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RESTAURATORSKO-KONZERVATORSKI RADOVI NA KASNOANTIČKOM MOZAIKU U KAPELI SV. IVANA U SAMOSTANU SV. FRANJE U PULI

RESTORATION-CONSERVATION WORKS ON A LATE ROMAN MOSAIC IN THE CHAPEL OF ST. JOHN IN THE MONASTERY OF ST. FRANCIS AT PULA

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UDK 738.5.025 4: 726.52](497.5 Pula)"652"
Stručni članak
Primljeno: 25. 8. 2010.
Odobreno: 19. 10. 2010.

U razdoblju od studenog do prosinca 2009., djelatnice Arheološkog muzeja Istre (AMI) restauratorice Andrea Sardoz i Monika Petrović te viša preparatorica Luana Milotić, u suradnji s djelatnicima i suradnicima Hrvatskoga restauratorskog zavoda (HRZ) konzervatorom-restauratorom Tonijem Šainom, voditeljem Prirodoslovnog laboratorija HRZ-a Domagojem Mudronjom te mozaičarom Matkom Kezeleom, izvršili su zaštitne konzervatorske radove na antičkom mozaiku u kapeli Sv. Ivana u samostanu Sv. Franje u Puli.
U članku je opisano zatečeno stanje mozaika, tijek konzervatorsko-restauratorskih radova, opis izvedenih konzervatorsko-restauratorskih radova te zaključak s osvrtom na dostupnu dokumentaciju i izvedene laboratorijske analize.

KLJUČNE RIJEČI: *mozaik, tesera, nucleus, opšav, konzervacija-restauracija, analiza soli*

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UDC 738.5.025 4: 726.52](497.5 Pula)"652"
An professional article
Received: August 25, 2010
Approved: October 19, 2010

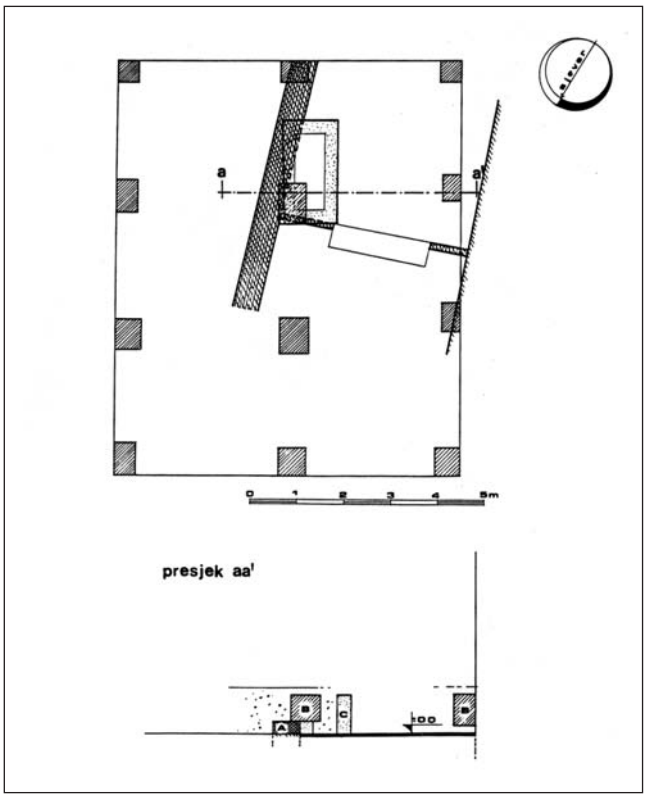
In the period from November to December 2009 a crew from the Archaeological Museum of Istria (AMI), the restorers Andrea Sardoz and Monika Petrović and senior preparator Luana Milotić, together with employees and co-workers from the Croatian Conservation Institute (CCI), conservator-restorer Toni Šaina, the head of the Natural Science Laboratory of the Croatian Conservation Institute Domagoj Mudronja, and mosaicist Matko Kezele, conducted a series of rescue conservation works on the Roman mosaic located in the chapel of St. John in the monastery of St. Francis at Pula.
The article describes the state of the mosaic at the beginning of the works, and the course of the conservation-restoration works, it then continues with a description of the executed conservation-restoration works, concluding with a review of the documentation at hand and the performed laboratory analyses.

KEY WORDS: *mosaic, tessera, nucleus, border, conservation-restoration, salt analysis*

1. Uvod

U staroj jezgri Pule, između Foruma i Kaštela, nalazi se crkva Sv. Franje. Prilikom uređenja samostalne muzejske zbirke u samostanu, odnosno u kapeli Sv. Ivana, 1963. provedeni su arheološki radovi u kojima su otkrivena tri kulturna sloja: rimski, srednjovjekovni i novovjekovni. U rimskom sloju nađeni su ostaci većeg dijela rimskog zdanja. Južni dio prostorije je u cijelosti prekriven mozaičkim podom. Razni autori datiraju mozaik u period između 2. i 3. stoljeća (Marušić B. 1982.-1983, Meder J. 1998.).

