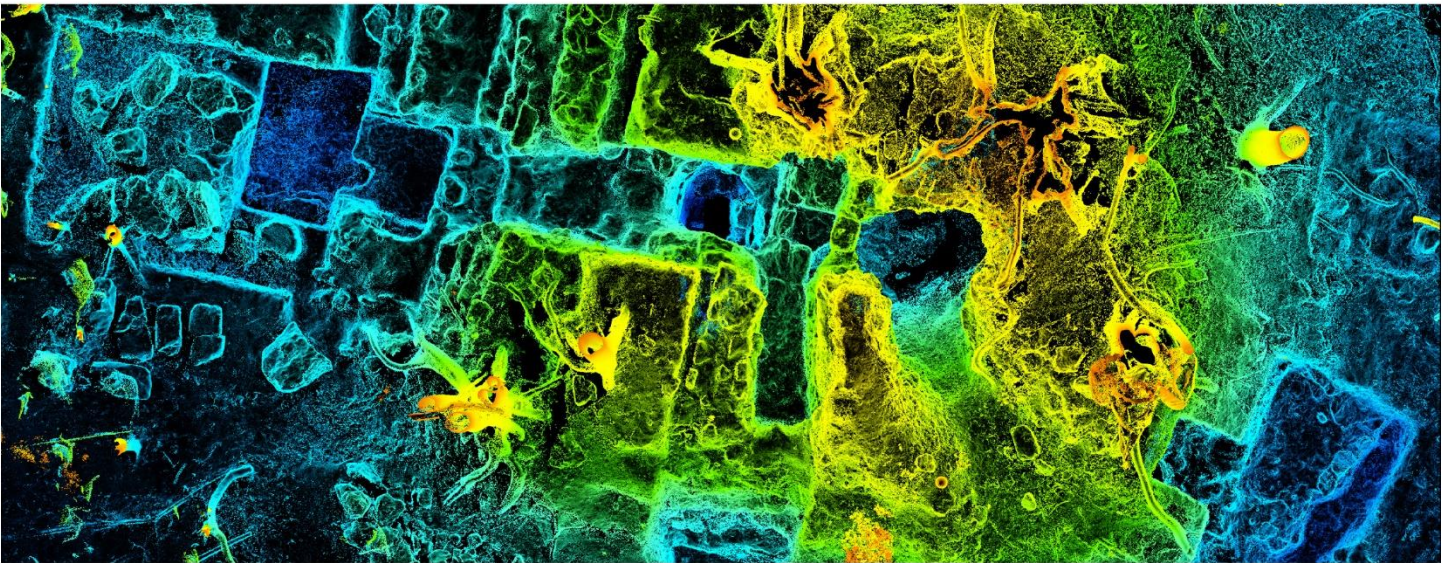


Digital heritage documentation of structures at the Maya sites of Birds of Paradise - North and Tz'unun in Belize



2019 Report
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&
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DIGITAL HERITAGE DOCUMENTATION OF STRUCTURES AT THE MAYA SITES OF BIRDS OF PARADISE – NORTH AND TZ’UNUN IN BELIZE

Ben Baaske and Bob Warden

INTRODUCTION

Digital documentation of structures continued at Tz’unun with a brief operation at Birds of Paradise – North. The bulk of the data collected during the field season occurred during sessions 1-3 and focused on multi-image photogrammetry of excavations at Tz’unun: Structure 4 & 5 (ballcourt), Structure 9, Structure 13, Structure 20 (E-Group radial pyramid), Structure 21, Structure 22 (E-Group eastern platform), and Chultun 18-05. In session 4, all excavations at Tz’unun were laser scanned with the exception of Chultun 18-05, which had been backfilled at the close of session 2.

