saturated with a 9-percent solution of ammonium carbonate. It would result in a soft mixture that would be applied to the surface of the stone in a 20mm-thick layer. The mixture would be covered with a polyethylene foil and would be left to take effect for 24 hours. After that, the sculpture would be thoroughly rinsed with water and the compresses of pure demineralized water and cellulose pulp would be wrapped around two times in order to extract the traces of the remaining ammonium carbonate, if any. By that time, the ammonium carbonate had softened the persistent deposits.

- Removal of organic contaminants. Fungi and algae were spotted on the lower part of the sculpture. They were repeatedly sprinkled with a 10-percent solution of hydrogen peroxide, after which the sculpture was thoroughly rinsed with water. Several times, the whole sculpture was also treated with a 5-percent solution of *Asepsol Eco*.

- Mechanical cleaning. The softened incrustation was removed with surgical scalpels. The thick calcification on the sculpture's rear side and the corrosion around the grooves for the arm were removed with an ultrasound needle. During the cleaning, the difference between the contaminants and noble patina was kept in mind, and so were the remains of the dye.

57 U početku se upotrebljavala 2,5-postotna, a zatim i 5-postotna otopina u vodi.

58 *Arbocel 200* (C. T. S.) je celuloza u prahu koja se sastoji od čistih celuloznih vlakana hidrofilne prirode, ne otapa se, ali ima svojstvo bubrenja, zbog čega se koristi kao inertno punilo za pripremu smjesa i sredstava za čišćenje koja se nanose na kamene površine i freske, https://www.ctseurope.com/en/scheda-prodotto.php?id=2669 (16. 9. 2019.).

57 In the beginning a 2.5-percent solution was used, and then a 5-percent solution in water.

58 *Arbocel 200* (C. T. S.) is a powder cellulose consisting of pure cellulose fibers of hydrophilic nature. It is not soluble but it expands, which is why it is used as an inert filler for preparation of the cleaning mixtures and agents applied to stone surfaces and frescoes, https://www.ctseurope.com/en/scheda-prodotto.php?id=2669 (16 September 2019).

10. Kip cara Tiberija[59]

Mjesto čuvanja: Stalni postav antike, Arheološki muzej Zadar, inv. br. A7301

Mjesto nalaza: Nin, vrt Josipa Đurovića, 1768. godine

Dimenzije: Ukupna visina 210 cm

Materijal: Mramor

Opis

Prikazuje muškarca u togi kojem nedostaju obje podlaktice i donji dio nogu. Datira se u julijevsko-klaudijevsko doba. Kip predstavlja cara odjevenog u togu, prekrivene glave (*velatio capitis*) poput augura, što se često javlja u ikonografiji julijevsko-klaudijevskog doba i prikazivanju cara Augusta. Prednju stranu odlikuje bogastvo draperije, dok je stražnja dosta neobrađena. Po sredini leđa nalazi se četvrtasti utor u koji je umetnuta željezna šipka koja je služila za podupiranje kipa. Dok je portret cara vrlo vješto klesarski obrađen, po sredini kipa u nekoliko vertikalnih nizova vidljive su duboke i tamne vene koje ukazuju na grešku u bloku mramora od kojeg se kip klesao. Vene su naknadno zapunjene voskom kako bi se spriječilo njihovo širenje te listanje i pucanje kamena, što ukazuje na prijašnju konzervaciju za koju nemamo podatke gdje se i kada izvela.

Zatečeno stanje:

Cijela skulptura prekrivena je smeđom patinom, dok se u utorima draperije nalaze deblje naslage i tamne kore. Uzdužno po sredini skulpture, u nekoliko vertikalnih nizova, gdje su duboke i tamne vene, vidljivo je listanje kamena. Utori zapunjeni voskom sivo-zelenkaste su boje, kao posljedica razvoja organskih i anorganskih onešišćenja. Na području donjeg dijela skulpture vidljive su žuto-crne mrlje od voska koji je također zasićen gljivicama i ostalim onečišćenjima, čemu je vosak kao prirodni materijal podložan. Draperija je oko glave popucala, kamen se razlistao i pocrnio. Po sredini stražnjeg dijela kipa vidljiv je veliki četvrtasti utor u kojem se nalazi metalna šipka kojom je kip bio poduprt o stijenu zida. Kip cara izrađen je od jednog bloka mramora, dok je glava s vratom izrađena posebno. Tragovi pompejansko crvene boje po draperiji s prednje strane skulpture (sl. 22, 22a).

Petrografska analiza (sl. 22b, 22c)

Makroskopski opis: Homogena tekstura i mliječno bijela boja.

Mikroskopski opis: Mramor. Mozaična struktura, srednjozrnati, granoblastični s kristalima kalcita prosječne veličine do 700 mikrona. U stijeni nalazimo i nešto akcesornih minerala.

59 Kip cara Tiberija pronađen je s još sedam kipova rimskih imperatora na periferiji forumskog prostora, u vrtu kuće Josipa Đurovića u Ninu ili, kako navodi M. Suić, u vrtu obitelji Medović. Osim četiriju kipova sačuvanih u Muzeju, ostalima se zametnuo trag. Kipovi su bili ukopani u zemlju i više-manje na okupu, što navodi na zaključak da su namjerno maknuti sa svog mjesta i zajedno pohranjeni. Izrađeni su od mramora u nadnaravnoj veličini. Nastali su kao proizvod jedne italske radionice, koja je u seriji izrađivala monumentalne skulpture prema predlošcima. Za sada je sigurno da su stajali u građevini u nišama jer im je stražnja strana nedorađena, vidi više u Š. Batović, J. Belošević, M. Suić 1968, 46.