Mozaik ima bijelu podlogu, tesera složenih u dijagonalu. U centralnom dijelu nalazi se središnji motiv kantarosa s motivom svastike u sredini. Svastika u središtu kantarosa izvedena je od crnih tesera. Kantaros je uokviren oktogonalnim motivom, izvedenim crnim i bijelim teserama. U polju iznad kantarosa nalazi se oštećena, višebojna latična rozeta. U kutnom kvadratu nalazi se još jedan motiv svastike monokromno izveden. Oko središnjeg oktogona razmješteni kvadrati i pravokutnici oblikuju osmerokrake rombne zvijezde. U manjim su poljima pelte proširenih krakova vezane za rub kompozicije. Rubni dio kompozicije, zajedno s crnom i bijelom bordurom, čini široka dvotračna pletenica. Pletenica je izvedena polikromno, uz crne i bijele tesere



Sl. 1 Tlocrt prema Marušiću, 1978., s označenim mozaikom
Fig. 1 The ground plan after Marušić, 1978, with the marked mosaic

1. Introduction

The church of St. Francis is located in the old section of Pula, between the Forum and the Kaštel. During the setting up of an independent museum collection in the monastery, i.e. in the chapel of St. John, in 1963, archaeological excavations had been carried out, which brought to light three culture layers: a Roman, medieval and New Age layer. The Roman layer concealed the better part of a large Roman structure. The southern section of the room was in its entirety covered with a Roman mosaic. Different authors date the mosaic into the period between the 2nd and 3rd centuries (Marušić B. 1982 - 1983, Meder J. 1998).

The mosaic has a white background of tesserae placed diagonally. Located in the central section is the central motif representing a kantharos with a swastika motif in the middle. The swastika at the center of the kantharos was executed with black tesserae. The kantharos itself is framed with an octagonal motif that was executed with black and white tesserae. Located in the field above the kantharos is a damaged, varicolored petal rosette. In a corner square is another swastika motif that was executed in monochrome fashion. The squares and rectangles placed around the central octagon form an eight-pronged rhomboid star. Located in the smaller fields are peltae with widened prongs, which are connected with the border of the composition. A wide two-strand plait, together with a black and white border, forms the border section of the composition. The plait is polychrome as it was executed with black, white and ocher tesserae. Depicted to the north of the geometrical section of the mosaic is a hypocamp whose body parts are delineated with finely hewn white tesserae. The entire central motif, together with the hypocamp, was framed with yet another black-white border. Part of the mosaic in its upper section, and a still bigger part in the central and lower sections of the rectangular surface, were destroyed due to the building material that fell onto the mosaic when the surrounding structure caved in.

2. The state of the mosaic before the works

a field inspection and examination of the mosaic in the monastery of St. Francis at Pula was organized in May of 2009, which led to the conclusion that the mosaic was in a critical state. Whereupon, in November and December of the same year, a crew from the Archaeological Museum of Istria, the restorers Andrea Sardoz and Monika Petrović and senior preparator Luana Milotić, together with employees and co-workers from the Croatian Conservation Institute, the conservator-restorer Toni

krase je i tesere oker boje. Sjeverno od geometrijskog dijela mozaika prikazan je hipokamp, čiji su dijelovi tijela naznačeni bijelim teserama fine obrade. Cijeli središnji motiv, zajedno s hipokampom, uokviruje još jedna crno-bijela bordura. Dio mozaika u gornjem dijelu te još veći dio mozaika u središnjem i donjem dijelu pravokutne površine uništen je uslijed urušavanja građevinskog materijala na mozaik.

2. Zatečeno stanje mozaika

Nakon što se prilikom terenskog obilaska i pregleda u svibnju 2009., utvrdilo da je podni mozaik u Franjevačkom samostanu u Puli u kritičnom stanju, djelatnice Arheološkog muzeja Istre restauratorice Andrea Sardoz i Monika Petrović te viša preparatorica Luana Milotić, u suradnji s djelatnicima i suradnicima Hrvatskoga restauratorskog zavoda, konzervatorom-restauratorom suradnikom Tonijem Šainom i Matkom Kezeleom, iste su godine u studenom i prosincu zatekli sljedeće stanje podnog mozaika.

Veliki dio oštećenja mozaika nastao je zbog vlage, koja se u širokom pojasu proteže uz sjeverni i zapadni rub bazena gdje se i zadržava. Prostoriji, u kojoj je smješten mozaik, promijenjeni su kriptoklimatski uvjeti zatvaranjem i postavljanjem radijatora u prostoriju. Zbog naglog isušivanja zraka došlo je do kristalizacije soli na površini. Preliminarnom analizom dokazana je štetna koncentracija klorida i nitrata u svim uzorcima žbuke, dok je štetna koncentracija sulfata dokazana samo u najdonjem sloju žbuke[1]. U području sušenja, vlaga dospijeva iz vlažnije zone, a s njom i nove količine iona raznih soli. Na taj način dolazi do akumuliranja sve većih nakupina soli, rasta kristala tih soli u pornom prostoru građevinskog materijala, koji širenjem uzrokuju razaranje. Metodom rendgenske difrakcije i FTIR spektroskopijom dokazano je da su iskristalizirane soli na površini mozaika natrijevi sulfati (mirabilit i tenardit). Dakle, prodorom vlage dolazi do kristaliziranja soli na površini mozaika i okolnih zidova pa se na taj način razara vezivo između mozaičkih tesera, podloga mozaika i same tesere. Tesere u pojedinim dijelovima "lebde" zbog mrvljenja podloge uslijed djelovanja soli. Određeni su se dijelovi mozaika uzdigli od njegove podloge zbog djelovanja vlage i soli, te razaranja mozaične podloge. Na pojedinim dijelovima mozaika tesere su počele otpadati zbog pucanja starih opšava.