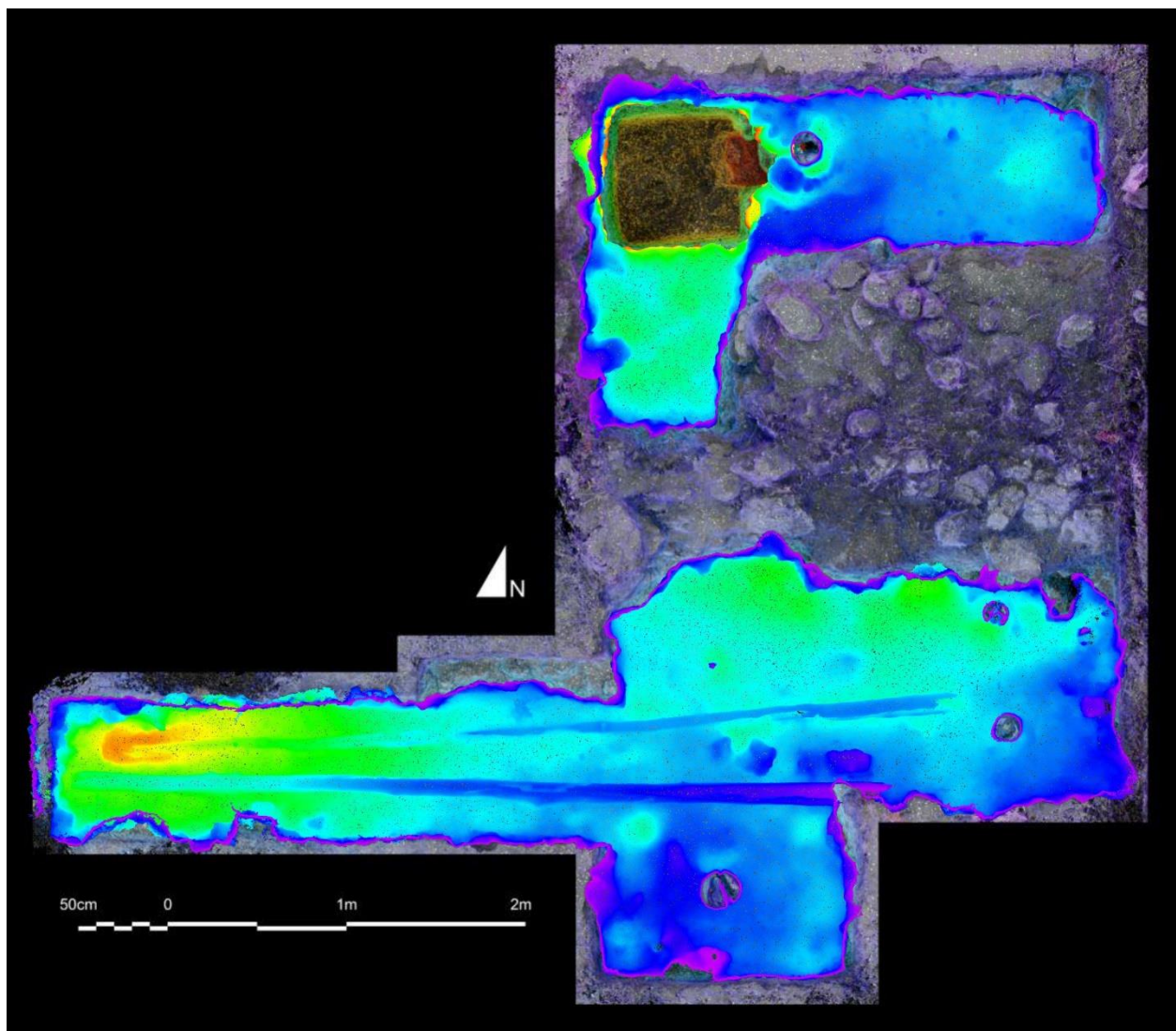


Figure 1. Plan (composite digital elevation map), Birds of Paradise – North, Structure 1, Sub-op F, Lot 21 [Photogrammetry; Agisoft Metashape registration; FARO Scene + Autodesk ReCap + Adobe Photoshop post-processing].