10. Emperor Tiberius' statue[59]

Kept in: Permanent Exhibition of Roman Antiquities, Archaeological Museum Zadar, Inv. No. A7301

Found at: Josip Đurović's vegetable patch in Nin, 1768

Dimensions: Total height 210cm

Material: Marble

Description

It is a statue of a man in toga, with both lower arms and lower legs missing. It was dated to the Julio-Claudian period. The statue shows the emperor clad in a toga, with his head covered (*velatio capitis*) like an augur – a depiction common in the iconography of the Julio-Claudian period and in representations of Emperor Augustus. The front side is characterized by rich drapery, while the rear side was left unfinished. A square groove for receiving the iron rod that supported the statue is located in the center of the statue's back. While the Emperor's portrait was very skillfully carved, a few deep and dark veins stretching down the center of the statue reveal the faults in the marble block the statue was carved from. The veins were subsequently filled with wax in order to prevent their expansion and exfoliation and cracking of the stone. This indicates that an earlier restoration took place, although it is not known where and when.

Condition:

The entire sculpture was covered with brown patina; thick deposits and dark crusts are found in the drapery folds. Longitudinally, along the center of the sculpture, exfoliation can be seen in several vertical lines, where deep and dark veins are. The drapery folds filled with wax are of gray and greenish color, as a result of the development of organic and non-organic contaminations. In the lower part of the sculpture, yellow and black wax stains can be seen. The wax is also saturated with fungi and other contaminants (it is prone to it, being a natural material). The drapery around the head is cracked; the stone is exfoliated and black. In the center of the statue's back, a large square groove can be seen. It contains a metal rod once used to press the statue against a wall. The emperor's statue was made of a single block of marble and the head with neck was made from a separate block. Traces of Pompeian red can be seen on the drapery on the sculpture's front side (Figs. 22, 22a).

Petrographic analysis (Figs. 22b, 22c)

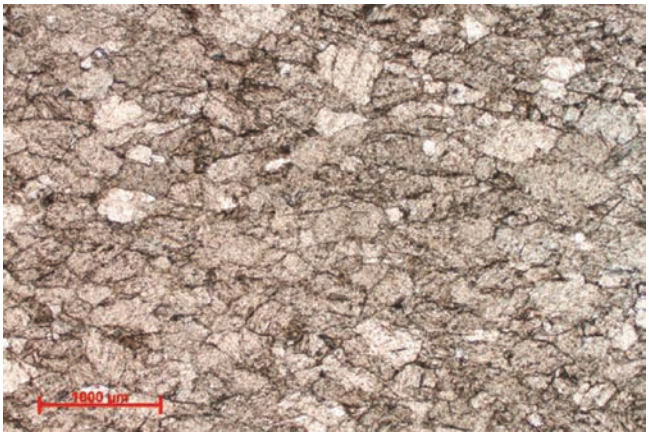
Macroscopic description: Homogenous structure and milk-white color.

Microscopic description: Marble. Mosaic structure, medium-grained, granoblastic, with calcite crystals of average size of up to 700 microns. Some accessory minerals can also be seen in the rock.

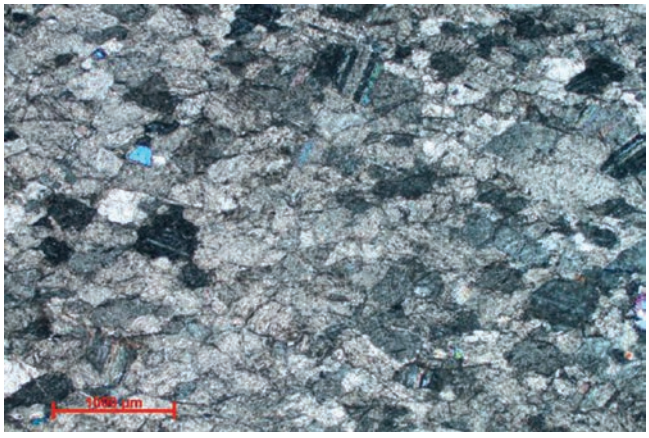
59 The statue of Emperor Tiberius and statues of seven other Roman emperors were found on the periphery of the Forum area, in the vegetable patch by Josip Đurović's house in Nin – or, according to M. Suić, in the garden of the Medović family. Four of them are kept in the Museum, but others are lost. The statues were buried in the ground together, more or less on the same place. This suggests that they were removed from their place on purpose and stored together. They are made of marble and are oversized. They were made in an Italic workshop that mass-produced monumental sculptures based on models. It is certain that the statues stood in niches inside some building, because their rear sides are not finished. See more in Š. Batović, J. Belošević, M. Suić 1968, 46.

Slika 22. Zatečeno stanje glave kipa prije konzervatorskih radova, inv. br. A7301, AMZd
Figure 22. Head of statue before conservation work, Inv. No. A7301, AMZd
foto / photo by: **M. Rajzl**

Slika 22a. Duboke vene po sredini kipa – stanje prije konzervatorskih radova
Figure 22a. Deep veins along center of statue – before conservation work
foto / photo by: **M. Zorica**



Slika 22b. Fotografija mikroskopskog preparata bez uključenog analizatora
Figure 22b. Photomicrograph in plane polarized light
foto / photo by: **V. Ćosović**



Slika 22c. Fotografija mikroskopskog preparata s uključenim analizatorom
Figure 22c. Photomicrograph in cross polarized light
foto / photo by: **V. Ćosović**

Obavljeni radovi:

- Skulptura je postavljena na drvene grede unutar montažnog bazena.

