

THE PHYSICAL RECONSTRUCTION
AND PHOTOGRAMMETRIC
DOCUMENTATION OF A 6TH CE
BAPTISMAL FONT (KANTHAROS)
FROM STOBI

FIZIČKA REKONSTRUKCIJA I
FOTOGRAMETRIJSKA
DOKUMENTACIJA POSUDE ZA
KRŠTENJE (KANTAROS) 6. VIJEKA IZ
STOBIJA

Miglena Raykovska
New Bulgarian University, Sofia
miglena.raykovska@gmail.com

UDK 904:726.596]:528.74(497.7)

Mishko Tutkovski
National Institution Stobi, R. Macedonia
mishko.tutkovski@stobi.mk

Mariana Filova
National Institution Stobi, R. Macedonia
mariana.filova@stobi.mk

Dr. George Bevan
Queen's University, Canada
george.bevan@gmail.com

Abstract:

“Digital Photogrammetry has a distinct advantage over other 3D recording techniques in archaeology because of its scale independence; the same software can be used at both the object and the site-levels. We show that modern photogrammetric techniques were successfully employed to record a large, reconstructed marble Kantharos, an important part of the Baptistery adjacent to the Episcopal Basilica at Stobi. From this 3D model we can extract cross-sections that would otherwise not be attainable with an object so large using traditional techniques for ceramic profiling. Finally, we point to the utility of Digital Photogrammetry in providing assets for a virtual anastylosis of the Baptistery ahead of the planned physically anastylosis”.

Keywords: photogrammetry, baptistery, kantharos, Stobi

Apstrakt:

Digitalna fotogrametrija ima veliku prednost u odnosu na druge tehnike 3D snimanja u arheologiji zbog razmera njene nezavisnosti; isti softver može da se koristi i za objekte i za nivoe nalazišta. Pokazali smo da su se moderne fotogrametrijske tehnike uspješno koristile za snimanje velikog, rekonstruisanog, mermernog kantarosa, važnog dijela krstionice pored Episkopske bazilike u Stobiju. Iz ovog 3D modela možemo izvući presijeke što u suprotnom ne bi mogli dostići kod ovako velikog objekta koristeći tradicionalne tehnike za keramičko profilisanje. Konačno, ukazujemo na korisnost digitalne fotogrametrije u omogućavanju sredstava za virtuelnu anastilozu krstionice na čelu sa planiranom fizičkom anastilozom.

Ključne riječi: fotogrametrija, krstionica, kantaros, Stobi

Introduction

The reconstruction of a large marble baptismal font excavated in the sixth-century ecclesiastical complex of Stobi, Republic of Macedonia, presented considerable technical challenges not only from a conservation perspective, but from the perspective of documentation. The surviving remains were very fragmentary, and the size of the vessel meant that, when reconstructed, traditional techniques of ceramic profiling could not be employed. In the 2015 field season students, as part of a four-week course on Advanced Photographic Documentation of Archaeological Materials run by Balkan Heritage Field School and Queen's University, it was demonstrated that photogrammetric methods could be effectively employed in a short period of time and with limited training to produce not only a digital surrogate of the kantharos, now available on the web, but also to produce conventional outputs such as profiles and sections. This modest contribution to the abundant literature on applications of photogrammetry to archaeology once again demonstrates that precisely the scale-independence of the technique -- the same software and equipment can be deployed on both the artefact- and site-scales -- makes it ideal for conservators and archaeologists alike.

The Baptistry

The first excavations on the Baptistry, south of the Episcopal Basilica at Stobi, were made by James Wiseman and Djordje Mano-Zissi in 1971 (Wiseman, Mano-Zissi, 1971; 1972). The building has several construction and painting phases and two mosaic phases (Dinsmoor 1975, Kolarik, Petrovski 1975, Kolarik 1981, Wiseman 1978; 1984, Aleksova 1997, Downing 1998, Dimitrova, Blaževska, Tutkovski 2012). The first phase (Fig. 1) was

Uvod

Rekonstrukcija velike mermerne krstionice otkrivene u šestovjekovnom crkvenom kompleksu Stobi, Republika Makedonija, predstavlja značajne tehničke izazove ne samo iz perspektive konzervacije, već i iz perspektive dokumentovanja. Očuvani ostaci su bili veoma fragmentovani, i veličina posude označava da, prilikom rekonstrukcije, tradicionalna tehnika profilisanja keramike nije mogla biti primijenjena. U kampanji 2015. god. studenti su, kao dio četvoronedjeljnog kursa Unapređivanje Foto Dokumentacije Arheološkog Materijala vođenog od strane *Balkan Heritage Field School* i *Queen's University*, pokazali da se fotogrametrijske metode mogu efikasno koristiti u kratkom vremenskom periodu i sa ograničenim iskustvom kako bi proizvele ne samo digitalnu zamjenu krstionice, sada dostupnu na internetu, nego takođe i da omoguće konvencionalne rezultate kao što su profili i presjeci. Ovaj skromni doprinos obimnoj literaturi o primjeni fotogrametrije uopšte, još jednom potvrđuje da upravo sa ovom tehnikom može da se izvrši više zadataka za kratak vremenski period i na veoma bezbjedan i precizan način. Isti softver i oprema mogu da se koriste prilikom dokumentovanja artefakata i arheoloških situacija na lokalitetima, čineći ih idealnim, jednako, za konzervatore i arheologe.