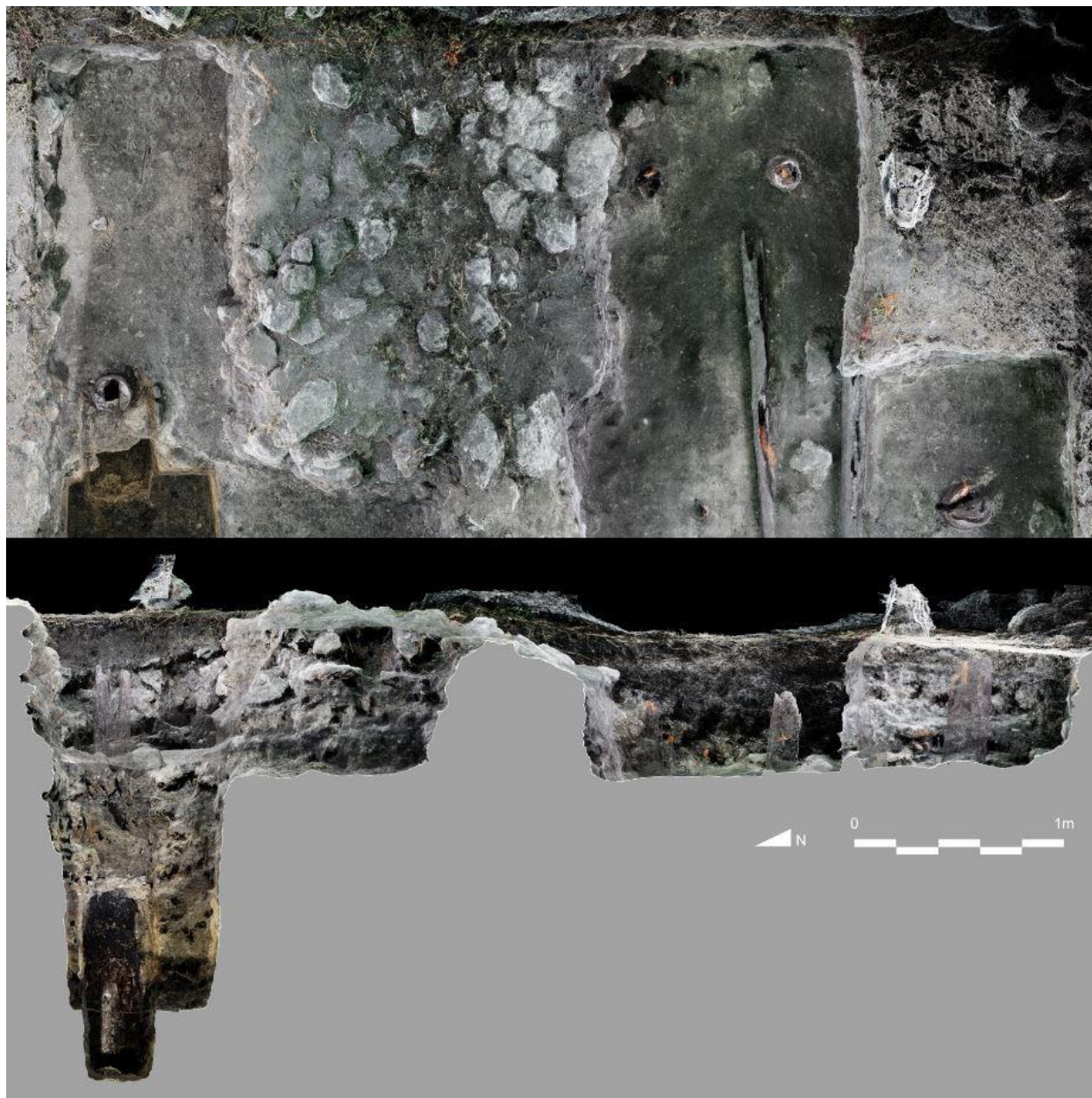


Figure 2. East Profile, Birds of Paradise – North, Structure 1, Sub-op F, Lot 21 [Photogrammetry; Agisoft Metashape registration; FARO Scene + Adobe Photoshop post-processing].