- Tragovi boje po prednjoj strani draperije zaštićeni su i stabilizirani u prvom sloju 2,5-postotnom otopinom *Mowiola 4-98*, a zatim u drugom sloju 5-postotnom otopinom *Paraloida B-72* u acetonu.

- Pranje skulpture izvršeno je u nekoliko navrata mekanim četkama i pH neutralnim deterdžentom *Contrad 2000*,[60] uklonjene su površinske nečistoće, naslage prljavštine i zemlje. Čišćenje vodenom parom pod povišenom temperaturom izvodilo se paralelno cijelo vrijeme tijekom procesa rada. Vodena para otapala je masnoće, omekšavala naslage, otapala vosak te uništavala gljivice i alge.

- Vosak zasićen gljivicama u dva navrata tretiran je oblozima od celulozne pulpe i *Arbocela 200*, zasićenima 10-postotnom otopinom vodikova peroksida, dok se cijela skulptura više puta prskala biocidnim i fungicidnim sredstvom *Asepsol Eco*[61] (sl. 23).

- Za desalinizaciju i omekšavanje naslaga, skulptura se tretirala oblozima od celulozne pulpe, sepiolite i destilirane vode u tri navrata, oblozi su ostavljani da djeluju tri tjedna. Skulptura je tretirana i oblozima od celulozne pulpe i destilirane vode u periodu od šest mjeseci, oblozi su ostavljani da djeluju po tjedan dana, s pomoću čijeg vodenog ekstrakta se radila analiza i pratilo otapanje soli.

- Za omekšavanje tvrdokornih naslaga i desalinizaciju kemijskim putem, skulptura se tretirala oblozima od celulozne pulpe i *Arbocela 200*, zasićenim 9-postotnim amonijevim karbonatom; sušenjem pulpe, uz amonijev sulfat, na površinu su migrirali i topljivi kloridi. Pulpa je uklonjena, a na površinu kamena nanesen je sloj celulozne pulpe namočene vodom s ciljem neutralizacije prethodnog postupka.

- Mehaničko čišćenje izvršilo se kirurškim skalpelima različitih dimenzija i profila, ultrazvučnom iglom i električnim motorom.

REZULTATI PETROGRAFSKE ANALIZE I KARAKTERIZACIJA MRAMORA

Istraživane su stijene iz kojih su napravljeni arheološki eksponati ili mramor ili vapnenac. Prirodno je kamenje građevno-arhitektonski i ukrasni kamen još od antičkog doba, što analizirani uzorci samo potvrđuju. Mnoge vrste stijena bile su upotrebljavane, ali mramor najčešće. Treba napomenuti kako u širem mediteranskom području eksploatacija mramora datira još iz neolitika, a vrhunac je dosegla tijekom grčko-rimskog perioda.[62]

Restoration work carried out so far:

- The sculpture was laid on the wooden beams within the assembly pool.

- Traces of dye on the front side of the drapery were protected and stabilized with a 2.5-percent solution of *Mowiola 4-98* as the first layer and a 5-percent solution of *Paraloida B-72* in acetone as the second layer.

- The sculpture was repeatedly washed using soft brushes and a pH-neutral detergent *Contrad 2000*.[60] Surface contaminants and deposits of dirt and soil were removed. Cleaning with water vapor at high temperature was carried out simultaneously throughout the cleaning process. The water vapor would melt greases, soften deposits, melt wax and destroy fungi and algae.

- The wax saturated with fungi was treated two times with the compresses of cellulose-pulp and *Arbocel 200*, saturated with 10-percent solution of hydrogen peroxide; the entire sculpture was repeatedly sprinkled with the biocidal and fungicidal agent *Asepsol Eco*[61] (Fig. 23).

- For desalination and deposit softening, the sculpture was three times treated with cellulose-pulp compresses soaked in sepiolite and distilled water; the compresses were left to take effect for three weeks. The sculpture was also treated with cellulose-pulp compresses and distilled water over a six-month period; the compresses were left to take effect for a week. Their water extract was used for the analysis and dissolution of salts was monitored.

- For chemical softening of persistent deposits and desalination, the sculpture was treated with the compresses of cellulose-pulp and *Arbocel 200*, saturated with 9-percent ammonium carbonate. As the pulp was drying, soluble chlorides migrated to the surface together with ammonium sulfate. The pulp was then removed and a layer of cellulosed pulp soaked in water was applied to the stone's surface in order to neutralize the preceding procedure.

- Mechanical cleaning was carried out with surgical scalpels of different dimensions and profiles, an ultrasound needle and an electric motor.

THE RESULTS OF THE PETROGRAPHIC ANALYSIS; ESTABLISHING MARBLE CHARACTERISTICS

The rocks from which the archaeological exhibits were made – marble or limestone – were examined. Natural stones had been used as building and decorative stones since antiquity, as is evidenced by the samples analyzed. Many sorts of rocks were used, but in most cases it was marble. It should be notes here that marble had been exploited in the Mediterranean since Neolithic, but it was the

60 U početku se koristila 3-postotna otopina, a zatim i 5-postotna otopina *Contrada 2000* u vodi, nakon čega se površina temeljito ispirala vodom.
61 U početku se koristila 2,5-postotna otopina, a zatim i 5-postotna otopina *Asepsol Eco* u vodi.
62 A. Moropoulou *et al*., 2019, 28.

60 In the beginning a 3-percent solution was used, and then a 5-percent solution of *Contrad 2000* in water, after which the surface would be thoroughly rinsed with water.
61 In the beginning a 2.5-percent solution was used, and then a 5-percent solution *Asepsol Eco* in water.