Krstionica

Prva istraživanja krstionice, južno od Episkopske bazilike u Stobiju, sprovedena su od strane James Wiseman i Djordje Mano-Zissi tokom 1971. god. (Wiseman, Mano-Zissi, 1971; 1972). Objekat ima nekoliko faza izgradnje i oslikavanja, kao i dvije faze mozaika (Dinsmoor 1975, Kolarik, Petrovski 1975, Kolarik 1981, Wiseman 1978; 1984, Aleksova 1997, Downing 1998, Dimitrova, Blaževska, Tutkovski

constructed at the same time as the old Episcopal Basilica, but this phase is no longer visible. At this time it was separate from the church proper and the baptismal chamber was reached through a series of rooms, and was likely roofed by a brick-dome, a hypothesis supported by the circular plan of the building (Dinsmoor 1975, Wiseman, Mano-Zissi 1975). The structure visible today was constructed at some time at the end of the 4th or beginning of the 5th century, perhaps concurrent with the last documented building activity at the old Episcopal Basilica (Dimitrova, Blaževska, Tutkovski, 2012). It was perhaps during this period that the piscina was built along with stairs for entry.

2012). Prva faza (Sl. 1) je izrađena u isto vrijeme kad i stara Episkopska bazilika, ali ta faza nije više vidljiva. Sada je odvojena od crkve i do odaja krstionice se može doći kroz niz prostorija, i vjerovatno je bila nadkrivena kupolom od opeke, što je pretpostavka kojoj ide u prilog kružni plan zgrade (Dinsmoor 1975, Wiseman, Mano-Zissi 1975). Konstrukcija koja je vidljiva i danas sagrađena je negdje pri kraju 4-og ili početkom 5-og vijeka, moguće da je konstruisana istovremeno sa poslednje dokumentovanim građevinskim aktivnostima na staroj Episkopskoj bazilici (Dimitrova, Blaževska, Tutkovski, 2012). Možda je to bilo u periodu kada je građena piscina zajedno sa stepeništem za ulaz.