BIRDS OF PARADISE – NORTH

Birds of Paradise – North, Structure 1, concluded excavation and was documented using multi-image photogrammetry and a total data station. 31 survey points were recorded using the total data station to produce a preliminary map of the structure. The points consisted of 5 photogrammetric targets, the boundaries of excavation units from this season and 2018, and the perimeter of the structure's platform. 451 images were taken using a combination of mounted flash, local flash, and no flash, for the purpose of generating a photogrammetric model of the excavation and the numerous in situ wooden posts. 117 additional images were taken of the western expansion of the unit with the two horizontal posts. When processed, the 568 total images yielded an

interesting result in terms of layering multiple excavation phases. Since the lot F21b images captured significant overlap with lot F21, the model aligned all but 18 of the images. This resulted in a composite model, showing the excavation expansion already tightly registered to the original model; a method which previously had been rudimentarily and haphazardly attempted using scaling in Agisoft Metashape Pro and FARO Scene. However, the apparent downfalls of this “new” method are the considerable increase in project file size, and the risk of non-registration if large gaps between data capture are allowed.

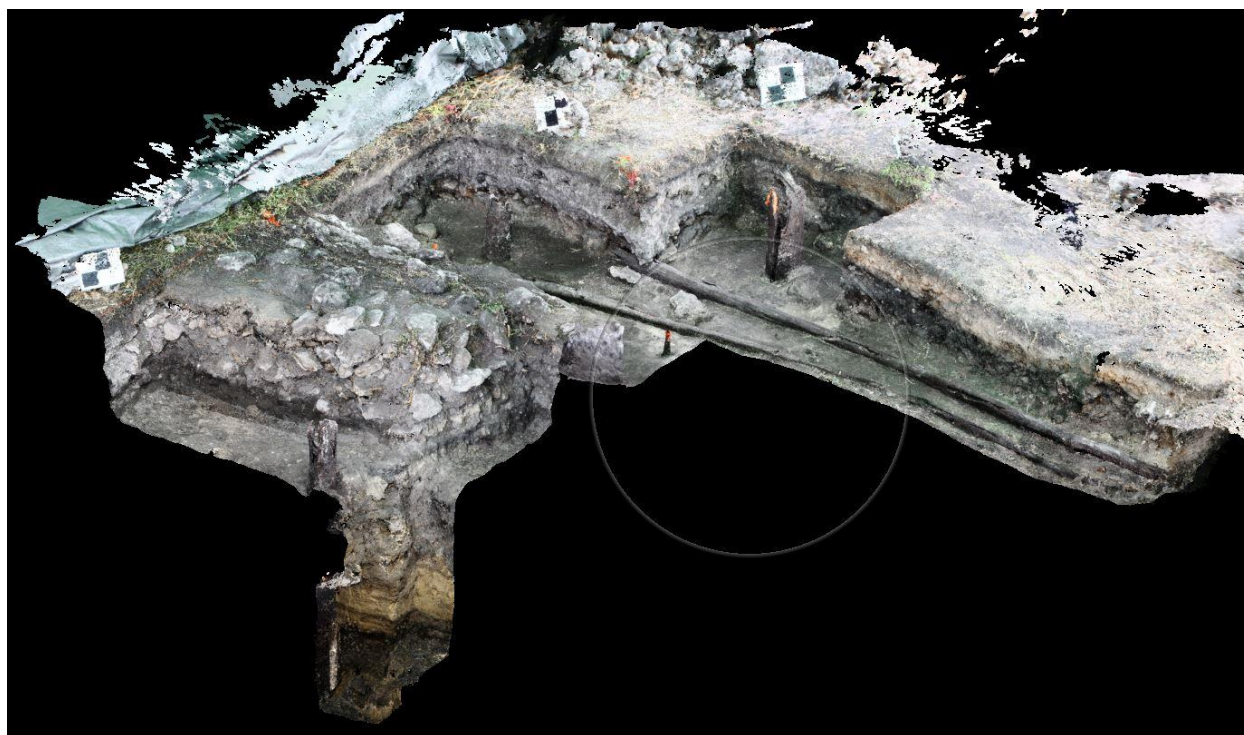


Figure 3. Northwest Isometric Section, Birds of Paradise – North, Structure 1, Sub-op F, Lot 21. [Photogrammetry; Agisoft Metashape registration; FARO Scene post-processing].