Slika 23. Oblog od celulozne pulpe i vodikova peroksida
Figure 23. Compress of celluloid pulp and hydrogen peroxide
foto / photo by: **M. Rajzl**

Prvi „znanstveni" pokušaj da se odredi podrijetlo mramora temeljem makroskopskih osobina datira s kraja 19. stoljeća.[63] Od tada su arheometrijska istraživanja jako napredovala i danas se, uz tradicionalne petrografske interpretacije, koriste rezultati geokemijskih analiza (omjer elemenata u tragovima, omjer stabilnih izotopa C i O), katodoluminiscencija, elektronska paramagnetska rezonancija.

Mramor je metamorfna stijena koja nastaje preobrazbom vapnenaca kao rezultat promjenjivih fizičko-kemijskih uvjeta u periodima koji traju milijunima godina. Uzroci tih transformacija kombinacije su promjenjivih uvjeta okolnog tlaka i temperature, tektonska kretanja, utjecaji kemijski aktivnih fluida i pretaljivanje. Ti uvjeti dovode do promjena teksture, strukture i mineralnog sastava stijena, nemaju tragova fosila ili slojevitosti. Pri metamorfozi stijena mogu nastati nove mineralne asocijacije s mineralima koji kristaliziraju pri višim (progradna metamorfoza) ili nižim (retrogradna metamorfoza) temperaturama. Promjene pri nastanku mramora teksturne su i strukturne naravi.

63 F. Antonelli, L. Lazzarini 2015, 400.

Greco-Roman period that saw the peak of its use.[62] The first "scientific" attempt to determine the origin of marble by its microscopic features was made in the late 19th century.[63] Ever since, the archaeometric research has made considerable progress. Today, in addition to the traditional petrographic interpretations, the results of geochemical analyses (ratio of trace elements, ratio of stable isotopes, ratio of C and O isotopes) are used, together with cathodoluminescence and electron paramagnetic resonance.

Marble is a metamorphic rock that forms through the metamorphism of limestone as a result of millions of years of exposure to changing physical and chemical conditions. These transformations are caused by a combination of changing pressure and temperature, tectonic movements, effects of chemically active fluids and re-melting. Such conditions lead to changes in the texture, structure and mineral composition of rocks; no fossils or layering remain. Metamorphosis of rocks can result in new mineral associations with the minerals crystallizing at higher temperatures (prograde metamorphosis) or lower temperatures (retrograde metamorphosis). The changes associated with forming of marble are of textural and structural nature. Marbles are characterized by a non-linear, fine-grained to coarse-grained texture. Typical is their crystalline structure

62 A. Moropoulou *et al.* 2019, 28.
63 F. Antonelli, L. Lazzarini 2015, 400.

Mramori se ističu nelinearnom, sitnozrnatom do krupnozrnatom teksturom. Karakteristična je njihova kristalična struktura zbog koje dolazi do specifičnog loma i refleksije svjetla. Pravi mramor bijele je boje, ali obično sadrži nečistoće i tragove drugih boja u vidu pruga, manjih površina, slojeva, nepravilnog uzorka točkica i površina, ali i sjena sive boje. Svijetle ili jače zamjetne boje ne javljaju se. Boja mramora ovisi o pigmentima koje ima vapnenac. Vrlo često pigment je grafit, koji je stabilan mineral, a nastao je preobrazbom organogene bituminozne ili ugljenite tvari u vapnencima. Bjeličasti mramori tijekom vremena, uslijed utjecaja atmosferilija i insolacije, mogu postati žućkasti i putenasto nijansirani. Te promjene u nizu slučajeva mogu biti uzrokovane oksidacijom dvovalentnog željeza koje može biti u kristalnoj rešetki kalcita ili dolomita. U Hrvatskoj ne postoji ležište mramora koje se koristi kao arhitektonsko-građevni kamen.

Petrografske analize za klasifikaciju mramora obuhvaćaju definiranje teksture (međusobni odnos sastojaka u kamenu te njihov prostorni raspored i orijentacija), strukture stijene (oblik pojedinih sastojaka i njihova veličina), oblik rubova kristala (*grain boundary shape*, GBD), veličinu kristala/zrna (*grain size*; najmanju – mGS, najveću – MGS i srednju veličinu – AGS), te procjenu i zastupljenost akcesornih minerala.[64] Kristali kalcita mogu imati povijene rubove (*curved*), ravne (*straight boundary*, katkada nastaju karakteristične trijade pod kutom od 120°), nazubljene (zrna se utiskuju jedno u drugo, zupčasta, suturirana ili šivana struktura, *sutured*) ili su pojedina zrna obavijena drugim zrnom (*embayed*). Kristali često pokazuju tlačne lamele (*polysithetic twnning*). Struktura može biti homeoblastična (zrna/kristali su podjednako veliki) i heteroblastična (različita veličina zrna; ksenoblastična – s većim, nepravilnim zrnima raspršenim u stijeni i porfiroblastična – kad se ističu izdužena zrna). Veličina kristala/zrna je najveći izmjereni dijametar na mikroskopskom preparatu s uključenim polarizatorom. Kako bi se dobio reprezentativni uzorak, na preparatu/fotografiji odabire se površina od 6 mm^2 u kojima se mjeri veličina zrna. Izmjereno je od 50 do 70 zrna u svakom mikroskopskom preparatu/fotografiji. Podatci su analizirani na dva načina, izračunata je srednja vrijednost veličine zrna te definirana najmanja i najveća vrijednost. Napravljeni su frekvencijski dijagrami, mjerenja su organizirana u histograme i tako je definirano koja je najčešća veličina zrna (*Most Frequent Size*, MFS).[65] U arheometriji razlikujemo sitnozrnate mramore s prosječnom veličinom zrna < 2 mm, srednjozrnate (AGS 2 – 45 mm) i krupnozrnate (AGS > 5 mm). S obzirom na teksturu mramori se klasificiraju kao mozaični, mramori s folijacijom, a neki su samo slabo rekristalizirani. Kristali dolomita mogu biti prisutni s različitom zastupljenošću.