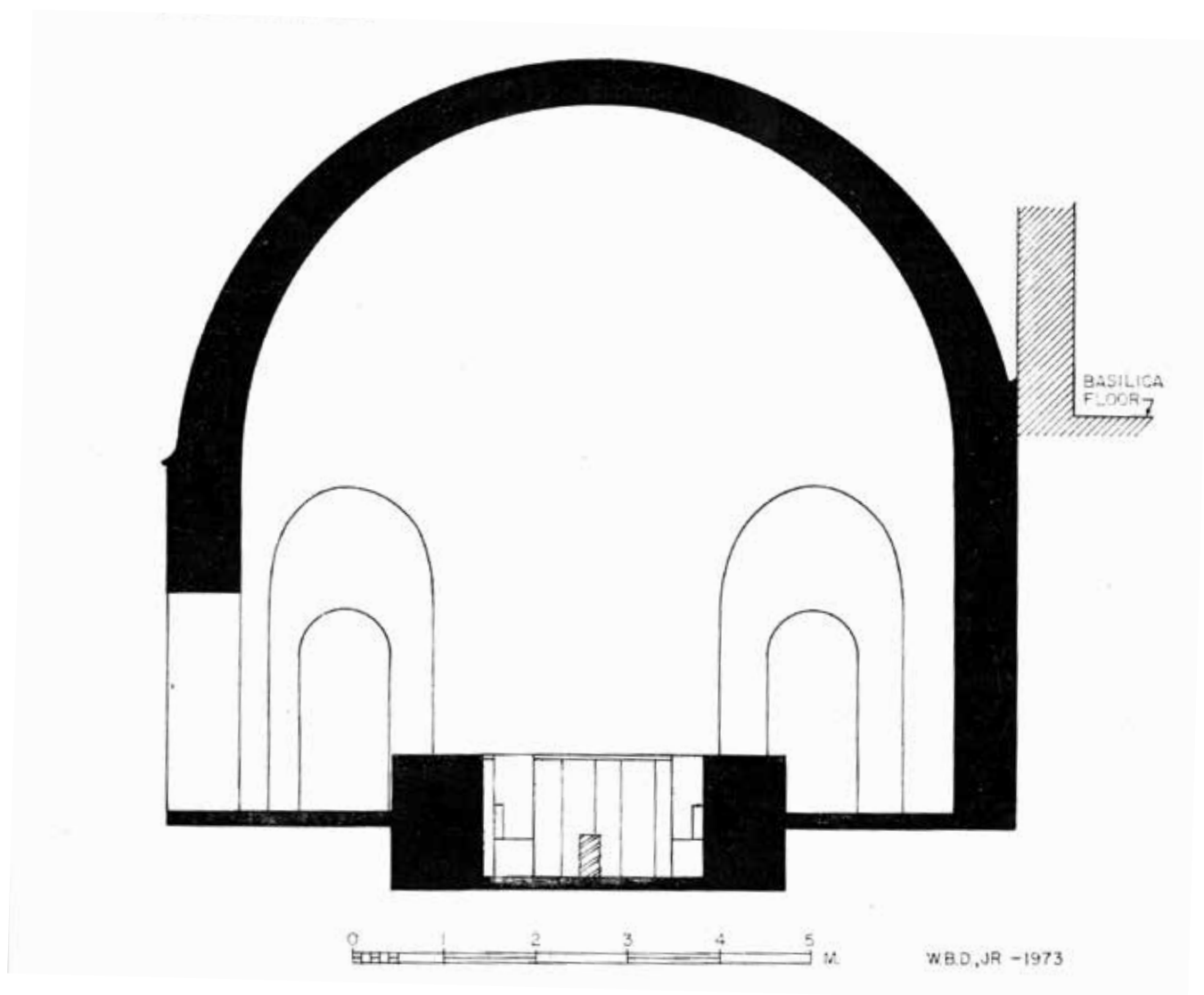


Fig. 1. First construction phase of the Baptistery (Dinsmoor 1975, 19).
Sl. 1. Prva faza gradnje krstionice (Dinsmoor 1975, 19).

Towards the end of the 5th or early 6th century the Basilica was partly renovated. The Baptistry was then included in the structure of the new Basilica. At that time the mosaics, which consist of a representation of the 41st Psalm of David and two representations of peacocks and deers around a kantharos, were installed (Fig.2). (Kolarik 1981, Dimitrova, Blaževska, Tutkovski, 2012).

The third construction phase of the Baptistry relates to the second phase of the new Basilica. During this phase the circular piscina is remodeled with the addition of two semicircular niches on the eastern and western sides (Fig.2); the southeast steps of the piscina are closed and re-

Krajem 5-og ili početkom 6-og vijeka bazilika je djelimično obnovljena. Krstionica je tada bila uključena u strukturu nove bazilike. U to vrijeme mozaici, koji sadrže prikaze 41-og Psalma Davida i dvije predstave pauna i jelena oko kantarosa, su bili postavljeni (Fig.2). (Kolarik 1981, Dimitrova, Blaževska, Tutkovski, 2012).

Treća faza izgradnje krstionice odnosi se na drugu fazu nove bazilike. Tokom ove faze kružna piscina je preuređena sa dodatkom od dve polukružne niše sa istočne i zapadne strane (Sl. 2); sjeveroistočno stepenište piscine je zatvoreno i zamijenjeno masivnim kantarosom (SL. 2, 3), koji služi za krštenje, vjerovatno, odojčadi i podsjeća na raniji dekorativni sadržaj