The large and intact horizontal post was captured in semi-situ under a tarp, as well as in mostly cloudy daylight with even lighting. Additionally, two medium fragments and two small fragments of the smaller horizontal post were recorded for multi-image photogrammetry. These models were not successfully registered. In moving the post out from under the tarp, the contrast between the exposed top side and damp underside was amplified. Furthermore, light rain on the top side (which was relatively dry) created a dynamic (in a sense) surface texture of the post, putting more pressure on the image overlap. It was also incorrectly assumed that despite rotating the post quarter turns while under the tarp, that it would be sufficient to rotate the post half turns i.e. capture images on one side, flip the post, and then capture images on the other side.

The failure to register full 3D models of the individual posts is disappointing, but the overall documentation of the excavation and in situ posts produced good and compelling outputs. More images were captured of the posts and post fragments than could be processed in the field and at the present time. Therefore, there is opportunity for further investigation and experimentation in attempts to register the models.



Figure 4. North Profile, Birds of Paradise – North, Structure 1, Sub-op F, Lot 21 [Photogrammetry; Agisoft Metashape registration; FARO Scene + Adobe Photoshop post-processing].

TZ'UNUN

Excavations at Tz'unun continued from the 2018 season at Structure 9, Structure 13, Structure 21, and Chultun 18-05. Structure 21 and Chultun 18-05 are part of the Western Group; Chultun 18-05 is closest to Structure 22 (the eastern platform of an E-Group that includes the radial pyramid, Structure 20). Operations opened excavation at Structure 20 (E-Group radial pyramid) and Structure 22 (E-Group eastern platform) in 2019.

Documentation at Structure 21 consisted of photogrammetry of the archaeological stratigraphy (Galeazzi 2016, 159-169; Galeazzi et al. 2016, 1-11; Baaske and Warden 2017; Baaske and Warden 2018; Mertes et al. 2017, 91-107) and a laser scan of the final phase of excavation for the 2019 season. 26 layers of archaeological stratigraphy were recorded using photogrammetry. Sub-operations of O (centerline trench), N (southwest corner of the building), and P (northeast corner of the building) were excavated simultaneously. Penetration through the top room of the structure, just south of the looters trench, revealed a tomb. Documentation of the excavation of the tomb and other segments of Sub-op O using photogrammetry were allowed to be more surgical. In other words, only portions of the excavation that had changed were captured for each strata.