that causes the specific refraction and reflection of light. True marble is white, but it usually contains impurities and traces of other colors in the form of stripes, smaller areas, layers, irregular pattern of dots and areas, and shades of gray. There are no bright or more conspicuous color. The color of marble depends on the pigments present in limestone. Very often, the pigment is graphite, a stable mineral formed by transformation of the organogenic bituminous or coal matters in limestone. Over time, the whitish marbles can acquire yellowish and tan shades due to weathering and insolation. In many cases, these changes can result from oxidation of the bivalent iron that can be present in the calcite or dolomite crystal grid. In Croatia there are no marble deposits where marble is quarried for building and decorative purposes.

Petrographic analyses intended for marble classification include defining of a rock's texture (interrelation of the components in the stone and their spatial distribution and orientation), structure (shape of individual components and their size), grain boundary shape (GBD), grain size (minimum – mGS, maximum – MGS and average size – AGS), and assessment and share of presence of accessory minerals.[64] Calcite crystals can have curved boundaries, straight boundaries (typical triple point junction at angle of 120 degrees are sometimes formed), sutured boundaries (grains are wedged into each other – a jagged, sutured or stitched structure) or sometimes some grains are embayed by another grain (interlocking). Crystals often manifest polysynthetic twinning. The structure can be homeoblastic (grains/crystals are of equal size) and heteroblastic (grains of various size; xenoblastic – with bigger, asymmetrical grains scattered in the rocks, and porphyroblastic – with conspicuous elongate grains). The crystal/grain size is the biggest diameter measured on a microscope preparation with polarizer. In order to obtain a representative specimen, an area of 6mm^2 is selected on a preparation/photograph, in which the size of grains is measured. In every thin section / photomicrograph, 50 to 70 grains were measured. The data were analyzed in two ways, a mean value of the grains was calculated and the minimum and maximum values were defined. Frequency charts were made and measurements were organized in histograms. This is how the most frequent size (MFS) of the grains was defined.[65] In archaeometry, there are fine-grained marbles with the average grains size < 2mm, medium-grained marbles (AGS 2-45mm) and coarse-grained marbles (AGS > 5mm). Given their texture, marbles are classified as mosaic marbles, marbles with exfoliation, and some are just poorly recrystallized. Dolomite crystals can be present to a various extent.

64 F. Antonelli, L. Lazzarini 2015, 400.
65 M. Brilli *et al*. 2018, 627.

64 F. Antonelli, L. Lazzarini 2015, 400.
65 M. Brilli *et al*. 2018, 627.

Istraživani uzorci pripadaju kategoriji sitnozrnatih mramora (veličina kristala manja je od 2 mm). Glavne petrografske osobine prikazane su u Tablici 1. Većina uzoraka ima heteroblastičnu strukturu, samo uzorak A7732 ima homeoblastičnu. Među heteroblastičnim uzorcima razlikuju se dvije grupe mramora. Kod jedne grupe ksenomorfni kristali kalcita imaju dvije generacije zrna, jedno su kalcitni porfiroblasti, a drugo su jako sitni neoblasti (uzorak: A7740). Kristali/zrna minerala kalcita dominiraju u svim istraživanim uzorcima, dok su pojedinačna zrna dolomita prisutna u sljedećim uzorcima: A7739, A7740, A7746, A7301. Svi ostali mramori imaju ksenoblastne kristale različitih veličina, ali razlike su manje izražene (na neki bi ih se način moglo smatrati i pseudohomeoblastičnim). Većina uzoraka ima mozaičnu strukturu (zrna su raspoređena poput saća, po tri se zrna dodiruju u jednoj točki, a kutovi su različiti). Ta je struktura okarakterizirana dvjema kategorijama kristala s obzirom na veličinu. Prva grupa, sastavljena od nešto većih kristala, obuhvaća hedralne i subhedralne kalcitne porfiroblaste (kristale pravilnog oblika) kojima je najveća veličina zrna (MGS) između 1,47 i 2,03 mm (najčešće vrijednosti u rasponu su 0,51 – 1,2). Drugu grupu uzoraka karakteriziraju sitnija zrna kalcita čija najveća vrijednost doseže 0,95 mm, a najčešće su vrijednosti u rasponu 0,36 – 0,42 mm. Granice zrna u istom uzorku pokazuju raznolikost, tako da ni u jednom istraženom uzorku nije uočen samo jedan tip granice. Uočene su deformacije, ksenomorfni kristali pokazuju tlačne lamele (polisintetičke lamele). U mikroskopskim preparatima nekih uzoraka (A10216, A7740) uočene su trake ili nakupine sastavljene od jako sitnih kristala kalcita, što ukazuje na to da je stijena pretrpjela dodatne tektonske deformacije.

Istraživani uzorci obilježeni su teksturnom sličnošću. Većina uzoraka ima heteroblastičnu-anizotropičnu strukturu što je karakteristično za mramore koji su bili izloženi određenom stupnju deformacija tijekom ili nakon metamorfoze. Ta je struktura obilježena ksenomorfnim kristalima koji su raspoređeni u dva modela (manja i velika razlika u veličini zrna). Strukture koje su homeoblastične ili pseudohomeoblastične nastale su u uvjetima čija je metamorfoza bila jednolika i bez naknadnih deformacija, što je karakteristično za mramore iz Carrare. Heteroblastična struktura u kombinaciji s veličinom zrna i tlačnim lamelama može olakšati utvrđivanje podrijetla mramora.[66] Iako postoje razlike u veličini pojedinih kristala, istraživani uzorci sitnozrnati su mramori, što nam omogućuje da iz popisa potencijalnih kamenoloma isključimo sve one iz kojih se vadio srednjozrnati ili krupnozrnati mramor. Sitnozrnati varijeteti poznati su iz kamenoloma Penteli i Hymmetos, Paros 1/Lychnites, Carrara i Afyon (Dokimeion) (tab. 1).