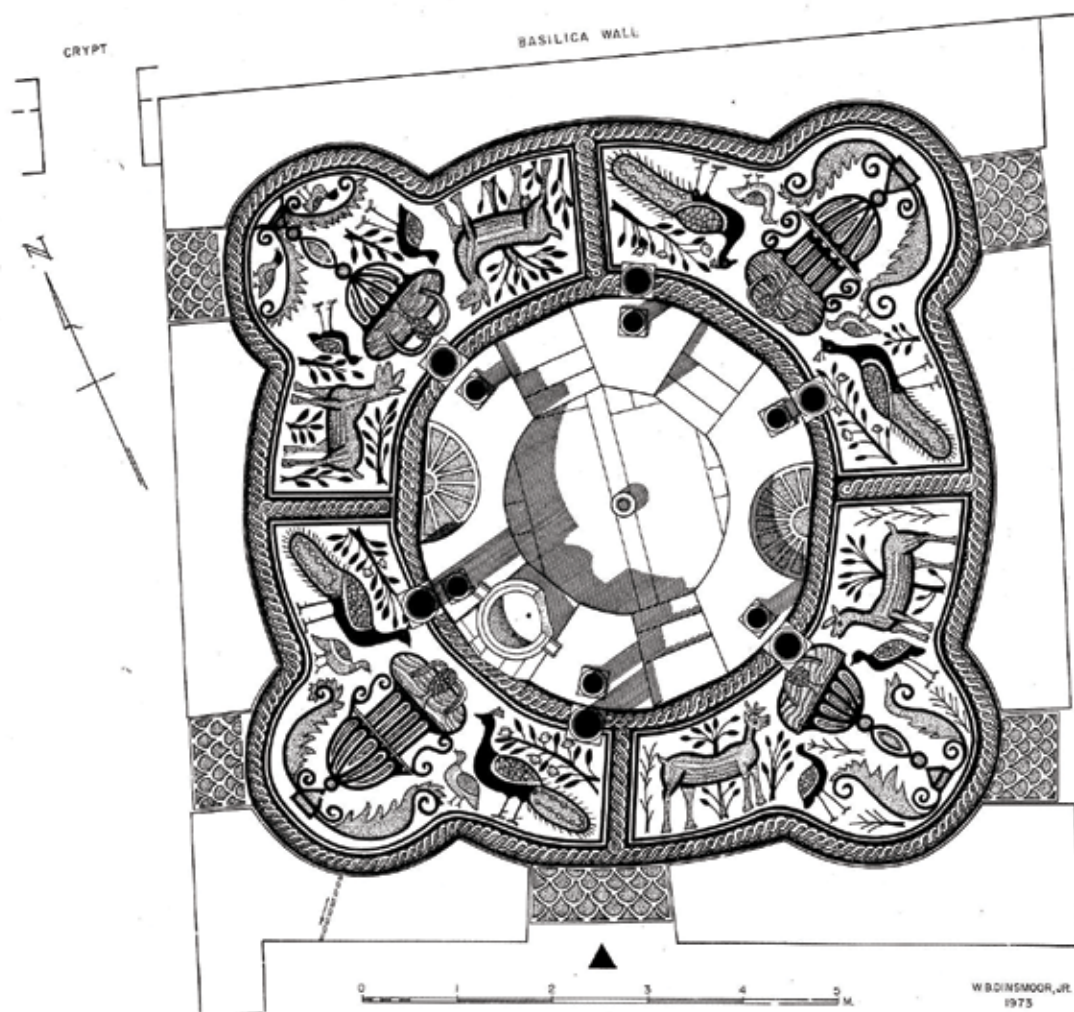


Fig. 2. Restored plan of the Baptistry in its final phase (Dinsmoor 1975).

Sl. 2. Restauriran plan krstionice u svojoj finalnoj fazi (Dinsmoor 1975).

placed by a massive kantharos (Fig.2, 3), which served for the baptism, presumably, of infants and echoes the earlier decorative program of the mosaics.¹ In addition a baldachin was erected and supported by six pairs of marble columns (Fig.2, 3).

mozaika.¹ Povrh toga podignut je baldahin koji je pričvršćen sa šest para mermernih stubova (Sl. 2,3).