[1] Analize soli, metodom rendgenske difrakcije, napravio je prof. dr. sc. Darko Tibljaš; analizu soli FT-IR spektroskopijom napravila je Marija Bošnjak, dipl. ing. kemije; kemijsku analizu soli napravila je Marijana Fabečić, viši konzervator tehničar, te analizu kamena i zaključak izveo je Domagoj Mudronja, prof. geologije.

Šaina and the mosaicist Matko Kezele, discovered that the condition of the floor mosaic is as follows.

A large portion of the damages ensued as a consequence of humidity that extends itself in a broad belt alongside the northern and western edges of the basin where it is also held up. The cryptoclimatic conditions of the premises that house the mosaic were altered when the room was closed and radiators were installed. Due to a rapid drying of air, a process of salt crystallization was started on the surface. A preliminary analysis showed a deleterious concentration of chlorides and nitrates in all mortar samples, whereas a harmful concentration of sulfates was proven only in the nethermost layer of mortar[1]. In the area affected by drying, humidity arrives from the more humid zone, and with it new quantities of ions pertaining to different salts as well. This results in an ever increasing accumulation of salt and the growing of crystals of these salts in the pores of the building materials, which due to their expansion cause devastation. Using the method of x-ray diffraction and FTIR spectroscopy it was proven that the salts that crystallized on the surface of the mosaic are natrium sulfates (mirabilite and thenardite). Consequently, the penetration of humidity triggers the process of salt crystallization on the surface of the mosaic and on surrounding walls, which in turn contributes not only to the destruction of binding material between mosaic tesserae, but also of the mosaic substrate and of the tesserae themselves. The tesserae "float" in some areas due to the crumbling of the substrate that is caused by the effects of salt. Certain sections of the mosaic lifted themselves from the substrate because of the effects of humidity and salt and the resulting destruction of the mosaic substrate. On still other sections of the mosaic the tesserae began to fall out because old borders began to crack.

Except for the presence of salt, a whole series of other damages are visible on the face of the mosaic, such as a thick layer of dust and dirt that had been accumulating for many years, as well as other garbage (candy and chocolate wrappings, paper...). Coins were thrown onto the mosaic for a longer period of time. The metal (coins) corroded, which in turn left corrosion traces and stains on the face of the mosaic. We were likewise able to spot traces of black paint or lacquer on the face of the mosaic, which were probably caused by workers painting the wooden beams on the ceiling above the mosaic. We assume that

[1] Salt analyses using the method of x-ray diffraction were performed by Prof. Dr. Darko Tibljaš; the salt analysis using FT-IR spectroscopy was made by Marija Bošnjak, graduate engineer of chemistry; the chemical analysis of salt was carried out by Marijana Fabečić, senior conservator-technician; the stone analysis and conclusion were conducted by Domagoj Mudronja, professor of geology.

Na licu mozaika, osim prisutnosti soli, vidljiva su mnogobrojna druga oštećenja kao što je veliki sloj dugogodišnje prašine i prljavštine, različito smeće (omoti papirića od bombona, čokolada, papiri…). Duže se vrijeme na mozaik bacalo novčiće. Metal (kovanice) je korodirao pa je na licu mozaika ostalo tragova i mrlja od korozije. Također su na licu mozaika vidljive mrlje od crne boje ili laka, koje su vjerojatno uzrokovali radnici koji su bojali drvene grede na stropu iznad mozaika. Rub mozaika restauriran je, pretpostavlja se odmah po nalasku mozaika. Starija restauracija uključivala je izradu opšava mozaika te "zalijevanje" dijelova gdje nedostaje mozaik cementnom žbukom. Stari cementni opšavi vrlo su fine izrade, ali posljednjih se godina preferira korištenje vapnene žbuke u restauraciji mozaika radi veće kompatibilnosti s originalnim materijalom i lakše reverzibilnosti u odnosu na cement. U ovom slučaju restauracije mozaika trebalo bi cement svakako izbjeći zbog kalijeva i natrijeva oksida koji vodom prelaze u hidrokside.