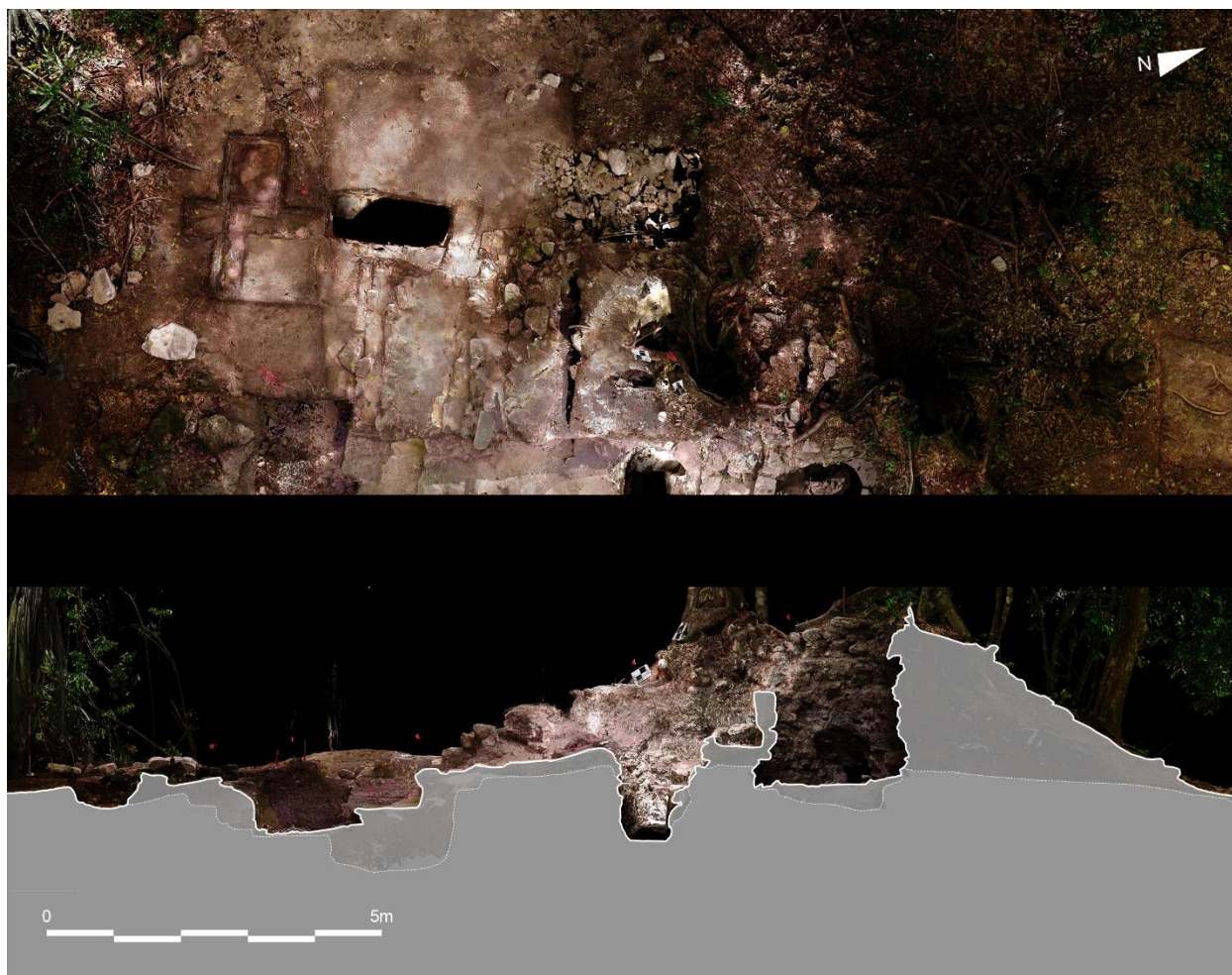


Figure 5. West Profile, Tz'unun, Structure 21, Sub-op P, Lot 137 [Laser scanning; FARO Scene registration; Adobe Photoshop post-processing].

An experiment in processing revealed that multiple strata could be registered into the same model output. This method can quickly become difficult to process, increasing the image input as well as the necessary computer processing speed and memory. Future processing should experiment with Capturing Reality's RealityCapture software, which handles large image inputs well and creates high-resolution outputs. So far, some

registration experiments between Agisoft Metashape and RealityCapture show Metashape does better with registering all images. However, whether this apparent success rate in registration is reliable compared to RealityCapture's occasional dismissal of a handful of images remains to be seen.