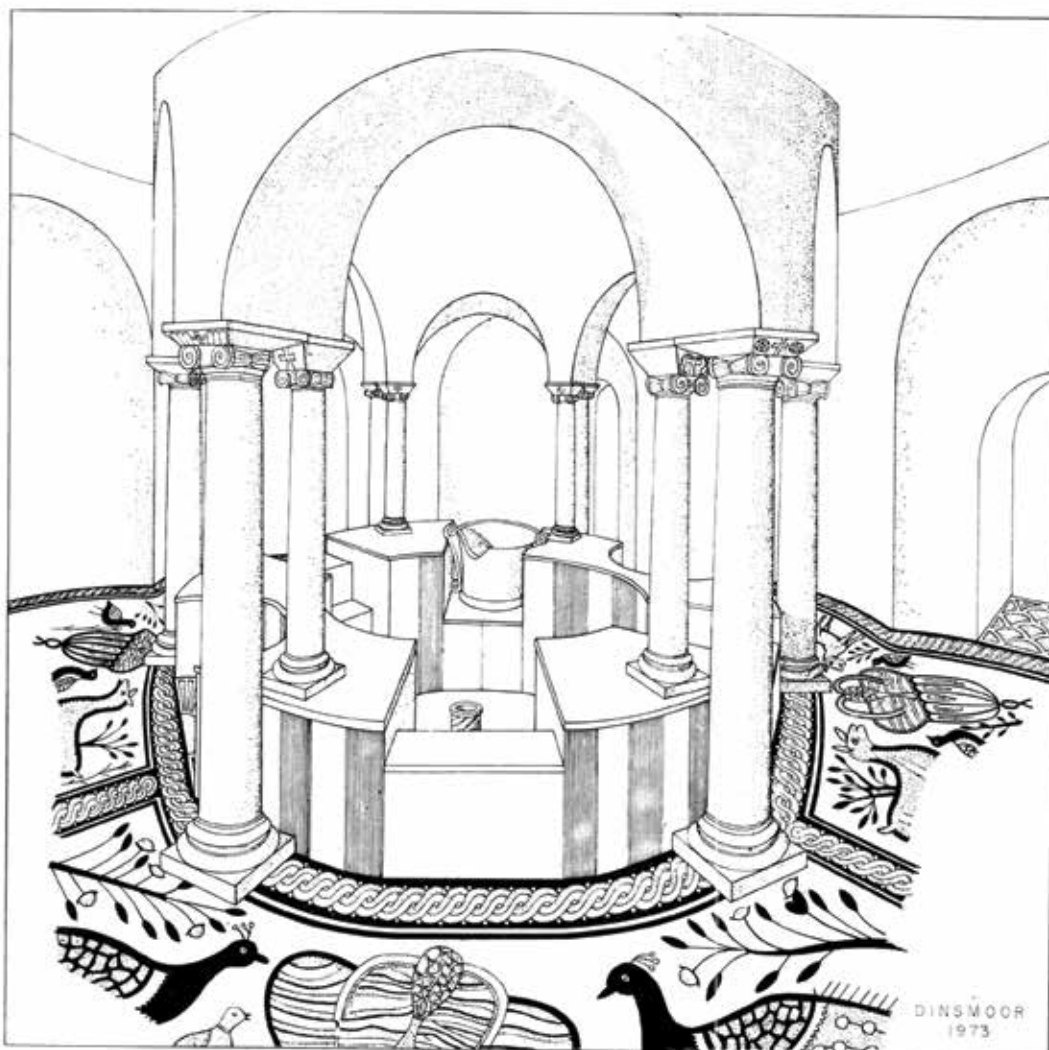


Fig. 3. Restored perspective of the Baptistery in it's final phase (Dinsmoor, 1975).
Sl. 3. Restauriran izgled krstionice u svojoj finalnoj fazi (Dinsmoor 1975).

¹ The excavators add that the installation of the kantharos in the piscina required significant remodelling: "The opening into which the Kantharos was set was one of the original 4 stairways, leading into the pool. The steps were removed, the base and the lower part of the vessel were set below the mosaic floor level at a point where the upper volutes of the marble handles would just clear the parapet coping, and a marble floor, at the level of the mosaic floor, was then installed around the vessel (Dinsmoor 1975, 21).

¹ Istraživači su dodali da je postavljanje kantarosa u piscinu zahtevalo značajne prepravke: Otvor u koji je kantaros smešten je predstavljao jedno od 4 originalnih stepeništa koja su vodila u bazen. Stepenci su uklonjeni, baza i donji dio posude su postavljeni ispod nivoa mozaičnog poda na mjestu gde se gornje volute mermernih drški jasno suočavaju sa parapetom, i mermerni pod, na nivou mozaičnog poda, je tada napravljen oko posude (Dinsmoor 1975, 21).



Fig. 4. The kantharos in situ in the Baptistry excavations in 1970 (NI Stobi archive).
 Sl. 4. In situ kantaros tokom istraživanja krstionice 1970 (NI Stobi arhiva).

The kantharos, a relatively late addition to the structure that surely signalled a change in the baptism ritual, was carved out of a single block of marble and stands 1.2m high, is 0.84 m in diameter across the upper rim, and 1.09m wide across the handles. The excavators conjectured that the vessel dated from the 2nd century CE (Dinsmoor 1975), but there is no information about the original use of the kantharos prior to its installation in the baptistry

Kantaros, relativno kasniji dodatak u izgradnji koji svakako označava promenu u ritualu krštenja, je izveden iz jednog komada mermera i iznosi 1,2 m visine, 0,84 m u prečniku preko gornje ivice, i 1,09 m širine preko drške. Istraživači pretpostavljaju da posuda potiče iz drugog vijeka (Dinsmoor 1975), ali ne postoje informacije o originalnoj upotrebi kantarosa prije njegovog postavljanja u piscinu krstionice. Činjenica da je profil evidentno bio



Fig. 5. The base of the kantharos in situ in the Baptistery excavations in 1972 (NI Stobi archive).

Sl. 5. Baza kantarosa in situ tokom istraživanja krstionice 1972 (NI stobi arhiva).

pool. The fact that a section has evidently been roughly chiselled out of the rim later to permit the priest to more easily access vessel, points to the likelihood that the vessel was not purpose-built for the Baptistery (Fig. 6). Similarly a hole has been drilled into the bottom of the vessel to permit the drainage of water, a feature visible on the 3D images below in cross-section (Fig. 11, 12), although it should be noted that the full geometry of the drain could not be completely modelled due constraints on camera-placement inside the vessel.