Sl. 2 Stanje mozaika -Meder, J.: "Podni mozaici u Hrvatskoj od 1. do 6. stoljeća", 2003.
Fig. 2 The state of the mosaic - Meder, J.: "Podni mozaici u Hrvatskoj od 1. do 6. stoljeća", 2003

Sl. 4 Motiv hipokampa s vidljivim nakupinama razarajućih soli.
Fig. 4 A hypocamp motif with visible accumulations of deleterious salts

the edge of the mosaic was restored immediately after its discovery. The older restoration also encompassed the erection of a mosaic border, and the filling of areas where the mosaic is missing with cement mortar. The old cement borders were finely made, however, in recent years we prefer to use lime mortar in mosaic restoration due to a greater degree of compatibility with the original materials and a greater reversibility as compared with cement. In this particular case of mosaic restoration we should avoid, by all means, the use of cement, due to potassium and sodium oxides that with water turn into hydroxides.

Sl. 3 Centralni dio mozaika, s vidljivom prljavštinom, smećem i novčićima po cijeloj njegovoj površini (2009.)
Fig. 3 The central section of the mosaic with visible dirt, garbage and coins strewn all over its surface (2009)

3. Conservation-restoration works executed in 2009

3.1 Introduction

All the works that were carried out in the field were performed by Andrea Sardoz, Monika Petrović and Luana Milotić, employees of the Archaeological Museum of Istria, in collaboration with their colleagues from the Croatian Conservation Institute, Toni Šaina, Domagoj Mudronja and Matko Kezele.

3. Konzervatorsko-restauratorski radovi izvedeni 2009. godine

3.1. Uvod

Radove na terenu izvodile su djelatnice AMI-a Andrea Sardoz, Monika Petrović i Luana Milotić u suradnji s djelatnicima HRZ-a Tonijem Šainom, Domagojem Mudronjom i Matkom Kezeleom.

Radovi su se sastojali od uzimanja uzoraka soli, žbuka, starih opšava i dijelova podloge mozaika za laboratorijske analize; čišćenja lica mozaika laganim i mekanim kistovima i metlicama; preventivne zaštite; izrade dokumentacije u mjerilu 1:1; izrade digitalne dokumentacije mozaika prije radova (povjereno Geo-servisu d.o.o); skidanja starih cementnih opšava skalpelom, dlijetom i čekićem; definiranja rubova mozaika; konsolidacije najugroženijih dijelova mozaika i podloge mozaika 5%-tnim Paraloidom B72 (ethyl metakrylate/methilakrylate, EMA/MA) otopljenim u acetonu; podljepljivanja kritičnih dijelova mozaika *Vinavilom 59 (polyvinylacetate PVAc)* i gazom; uklanjanja produžne žbuke s rubova mozaika; postavljanja novih vapnenih opšava; postavljanja zaštitnog sloja celulozne pulpe. Uzorke soli, žbuka, starih opšava i dijelova podloge mozaika za laboratorijske analize uzeo je Toni Šaina, a analizirala Mirjana Jelinčić, dipl. ing. kem. teh., pod vodstvom voditelja prirodoslovnog laboratorija Domagoja Mudronje, prof. geologije.

3.2. Opis izvedenih konzervatorsko-restauratorskih radova

Prilikom prvog obilaska terena djelatnika HRZ-a, uzeti su uzorci tesera, soli, izvornih i restauratorskih žbuka za laboratorijsku analizu materijala. Temeljem izvršenih ispitivanja žbuke zaključak je sljedeći: vezivo je vapneno u svim uzorcima, na osnovu odnosa veziva i punila možemo zaključiti da se radi o sličnim žbukama koje karakterizira oko 83,2 % vapnenog veziva i oko 16,8 % punila, granulometrijska analiza uzoraka žbuka nije rađena zbog premale količine netopljivog ostatka.

Djelatnice AMI-a izvršile su osnovno čišćenje mozaika. Osnovno čišćenje od nakupljenih nečistoća, soli i odbačenih kovanica, učinjeno je mekanim kistovima i metlicama. Nakon toga izvedena je dokumentacija u mjerilu 1:1. Zbog izrazito lošeg stanja mozaika, uz crtaću dokumentaciju 1:1, naručena je i izrada digitalne dokumentacije od geodetske tvrtke Geo-servis d.o.o. Napravljen je fotogrametrijski snimak i skeniranje 3D skenerom.

Dolaskom djelatnika HRZ-a na teren, pristupilo se uklanjanju starih restauratorskih opšava koji su zamijenjeni vapnenom žbukom. Vapnena se žbuka sastoji od jednog

The works encompassed the gathering of samples of salt, mortar, old borders and sections of the mosaic substrate for laboratory analyses; the cleansing of the mosaic surface using soft, light brushes and brooms; preventive protection measures; the compilation of documentation in 1:1 scale; the compilation of digital documentation regarding the state of the mosaic before the works (this task was given to Geo-servis Ltd.); the removal of old cement borders using a cutter, chisel and hammer; the definition of the borders of the mosaic; the consolidation of sections of both mosaic and substrate which were most at risk, using a 5% solution of Paraloid B72 (ethyl metacrylate/methylacrylate, EMA/MA) diluted in acetone; the gluing of mosaic sections that are in a critical condition, using *Vinavil 59 (polyvinylacetate PVAc)* and gauze; the removal of mortar from the borders of the mosaic; the erection of new borders using lime mortar; and finally, the placing of a protective layer of cellulose pulp. Toni Šaina gathered samples of salt, mortar, old borders as well as sections of the mosaic substrate, which were then used in subsequent laboratory analyses performed by Mirjana Jelinčić, graduate engineer of chemistry, under the supervision of the head of the Natural Science Laboratory Domagoj Mudronja, professor of geology.