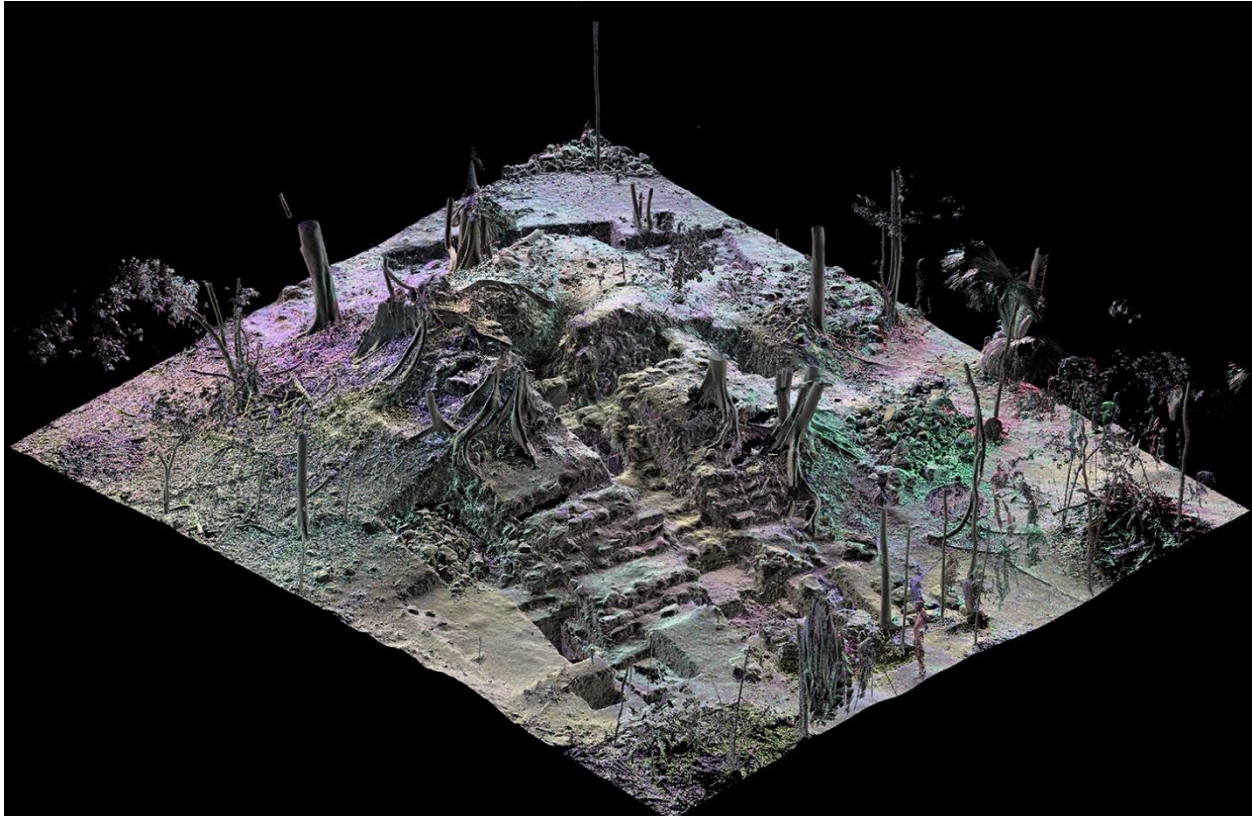


Figure 6. Southwest Isometric (scan location map), Tz'unun, Structure 21, Sub-op P, Lot 137 [Laser scanning; FARO Scene registration; Autodesk ReCap + Adobe Photoshop post-processing].

Laser scanning at Structure 21 required 38 scan positions with the FARO Focus3D X330 HDR (the HDR setting was not used due to time constraints and minimal benefit). The latest lot at the time of scanning was Sub-op P, Lot 137. Mean point error was 6.0mm; maximum point error was 12.8mm; and the minimum overlap was 13.7%. Registration was done in FARO Scene 2019, using auto-registration with the top-view-and-cloud-to-cloud method. Checkerboard targets and sphere targets were placed and in the scan project. The checkerboard targets were recorded with a Total Data Station using the coordinate system created in 2018. We were also able to use these survey points to help register the local point cloud within itself, as well as register it in relation to the other structures and other years of excavation (Baaske and Warden 2016; Baaske and Warden 2017; Baaske and Warden 2018; Glowacki et al. 2016; Glowacki, Baaske, and Billingsley 2019).