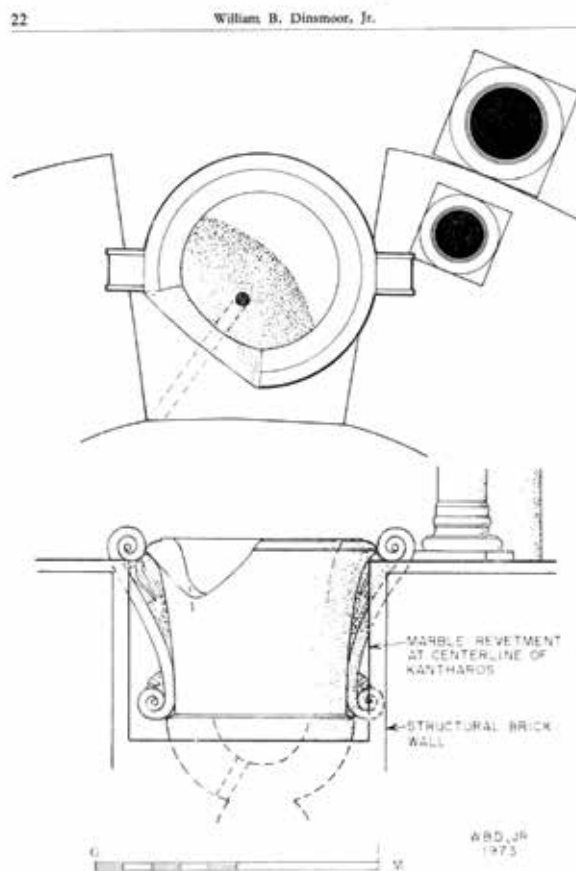


Fig. 6. Plan and elevation of the kantharos in its final setting place (Dinsmoor 1975, 22).

Sl. 6. Plan i elevacija kantarosa u njegovom konačnom odredištu (Dinsmoor 1975, 22).

grubo isklesan iz oboda kasnije, kako bi sveštenici imali lakši pristup posudi, ukazuje na verovatnoću da posuda nije namjenski sagrađena za krstionicu (Sl. 6). Na sličan način rupa je izbušena u dno posude kako bi omogućila drenažu vode, funkciju vidljivu na 3D slikama ispod, u poprečnom prijeseku (Sl. 11, 12), mada treba napomenuti da cjelokupna geometrija odvoda ne može biti u potpunosti modelovana uslijed ograničenja položaja kamere unutar posude.

Restoration

After its discovery in 1971, the kantharos was removed from its original context and was placed in an adjacent room of the baptistery, where it was partially conserved in situ (only separate fragments were conserved, since the base was not yet discovered) for the first time in 1972 by Dragan Vergovski-Alpi. The kantharos remained there for several years until an unsuccessful attempt was made to transfer the kantharos. The failed transfer sadly caused the vessel to be broken again, but into many more pieces than even at the point of its first excavation.



Fig. 7. Kantharos prior the conservation in 2012.

Fig. 7. Kantaros prije konzervacije 2012.

These fragments were left in the same room until 2012 (Fig. 7), when National Institution of Stobi began a project for the final conservation and restoration

Restauracija

Nakon njegovog otkrića 1971. godine, kantaros je pomeren iz svog originalnog konteksta i premješten u prostoriju pored krstionice, gde je parcijalno konzerviran in situ (samo su odvojeni dijelovi konzervirani, pošto baza tada još uvijek nije bila otkrivena) po prvi put 1972. god. od strane Dragana Vergovskog-Alpija. Kantaros je ostao tamo nekoliko godina dok nije uslijedio neuspjeli pokušaj njegovog premještanja. Neuspjeli premještaj je, nažalost, prouzrokovao ponovno lomljenje posude, ali u mnogo više komada nego kada je prvi put otkrivena.

Ovi fragmenti su stajali u istoj prostoriji sve do 2012. god. (Sl. 7), kada je Nacionalna Institucija Stobi započela projekat finalne konzervacije i restauracije kantarosa, koji su sproveli Mariana Filova i Dragan Vargovski-Alpi. U tom periodu, svi fragmenti kantarosa, ukupno 83, su premešteni u laboratoriju za konzervaciju, gde su detaljno dokumentovani i očišćeni. Fragmenti su varirali u veličini od 1 cm do 40 cm. Postojala su dva veća komada, koja su zauzimala dvije trećine tijela kantarosa, kao i baze, a ostali su neoštećeni. Proces lijepljenja i ponovnog sastavljanja svih djelova kantarosa trajao je oko dva mjeseca. Nakon toga sve praznine i djelovi koji fale pažljivo su popunjeni sa mješavinom lijepka i mermernog brašna čija je svrha da imitira originalni izgled i teksturu površine kantarosa (Sl. 8). Ovo je bio prvi put da je kantaros u potpunosti konzerviran i obnovljen (Sl. 9), nakon čega je postavljen kao eksponat u Nacionalnoj Banci Republike Makedonije u Skoplju, kao dio izložbe pod nazivom „Ranohrišćansko zidno slikarstvo iz Episkopske bazilike u Stobima” 2012.godine (Dimitrova, Blaževska, Tutkovski 2012).