3.2 A description of the executed conservation-restoration works

On the occasion of the first field inspection of the mosaic, employees of the Croatian Conservation Institute gathered samples of tesserae, salt, as well as of both the original and restoration mortar, in order to perform laboratory analyses of these materials. Based on the performed mortar analyses, the following can be concluded: the binder material in all samples is lime-based, and further, with regard to the relationship between binder and aggregate material, we can conclude that both mortars are similar as they are characterized by approximately 83.2% of lime-based binder material and approximately 16.8% of aggregate material; the granulometric analysis of the mortar samples was not performed because of the scarce amount of insoluble residue.

The crew from the Archaeological Museum of Istria completed the basic cleansing of the mosaic. The cleaning of the accumulated filth, salts and coins was done using soft paintbrushes and small brooms. Afterwards, the condition was documented in 1:1 scale. Beside the drawn documentation in 1:1 scale, the mosaic was also digitally documented because of its extraordinarily bad condition, which was executed by Geo-servis Ltd, a firm specializing in geodesic services. A photogrametric

dijela prosijanoga gašenog vapna i tri dijela kvarcnog pijeska. Skidanje opšava i "zakrpa" izvodilo se mehanički korištenjem skalpela, pinceta, dlijeta i čekića.

Na središnjem dijelu mozaika, gdje nedostaju tesere, vidljiva je podnica. Podnica je dobro izmetena i usisana, te je nakon toga konsolidirana 5-postotnom otopinom *Paraloida B72* u acetonu. Napravljene su i probe konsolidacije *Sytonom W30* koji je razrijeđen destiliranom vodom u omjeru 1:6 i 5-postotnom otopinom *Paraloida B72* u acetonu. Probe izvedene *Sytonom W30* nisu dale zadovoljavajuće rezultate jer je na tretiranim mjestima došlo do cvjetanja soli. Probe izvedene *Paraloidom B72* dale su zadovoljavajuće rezultate, podnica je djelomično učvršćena i više se ne mrvi i ne raspada.

Dio opšava se raspao, a tesere su se rasipale i odvajale od mozaičkog tepiha. Pojedini dijelovi mozaika su se podigli i odvojili od podnice uslijed nakupljanja soli u žbuci ispod tesera. Odvojene, podignute i rasipane tesere vraćene su na izvorno mjesto uz pomoć pinceta i skalpela. Tako obrađeni dijelovi mozaika podlijepljeni su ljepilom *Vinavil 59* i gazom koja je rezana u manje komade veličine cca 15 x 20 cm. Gaza je postavljana u dva sloja, a svaki je sloj dobro namočen navedenim ljepilom. Ljepilo se nanosilo tupkanjem kistovima.

Sl. 5 Čišćenje lica mozaika.
Fig. 5 The cleaning of the mosaic surface

survey was performed, as well as scanning with a 3D scanner.

With the arrival of workers from the Croatian Conservation Institute on the field, work began on the removal of old restoration borders that were replaced with lime mortar. Lime mortar consists of one part sieved hydrated lime and three parts quartz sand. The removal of borders and "patches" was done mechanically, using cutters, pincers, chisels and hammers.

In the central section of the mosaic, where there are tesserae missing, the underlying substrate is visible. This substrate was meticulously swept and then vacuum cleaned, and afterwards it was consolidated with a 5% solution of *Paraloid B72* in acetone. Trial consolidations were likewise executed, using *Syton W30* diluted with distilled water in a 1:6 ratio and a 5% solution of *Paraloid B72* in acetone. The trials with *Syton W30* did not give any satisfactory results because a salt-flowering process was triggered on the treated areas. On the other hand, trials using *Paraloid B72* did give us satisfactory results, the underlying substrate was partially strengthened and it is no longer crumbling and disintegrating.

A section of the border disintegrated, tesserae were strewn around and were severing themselves from the mosaic substrate. Separate sections of the mosaic also lifted and severed themselves from the substrate due to the accumulation of salt in the mortar underneath the tesserae. These severed and strewn tesserae were then returned to their original place with the help of pincers and cutters. Thus treated sections of the mosaic were then glued from underneath using *Vinavil 59* glue and gauze that was cut into smaller patches measuring approximately 15 x 20 cm. The gauze was installed in two layers and each layer was well soaked with the above mentioned glue. The glue was applied with the help of paintbrushes. In 2009 there were no plans to lift the mosaic even though the experts from the Croatian Conservation Institute initially suggested this and, hence, the mosaic was covered with a layer of cellulose pulp after it was subjected to the most urgent preventive interventions. The function of the pulp is to lessen the deleterious effects of salts. The cellulose pulp was mixed with distilled water and afterwards it was applied by hand onto the mosaic. Japanese paper was placed onto the substrate of the mosaic before the pulp was spread in order to facilitate the changing of the pulp. The performed analyses of water cellulose pulp have heretofore given satisfactory results.