The examined samples are fine-grained marbles (with grain size below 2mm). Their main petrographic characteristics are shown in Table 1. Most of the samples have a heteroblastic structure; only sample A7732 has a homeoblastic structure. Two different types of marble are represented among the heteroblastic samples. In one group, the xenomorphic calcite crystals have two generations of grains: calcite porphyroblasts and very tiny neoblasts (sample A7740). The calcite crystals/grains are dominant in all the samples examined. Individual dolomite grains were found in the following samples: A7739, A7740, A7746, A7301. All other marbles have xenoblastic crystals of various size, but the differences between them are less prominent (in a way, they could be considered pseudo-homeoblastic). Most of the samples have a mosaic structure (the grains form a honey-combed pattern: three of them are interconnected in a single point and their angles are different). In terms of the size of its crystals, this structure has two categories: The first group – consisting of somewhat larger crystals – includes hedral and subhedral calcite porphyroblasts (symmetrical crystals) with maximum grain size (MGS) ranging from 1.47 and 2.03mm (with the size of most of them ranging from 0.51 to 1.2mm). The second group of samples is characterized by smaller calcite grains with a maximum size of 0.95mm (with the size of most of them ranging from 0.36 to 0.42mm). The same sample is also characterized by diversity of grain boundaries: none of the examined samples is characterized by a single boundary type. Deformations were observed; xenomorphic crystals manifest polysynthetic twinning. Bands or accumulations of very tiny calcite crystals were observed in the microscope preparations of some samples (A10216, A7740). This indicates that the rock had undergone additional tectonic deformations.

The examined samples have similar textures. Most of them have a heteroblastic-anisotropic structure typical of the marbles that underwent a certain degree of deformation during or after their metamorphosis. This structure is characterized by xenomorphic crystals arranged in two models (minor and major differences in grain size). The homeoblastic or pseudo-homeoblastic structures were formed in the conditions of uniform metamorphosis, without subsequent deformations – which is typical of the Carrara marbles. Together with grains size and polysynthetic twinning, heteroblastic structure can help us identify the origin of a marble.[66] While there are differences in the size of individual crystals, the examined samples are fine-grained marbles, which makes it possible to remove from the list of potential quarries all those where medium-grained or coarse-grained marbles were quarried. The fine-grained varieties are known from the following quarries: Pentelicus and Hymmetos, Paros 1/Lychnites, Carrara and Afyon (Dokimeion) (Tab. 1).

66 F. Antonelli, L. Lazzarini 2015, 400.

66 F. Antonelli, L. Lazzarini 2015, 400.

Karta 1. Karta središnjeg i istočnog dijela Sredozemlja s označenim lokacijama kamenoloma mramora (1) Candoglia; (2) Carrara; (3) Campiglia, (4) Doliana; (5) Mani; (6–7) Penteli i Hymettus planine; (8) Tynos; (9) Paros; (10) Naxos; (11) Kos; (12) Fourni; (13) Ikaria; (14) Samos; (15) Miletus; (16) Goktepe; (17) Aphrodisia; (18) Denizli; (19) Thiounta; (20) Docimium; (21) Sardis; (22) Ephesos; (23) Skyros; (24) Thasos; (25) Proconnesus.

Map 1. A map of Central and Eastern Mediterranean with locations of marble quarries: (1) Candoglia; (2) Carrara; (3) Campiglia, (4) Doliana; (5) Mani; (6–7) Mount Pentelicus and Mount Hymettos; (8) Tynos; (9) Paros; (10) Naxos; (11) Kos; (12) Fourni; (13) Ikaria; (14) Samos; (15) Miletus; (16) Goktepe; (17) Aphrodisia; (18) Denizli; (19) Thiounta; (20) Docimium; (21) Sardis; (22) Ephesus; (23) Skyros; (24) Thasos; (25) Proconnesus.

prema / according to: **F. Antonelli, L. Lazzarini 2015, 401.**

U pokušaju da se što preciznije odredi provenijencija mramora, u obzir su uzeti sljedeći petrografski parametri: najveća veličina zrna (MGS), najveća učestalost pojavljivanja zrna i oblik granice. Ako bi se uzela samo veličina zrna, tada je Carrara moguća lokacija. Uzorci mramora iz Carrare imaju MGS vrijednosti 0,2 – 0,4 u 80 % mjerenja.[67] U istraživanim uzorcima učestalost je potvrđena, 75 % analiziranih kristala je u tom rasponu MGS vrijednosti. Međutim, prema dostupnoj literaturi, mramori iz Carrare (broj 2, karta 1) imaju relativnu dominaciju ravnih rubova kristala. U istraživanim uzorcima to nije uvijek bilo tako, stoga su mogući izvori mramora za uzorke A7740 i A7744 kamenolomi na otoku Parrosu (broj 9, karta 1), a za uzorak A7301 kamenolom u planini Penteli i Hymmetos (broj 6–7, karta 1).