Fig. 8. Conservation in progress.
Sl. 8. Konzervacija u toku.

of the kantharos, conducted by Mariana Filova and Dragan Vergovski-Alpi. In that period, all the fragments of the kantharos -- 83 in total -- were transferred to the conservation lab, where they were carefully documented and cleaned. The fragments varied in sizes from 1cm to 40cm. There are two large pieces, which cover two-thirds of the kantharos body, as well as the base, which remained intact. The process of gluing and re-assembling all the pieces from the kantharos took around two months. After that all the gaps and missing parts were carefully filled with a mixture of glue and marble dust in order to imitate the original look and texture of the kantharos surface (Fig. 8). This was the first time that the kantharos was fully conserved and restored (Fig. 9), after which point it was put on display in the National Bank of the Republic of Macedonia in Skopje, as part



Fig. 10. The capture process.
Sl. 10. Proces fotografisanja.

of the exhibition entitled “Early Christian wall paintings from the Episcopal basilica in Stobi” in 2012 (Dimitrova, Blaževska, Tutkovski 2012).

Method

Relatively simple, inexpensive and field-portable equipment was employed for the capture of the images. A Nikon D7000 (16 mega-pixels) with a 24mm f/2.8D Nikkor lens (effective focal length of 36mm on the APS/C cropped sensor of the D7000) was fitted on a telescoping light-stand so as to enable all angles of the vessel to be captured in stereo-pairs. Because the viewfinder was frequently at an inconvenient height for the photographer (either too high or too low), a battery-powered WIFI router provisioned with custom-firmware by CamRanger was employed to control the camera remotely using a tablet (Fig. 10). An X-Rite ColorChecker Passport was put at the base of the kantharos to ensure the colour fidelity of the final images, along with several scale-bars with both centroiding and coded targets to establish the scale of the resulting model.

Images were captured in four rows around the entire vessel. 75 images in NEF (Nikon Electronic Format) were chosen and converted to JPEGs for processing in Agisoft Photoscan (Photoscan 2015). This software, which uses the Semi-Global Matching algorithm to find matching points (Dall’Asta, Roncella 2014) can generate 3D surfaces even where little texture is visible, such as on much of the white marble exterior of the kantharos. Within the software the background was masked-out to improve the image accuracy as points in the foreground and background were not within the depth-of-field and hence blurry. The model was then built as a “high” dense-cloud (resampling the images by one-half, ie. 8 megapixels) with colour-corrected images.

Metoda

Relativno jednostavna, jeftina tehnika pogodna za korišćenje na terenu je korišćena za fotografisanje. Nikon D7000 (16 mega pixela) sa 24 mm f7.2.8D Nikkor objektivom (efektivna fokusna daljina 36 mm na APS/C izrezan senzor na D7000) je postavljen na teleskopskom osvijetljenom postolju kako bi se omogućilo hvatanje svih unutrašnjih uglova posude u stereo-parovima. Zato što je okular često u nezgodnoj visini za fotografa (ili previsoko ili prenisko) WiFi ruter sa punjenjem na baterije snabdjeven sa prilagođenim kablom *CamRanger* firme je imao funkciju da kontroliše kameru uz pomoć tableta (Sl. 10). *X-Rite ColorChecker Passport* je postavljen u dno kantarosa kako bi se osigurala vjerodostojnost boja na finalnoj fotografiji, zajedno sa nekoliko razmjernika sa centroidnim i kodiranim ciljevima za utvrđivanje razmera dobijenog modela.

Slike su fotografisane u četiri reda oko čitave posude. 75 slika u NEF (Nikon Electronic Format) je izabrano i prebačeno u JPEG zbog obrade u *AgisoftPhotoscan* (Photoscan 2015). Softver, koji koristi Semi-Global Matching algoritam kako bi pronašao podudarne tačke (Dall’Asta, Roncella 2014) može proizvesti 3D površinu uprkos slaboj vidljivosti teksture, kao što je slučaj sa većim delom bijele mermerne spoljašnje površine kantarosa. Uz pomoć softvera pozadina je bila zamaskirana kako bi se poboljšala preciznost slike s obzirom da tačke u prvom planu i one u pozadini nisu bile u okviru dubinske oštine stoga su mutne. Model je zatim izgrađen kao „high” *dance-cloud* (uzimajući ponovo uzorke za jednu polovinu tj. 8 megapiksela) sa slikama na kojima je ispravljena boja.

Results

A dense point-cloud of some 2,728,837 points and a mesh of 536,849 faces and 268,545 vertices was generated over the course of one day in Agisoft Photoscan (Fig. 11). This point-cloud was exported to PointCab Suite (PointCab 2015), a software program designed to create scaled cross-sections from point-clouds (Fig. 12). These two-dimensional images can be imported into AutoCAD and then traced to scale.

Rezultati

Dance point-cloud od nekih 2,728,837 tačaka i mreža od 536,849 lica i 268,545 vrhova je generisano u jednom danu u *AgisoftPhotoscan*-u (Sl. 11). Ovi *point-cloud* su prebačeni u *PointCab Suite* (PointCab 2015), softverski program dizajniran da napravi mjere presjeka od *point-clouds* (Sl. 12). Ove dvodimenzionalne slike mogu biti prebačene u *AutoCAD* i tako može da se izradi tehnički crtež u razmjeru.