Sl. 6a i b Stanje hipokampa prije i nakon laganog čišćenja.
Fig. 6a and b The condition of the hypocamp before and after a gentle cleaning

Za 2009. godinu nije predviđeno dizanje mozaika, koje je prvobitno preporučeno od strane djelatnika HRZ-a, pa se nakon izvršenih najnužnijih preventivnih zahvata cijeli mozaik prekrio slojem celulozne pulpe. Pulpa bi trebala ublažiti štetno djelovanje soli. Celulozna pulpa miješana je s destiliranom vodom i nakon toga rukom nanošena na mozaik. Prije polaganja pulpe, na podnicu mozaika stavljen je japanski papir radi jednostavnijeg mijenjanja pulpe. Analize vodene celulozne pulpe do sada su dale zadovoljavajuće rezultate.

4. Zaključak s osvrtom na dostupnu dokumentaciju i izvedene laboratorijske analize

Tijekom konzervatorsko-restauratorskih radova na mozaiku moglo se bolje sagledati njegovo stanje. Veći se dio *tessellatuma* više ne drži za završni sloj (prihvatnicu), koja je ovdje najvjerojatnije u potpunosti nestala. Tesere se međusobno drže zahvaljujući žbukanim opšavima i djelomično međusobnim sljubnicama. Utjecaj vlage i soli najviše je vidljiv u širokom pojasu duž sjevernoga i zapadnog dijela mozaika. Donji dio središnjega mozaičkog, figuralno-geometrijskog tepiha je prilikom otkrivanja 1963. već bio uništen, najvjerojatnije urušavanjem građevinskog materijala na mozaik.
Pažljivijim promatranjem mozaika uočavaju se dijelovi koji su valovito podignuti zbog djelovanja soli, koje se u velikim količinama kristaliziraju između mozaičkih tesera i žbuke nucleusa.

Nakon uklanjanja prašine, kristaliziranih soli i izmrvljene žbuke iz velike središnje lakune, uočeno je kako je podnica mozaika znatno propala. Promatrajući stare opšave, zaključuje se da se sloj nucleusa izmrvio i degradirao za gotovo 1 cm. Uspoređujući dostupnu

Sl. 7 Podljepljivanje kritičnog dijela
Fig. 7 The application of glue on the nether section of the critical area

4. Conclusion, including a review of the available documentation and the performed laboratory analyses

A better insight into the state of the mosaic was gained in the course of the conservation-restoration works that were executed. For the most part the *tessellatum* does no longer adhere to the bedding layer that has in all probability completely disappeared. The tesserae are held together thanks to the mortar borders and, partially, due to mutual amalgamation. The effects of humidity and salt are visible at its best in a broad band alongside the northern and western sections of the mosaic. The lower section of the central figural-geometrical mosaic carpet was destroyed already at the time of its discovery in 1963, probably as a result of the rubble that fell onto the mosaic when the structure caved in. Upon closer examination, we can detect certain wavy sections of the mosaic that

Sl. 8a i b. Izrada novih, vapnenih opšava i postavljanje zaštitnog sloja celulozne pulpe.
Fig. 8a and b The execution of new lime borders and the installation of the protective layer of cellulose pulp

foto-dokumentaciju nakon otkrivanja mozaika 1963., prije postavljanja čelične rešetke iznad mozaika 2003. i tijekom konzervatorsko-restauratorskih radova 2009. godine, može se uočiti da mozaik polako, ali sigurno degradira na cijeloj zapadnoj strani i središnjem dijelu figuralno-geometrijskog motiva. Od otkrivanja do danas degradiralo je otprilike 15% mozaika. Najveća oštećenja nastala su nakon 2003. godine kada je preuređena kapela Sv. Ivana. Tada je postavljena čelična rešetka iznad mozaika, ugrađeni su prozori i vrata, a naknadno je postavljeno i centralno grijanje.

Zatvaranjem i grijanjem prostorije u potpunosti su se promijenili kriptoklimatski uvjeti u kojima se mozaik prije nalazio. Zrak se isušio i tako povukao lako topljive soli iz okoline na površinu mozaika. Dio soli kristalizirao je prije površine, odnosno između sloja tessellatuma i nucleusa, pa su soli uzrokovale mrvljenje žbuke. Koncentracija soli je na nekim mjestima bila toliko velika da su se dijelovi mozaika odvojili od podloge ili izmrvili. Nekoliko manjih dijelova opšivenog mozaika se raspadalo te su se zbog prečvrstih opšava izdigli i izdvojili od podloge.

Sl. 9 3D snimak spojen s orto-foto snimkom mozaika 2009. (Geo-servis d.o.o.)
Fig. 9 A 3D photograph combined with an orto-photo snapshot of the mosaic in 2009. (Geo-servis Ltd.)

have been lifted due to the effects of salts that crystallize in huge amounts between the mosaic tesserae and the mortar of the nucleus.