Na istraživanje vapnenaca utjecala je mala veličina uzorka A7305, koja je samim time diktirala veličinu i broj

In order to identify the origin of marble as accurately as possible, the following petrographic parameters were taken into account: maximum grains size (MGS), maximum frequency of grains, and shapes of boundaries. If only the grains size were taken into account, then Carrara would be a possible location. In 80% of measurements, it was established that the MGS values of the Carrara marble samples ranged from 0.2 to 0.4.[67] This size range was found at 75 % of all studied crystals; a large number of the grains falls within this range of MGS values. However, according to available literature, the Carrara marbles (No. 2, Map 1) are characterized by relative predominance of crystals with straight boundaries. As it was not always so in the examined samples, possible sources of marble for the samples A7740 and A7744 are the quarries on the island of Paros (No. 9, Map 1), and for the sample A7301

67 M. Brilli *et al*. 2018, 640.

67 M. Brilli *et al*. 2018, 640.

mikroskopskih preparata što je znatno otežalo, odnosno onemogućilo preciznije određivanje podrijetla kamena. Kod vapnenaca je karakteristično da isti fizičko-kemijski uvjeti u okolišu taloženja, bez obzira na to kad se događaju, rezultiraju taloženjem istog tipa (litofacijesa) stijene. Ako stijena sadržava provodne fosile, moguće je datiranje, a ako ih ne sadrži, starost naslaga određuje se drugim geološkim alatima (ali samo na terenu). Dakle, iz mikroskopskog preparata vapnenca bez fosila nemoguće je odrediti starost stijene (potencijalni kamenolom). Kako u mikroskopskom preparatu nije nađen fosil koji bi uputio na starost, nemoguće je odrediti provenijenciju kamena. Slojevi vapnenca pokazuju veliku lateralnu raznolikost što dodatno otežava potragu za izvorišnom stijenom. Ono što se može zaključiti jest da svi kamenolomi u naslagama mlađe krede u području Dalmacije (ali i šire) mogu biti izvorište originalnog kamena.

ZAKLJUČAK

Spomenici iz kamena na našim područjima lokalnog su podrijetla ili su uvezeni kao gotovi ili polugotovi proizvodi, ovisno o vrsti materijala od kojih su napravljeni. Za spomenike iz vapnenca sa sigurnošću možemo reći da nisu uvezeni jer se vapnenac nije uvozio, već se vadio u kamenolomima diljem jadranske obale i otoka. Skulpture od mramora su ili već uvezene kao gotov proizvod ili su isklesane u domaćim radionicama od uvezenog mramornog bloka.[68] Dijagnostika vrste i podrijetla kamena služi konzervatorima – restauratorima pri odabiru odgovarajuće metode i pri izboru adekvatnih materijala, a uvelike može pomoći povjesničarima i arheolozima u rasvjetljavanju teme antičkih kamenoloma i njhove upotrebe.

Konzervatorsko-restauratorske radove potrebno je nastaviti na spomenicima koji nisu prošli potpuni proces zaštite, a spomenike koji su ga prošli treba i dalje nadzirati, pratiti promjene i daljnja reagiranja u novim uvjetima. Tijekom rada upotrebljavala su se reverzibilna i paropropusna sredstva, po pravilima struke i prema vlastitom iskustvu. Svi konzervatorsko-restauratorski zahvati, kao i izrada sredstava i materijala, izvedeni su u konzervatorsko-restauratorskoj radionici Arheološkog muzeja Zadar.

the quarry in the Mounts Pentelicus and Hymmetos (No. 6–7, Map 1).

The small size of the sample A7305 had an effect on the examination of limestone. As such, it dictated the size and number of thin sections, microscope preparations, thus making it much more difficult – or impossible – to identify the exact origin of the stone. Typical of limestone is that, in a sedimentation environment, the same physical and chemical conditions result in depositing of the same type (lithofacies) of rock, regardless of when they actually take place. If the rock contains index fossils, it can be dated. If it doesn't, other geological tools must be used for dating the deposits (only in the field, though). It is therefore impossible to date a rock (and thus identify the potential quarries of its origin) from a thin section of non-fossiliferous limestone. As no index fossil was found in the thin sections, it is impossible to establish the origin of the stone. Limestone layers manifest substantial lateral diversity, which is another factor that makes tracing of the source rock more difficult. It is, however, possible to conclude that all the quarries in the Upper Cretaceous deposits in Dalmatia (and beyond) can be considered potential sources of the original stone.

CONCLUSION

The stone monuments in Dalmatia were either made locally or were imported as finished or semi-finished products, depending on the material they were made of. For the monuments made of limestone we can positively say that they were not imported, because limestone used to be quarried along the Eastern Adriatic coast and its islands and required no importing. The marble sculptures were either imported as finished products or were carved from imported marble blocks in local workshops.[68] Diagnosing the type and origin of a stone helps conservators and restorers choose adequate methods and materials. It can also help historians and archaeologists to cast more light on the problem of Roman-period quarries and their exploitation.

The monuments that have not been through a full protection procedure should undergo the conservation and restoration work. Those that have undergone it should be monitored for any changes or reactions in the new conditions. Based on good professional practice and experience, reversible and steam-permeable agents were used during the work. The whole conservation and restoration work and preparation of agents and materials were carried out in the conservation and restoration workshop of Archaeological Museum Zadar.