Fig 11. A digital still image (left), untextured mesh (middle), and textured mesh (right).
Sl. 11. Digitalna slika (lijevo), mreža bez teksturom (sredina), i mreža sa teksturom (desno).

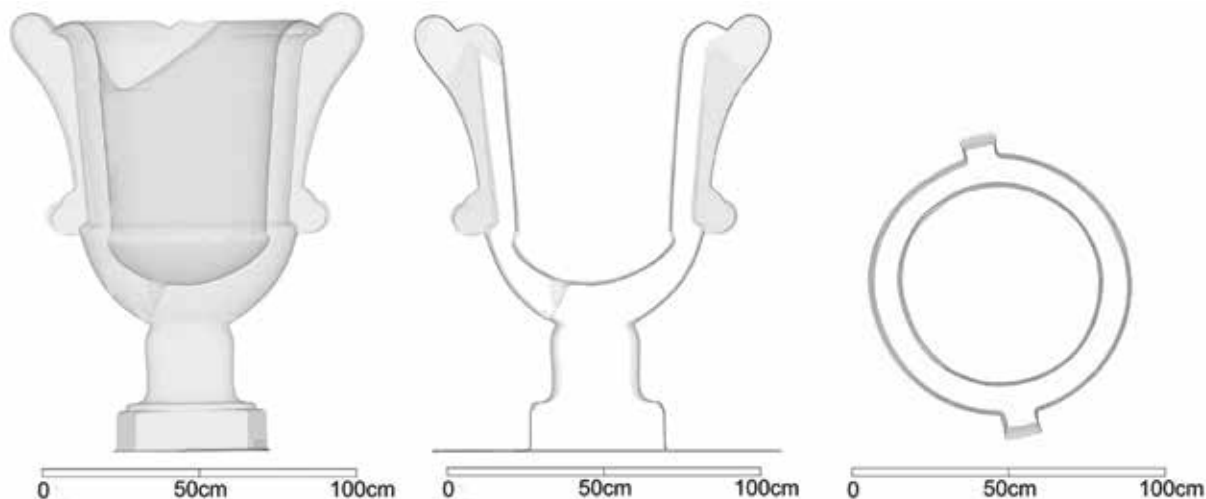


Fig 12. The point cloud (right) and vertical (middle), and horizontal scaled cross-sections.
Sl. 12. *Point-cloud* (desno) i vertikalni (sredina), i horizontalan prjesek u razmjeru.

Discussion

The photogrammetry of the kantharos not only permitted the successful technical documentation of the vessel, but also opened up the possibility of a “virtual” anastylosis, that is to say, the repositioning of the kantharos digitally in a 3D model of the Baptistery. Extensive photogrammetric documentation was performed not only of the Baptistery building in the 2015 field season, but also of displaced architectural components (column bases, capitals and column segments) that are stored in the rooms adjacent to the Baptistery. In AutoDesk 3DS Max software the scaled components, along with the kantharos, were re-installed into the image-based model of the Baptistery (Fig. 13). This exercise in anastylosis confirmed the earlier observation of the original excavators that the kantharos cannot be fit with the handles in line with the piscina walls, but must be turned at an oblique angle. This finding, a happy offshoot of the kantharos documentation, opens up important questions for the planned physical anastylosis of the Baptistery in the coming years. The authors hope that as this process continues the critical issue of the kantharos’ correct orientation, especially as regards the drain carved into the bottom can be conclusively solved in future publications.

Diskusija

Fotogrametrija kantarosa ne samo da omogućava uspješnu tehničku dokumentaciju posude, nego i otvara mogućnost „virtualne” anastiloze, ili bolje reći, digitalno pozicioniranje kantarosa u 3D modelu krstionice. Opsežna fotogrametrijska dokumentacija nije urađena samo za zgradu krstionice tokom kampanje istraživanja 2015., već i za dislocirane arhitektonske komponente (baze stubova, komponente kapitela i stubova) koje se čuvaju u prostorijama pored krstionice. U *AutoDesk 3DS Max* softveru prilagođene komponente, zajedno sa kantarosom, su ponovo instalirane u model krstionice zasnovan na osnovu fotografije (Sl. 13). Ova vježba u anastilozi potvrđuje ranija zapažanja prvobitnih istraživača da se kantaros zajedno sa drškama nije mogao uklopiti u prostor između zidova piscine, već mora da se iskosi. Ovaj nalaz, kao deo dokumentacije kantarosa, otvara važna pitanja o planiranoj fizičkoj anastilozi krstionice u predstojećim godinama. Autori se nadaju ako se ovaj process nastavi da će ključna pitanja o tačnoj orijentaciji kantarosa, naročito u pogledu odvoda urezanog u dno, biti konačno riješenja u budućim publikacijama.



Fig 13. A virtual anastylosis of the kantharos in the Baptistery along with one complete column.
Sl. 13. Virtualna anastiloza kantarosa u krstionici zajedno sa jednom gotovom kolonom.

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