After we removed the dust, the crystallized salts and the crumbling mortar from the central section, we were able to see that the substrate of the mosaic had sunk considerably. By observing the old borders we concluded that the nucleus layer crumbled and hence degraded by almost a whole centimeter. We furthermore compared the available photo-documentation that was made after the discovery of the mosaic in 1963, before the installation of the iron grid over the mosaic in 2003, and in the course of conservation-restoration activities in 2009, and we concluded that the mosaic is slowly but surely degrading on its entire western side and in the central section of the figural-geometrical motif. Since its discovery and up to the present, approximately 15% of the mosaic degraded. The biggest damages were

Sl. 10 Tijekom restauratorsko-konzervatorskih radova 2009.
Fig. 10 During restoration-conservation works in 2009.

Sl. 11 Stanje mozaika s celuloidnom pulpom nakon restauratorsko-konzervatorskih radova 2009.
Fig. 11 The state of the mosaic with the installed cellulose pulp layer after the restoration-conservation works performed in 2009.

Laboratorijskim kemijskim analizama soli dokazana je štetna koncentracija klorida i nitrata u svim uzorcima žbuke. Najveća količina soli nalazi se u gornjem sloju žbuke (nucleusu). Metodom rendgenske difrakcije i FTIR spektroskopijom dokazano je da su iskristalizirane soli na površini mozaika natrijevi sulfati (mirabilit $Na_2SO_4 \cdot 10H_2O$ i tenardit Na_2SO_4). Za otapanje natrijevih sulfata potrebna je vrlo visoka relativna vlaga zraka (tenardit 82%, mirabilit 93,6%) pri 20 °C, dok sve vrijednosti ispod spomenutog postotka vlage zraka rezultiraju kristalizacijom onih prvih. Drugim riječima, ako želimo natrijev sulfat zadržati otopljen u žbuci, relativna vlaga zraka bi trebala biti veća od 93,6% pri temperaturi od 20 °C, u protivnom dolazi do kristalizacije soli koja polako, ali sigurno uništava žbukanu podnicu, pa tako i sam mozaik, što svakako nije poželjna situacija kako za mozaik tako i za okolne žbuke. Kako je najvažnije spriječiti daljnje propadanje mozaika, trebalo bi svakako najprije onemogućiti nove prodore vlage (vode) prema podlozi mozaika. Dakle, potrebno je ukloniti izvore vlaženja mozaika, te se postupci sanacije vlage moraju izvoditi uporno i savjesno od strane svakoga restauratora i/ili konzervatora-restauratora.

inflicted after 2003, when the chapel of St. John was refurbished. It was then that an iron grid was placed over the mosaic, windows and doors were fitted, and subsequently, central heating was likewise installed.

By closing and heating the premises, the cryptoclimatic conditions in which the mosaic was previously housed were completely altered. The air dried and thus it drew out the easily soluble salts from the surroundings onto the surface of the mosaic. Part of the salts crystallized before they reached the surface, i.e. between the layer of tessellatum and the nucleus, which resulted in the crumbling of the mortar. Salt concentration on certain spots was so great that it caused certain sections of the mosaic to either sever themselves from the base or crumble. Several smaller sections of the bordered mosaic were falling apart, lifting themselves from the substrate due to inflexible borders.

With the help of laboratory chemical analyses of salt, we were able to prove a deleterious concentration of chlorides and nitrates in all mortar samples. The greatest amount of salt is to be found in the upper layer of the mortar (nucleus). Using the method of x-ray diffraction and FTIR spectroscopy, we likewise proved that the crystallized salts located on the surface of the mosaic are sodium sulfates (mirabilite $Na_2SO_4 \cdot 10H_2O$ and thenardite Na_2SO_4). To dissolve sodium sulfates a very high relative air humidity is needed (thenardite 82%, mirabilite 93.6%) at a temperature of 20°C, whereas all values underneath the mentioned percentage of air humidity result in their crystallization. In other words, if we desire to keep the sodium sulfates dissolved in the mortar, the relative air humidity should be greater than 93.6% at a temperature of 20°C, on the contrary a process of salt crystallization sets in, which in turn slowly but surely destroys the mortar substrate and the mosaic itself, which is, of course, a very unfavorable condition for both the mosaic and the surrounding mortar. As our primary goal is to prevent the further dilapidation of the mosaic, the prime task is to stop humidity (water) from penetrating the substrate of the mosaic. It is, therefore, necessary to remove all sources of humidity which affect the mosaic. Every restorer and/or conservator-restorer is, hence, obliged to deal with this matter in a scrupulous way over a prolonged period of time.