68 N. Cambi 2002, 93; M. Parica 2012, 345.

68 N. Cambi 2002, 93; M. Parica 2012, 345.

Slika 1.
Glave nakon konzervatorskih radova, Stalni postav antike, AMZd
Figure 1. Heads after conservation work, Permanent Exhibition of Roman Antiquities, AMZd
foto / photo by: **I. Čondić**

Slika 2. Prednja strana kipa cara Tiberija nakon konzervatorskih radova, Stalni postav antike, AMZd
Figure 2. Front side of Emperor Tiberius' statue after conservation work, Permanent Exhibition of Roman Antiquities, AMZd
foto / photo by: **M. Rajzl**

Slika 2a. Stražnja strana kipa cara Tiberija nakon konzervatorskih radova, Stalni postav antike, AMZd
Figure 2a. Rear side of Emperor Tiberius' statue after conservation work, Permanent Exhibition of Roman Antiquities, AMZd
foto / photo by: **M. Rajzl**

Slika 3. Prednja strana akefalne ženske skulpture nakon konzervatorskih radova, Stalni postav antike, AMZd
Figure 3. Front side of acephalous woman's statue after conservation work, Permanent Exhibition of Roman Antiquities, AMZd
foto / photo by: **M. Zorica**

Slika 3a. Stražnja strana akefalne ženske skulpture nakon konzervatorskih radova, Stalni postav antike, AMZd
Figure 3a. Rear side of acephalous woman's statue after conservation work, Permanent Exhibition of Roman Antiquities, AMZd
foto / photo by: **M. Zorica**

Uzorak / Sample	**Glavne osobine mikrostrukture / Main features of microstructure**	**Sortiranost / Fabric texture**	**Granice kristala / Grain boundary shape**	**AGS (mGS – MGS) [mm]**	**MFS (mm)**	Dodatni minerali / Additional minerals	**Potencijalni kamenolom sitnozrnatih mramora / Potential quarries of ultra-fine grained marble**
A 7739	Mozaična / Mosaic	Heteroblastični-izometrični kristali Heteroblastic – isometric crystals	Suturirane, povijene/ Sutured, curved	0.22 (0.08 – 0.47)	25 % = 0.15; 75 % = 0.28		Pentelicus, Hymmetos, Paros2 / Lychnites, Carrara, Afyon (Dokimeion)
A 7732	Mozaična / Mosaic	Homeoblastični (lagano heteroblastični) – anizometrični kristali / Homeoblastic (slightly heteroblastic) – anisometric crystals	Povijene, ravne/ Curved, straight	0.5 (0.2-0.8)	25 % = 0.34; 75 % = 0.67		Pentelicus. Hymmetos, Paros2 / Lychnites, Carrara, Afyon (Dokimeion)
A 7744	Lineacija / Lineation	Heteroblastični – anizometrični kristali/Heteroblastic – anisometric crystals	Ravne, suturirane / Straight, sutured	0.82 (0.25 – 1.51)	25 % = 0.41; 75 % = 1.26		Pentelicus. Hymmetos, **Paros2 / Lychnites**, Carrara, Afyon (Dokimeion)
A 7740	Lineacija (trake sastavljene od sitnih kristala kalcita) / Lineation (bands consisting of tiny calcite crystals)	Heteroblastični – anizometrični kristali/Heteroblastic – anisometric crystals	Povijene, suturirane, ravne / Curved, sutured, straight	0.5 (0.28 – 1.47	25 % = 0.37; 75 % = 0.63	Nečistoća / Impurities	Pentelicus. Hymmetos, **Paros2 / Lychnites**, Carrara, Afyon (Dokimeion)
A 7743	Mozaična / Mosaic	Heteroblastični – anizometrični kristali / Heteroblastic – anisometric crystals	Povijene, ravne / Curved, straight	0.39 (0.1 – 0.84)	25 % = 0.26; 75 % = 0.48		Pentelicus. Hymmetos, Paros2 / Lychnites, **Carrara**, Afyon (Dokimeion)

A 7746	Mozaična / Mosaic	Heteroblastična – izometrični kristali / Heteroblastic – isometric crystals	Povijene, ravne / Curved, straight	0.44 (0.12 – 0.95)	25 % = 0.31; 75 % = 0.54	Pentelicus. Hymmetos, Paros2 / Lychnites, **Carrara**, Afyon (Dokimeion)
A 7745	Mozaična / Mosaic	Heteroblastični – anizometrični kristali / Heteroblastic – anisometric crystals	Ravne, suturirane / Straight, sutured	0.32 (0.1 – 0.84)	25 % = 0.26; 75 % = 0.42	Pentelicus. Hymmetos, Paros2 / Lychnites, **Carrara**, Afyon (Dokimeion)
A 7301	Mozaična (rekristalizirani) / Mosaic (recrystallized)	Heteroblastični, porfirnoblastični – anizometrični kristali / Heteroblastic, porphyroblastic – anisometric crystals	Ravne, povijene / Straight, curved	0.59 (0.24 – 1.48)	25 % = 0.42; 75 % = 0.69	**Pentelicus**, Hymmetos, Paros2 / Lychnites, Carrara, Afyon (Dokimeion)
A 102016	Mozaična / Mosaic	Heteroblastični (ksenoblasični) – anizometrični kristali / Heteroblastic (xenoblastic) – anisometric crystals	Ravne, povijene, suturirane / Straight, curved, sutured	0.40 (0.17 – 0.65)	25 % = 0.25; 75 % = 0.55	Pentelicus, Hymmetos, Paros2 / Lychnites, Carrara, Afyon (Dokimeion)

Tablica 1.
Opis istraživanih uzoraka mramora. U stupcu s potencijalnim kamenolomima podebljano su označeni mogući kamenolomi, a tamo gdje to nije bilo moguće pretpostaviti, ostao je samo popis
Table 1. Description of marble samples examined. In the column with the potential quarries, the possible ones are designated with bold letters. The ones for which the possibility could not be established are listed with regular letters. AGs= average grain size (diameter in mm); mGS= minimum grain size (diameter in mm); MGS= maximum grain size (diameter in mm); MFS= the most frequent size.
izradila / prepared by: **V. Ćosović**

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