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SAŽETAK

RESTAURATORSKO-KONZERVATORSKI RADOVI NA KASNOANTIČKOM MOZAIKU U KAPELI SV. IVANA U SAMOSTANU SV. FRANJE U PULI

Andrea SARDOZ, *Toni* ŠAINA

Nakon što se prilikom terenskog obilaska i pregleda, u svibnju 2009., utvrdilo da je podni mozaik u Franjevačkom samostanu u Puli u kritičnom stanju, restauratori iz Arheološkog muzeja Istre i Hrvatskog restauratorskog zavoda krenuli su u njegovu restauraciju, odnosno konzervaciju. Veliki dio oštećenja mozaika nastao je zbog vlage, koja se u širokom pojasu proteže uz sjeverni i zapadni rub bazena gdje se i zadržava. Preliminarne analize pokazale su prisutnost soli. Nakon uklanjanja prašine, kristaliziranih soli i izmrvljene žbuke iz velike središnje lakune, uočeno je kako je podnica mozaika znatno propala. Promatrajući stare opšave, zaključeno je da se sloj nucleusa izmrvio i degradirao za gotovo 1 cm. Nakon izrađene crtaće dokumentacije u mjerilu 1:1, uklonjena je površinska prašina, kristalizirane soli s površine mozaika i izmrvljena žbuka. Napravljen je fotogrametrijski snimak i skeniranje 3D skenerom. Pristupilo se zatim uklanjanju starih restauratorskih opšava koji su zamijenjeni vapnenom žbukom. Podnica mozaika dobro je izmetena i usisana, te je nakon toga konsolidirana 5-postotnom otopinom *Paraloida B72* u acetonu. Odvojene, podignute i rasipane tesere vraćene su na izvorno mjesto uz pomoć pinceta i skalpela. Tako obrađeni dijelovi mozaika podlijepljeni su ljepilom *Vinavil 59* i gazom. U 2009. godini nije predviđeno dizanje mozaika, pa se nakon izvršenih najnužnijih preventivnih zahvata cijeli mozaik prekrio slojem celulozne pulpe. Pulpa bi trebala ublažiti štetno djelovanje soli, i to tako da se vodena celulozna pulpa kontinuirano izmjenjuje kroz dulji period, sve dok analize iste ne bi dale zadovoljavajuće rezultate, odnosno pokazale izostanak topljivih soli na mozaiku. Na taj bi način bilo moguće trajno ukloniti štetne soli. Važno je napomenuti da je kota razine mozaika niža od kote vanjskog tla, što predstavlja dodatan problem uklanjanja vlage. Da bi se spriječilo daljnje propadanje mozaika, trebalo bi najprije onemogućiti nove prodore vlage (vode) prema podlozi mozaika. Dakle, potrebno je ukloniti izvore vlaženja mozaika, te se postupci sanacije vlage moraju izvoditi uporno i savjesno od strane svakoga restauratora i/ili konzervatora-restauratora.

SUMMARY

RESTORATION-CONSERVATION WORKS ON A LATE ROMAN MOSAIC IN THE CHAPEL OF ST. JOHN IN THE MONASTERY OF ST. FRANCIS AT PULA

Andrea SARDOZ, *Toni* ŠAINA

In May of 2009 a field inspection and examination of the mosaic in the monastery of St. Francis at Pula was organized, which led to the conclusion that it was in a critical state, whereupon restorers from the Archaeological Museum of Istria and the Croatian Conservation Institute started with their restoration/conservation activities. A large portion of the damages ensued as a consequence of humidity that extended itself in a broad belt alongside the northern and western edges of the basin where it was also held up. Preliminary analyses showed a presence of salt. After the removal of dust, crystallized salts and crumbled mortar from the large central section, it became apparent that the nucleus degraded quite a bit. By observing the old borders we concluded that the nucleus layer crumbled and hence degraded by almost a whole centimeter. After the drawn documentation in 1:1 scale was finished, the dust and crystallized salts from the surface as well as the crumbled mortar were removed. A photogrametric survey was performed as well as scanning with a 3D scanner. Afterwards, work began on the removal of old restoration borders that were replaced with lime mortar. The nucleus of the mosaic was well swept and vacuum cleaned, and was thereupon consolidated with a 5% solution of *Paraloid B72* in acetone. The severed, lifted and strewn tesserae were then returned to their original position with the help of pincers and cutters. Thus treated sections of the mosaic were then glued from underneath using *Vinavil 59* glue and gauze. In 2009 there were no plans to lift the mosaic, and so after the most urgent preventive interventions were performed, it was covered with a layer of cellulose pulp. The pulp should lessen the deleterious effects of salt, and this could be achieved by continuously changing the watery cellulose pulp over a longer period of time, until the analyses of the pulp showed a satisfactory result, i.e. that there are no soluble salts on the mosaic. In this manner it would be possible to get rid of the deleterious salts on a permanent basis. It is important to mention, however, that the elevation of the surface of the mosaic is inferior to the elevation of the external surrounding ground, which represents an additional problem when combating humidity. In order to prevent a further destruction of the mosaic, the prime task should be to stop humidity (water) from penetrating the substrate of the mosaic. It is, therefore, necessary to remove all sources of humidity, which affect the mosaic. Every restorer and/or conservator-restorer is, hence, obliged to deal with this matter in a scrupulous way over a prolonged period of time.