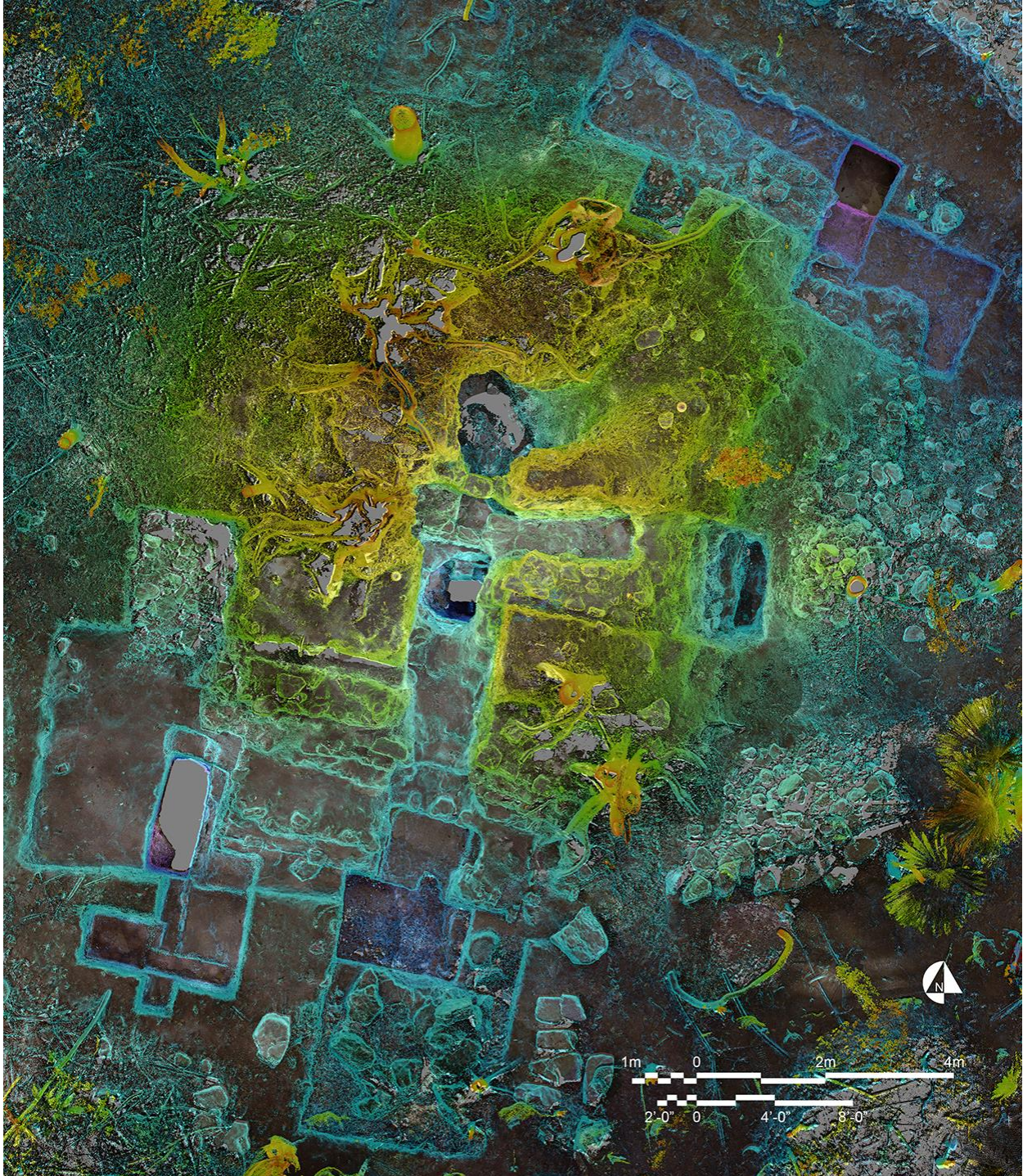


Figure 7. Plan (digital elevation map), Tz'unun, Structure 21, Sub-op P, Lot 137 [Laser scanning; FARO Scene registration; Autodesk ReCap + Adobe Photoshop post-processing].

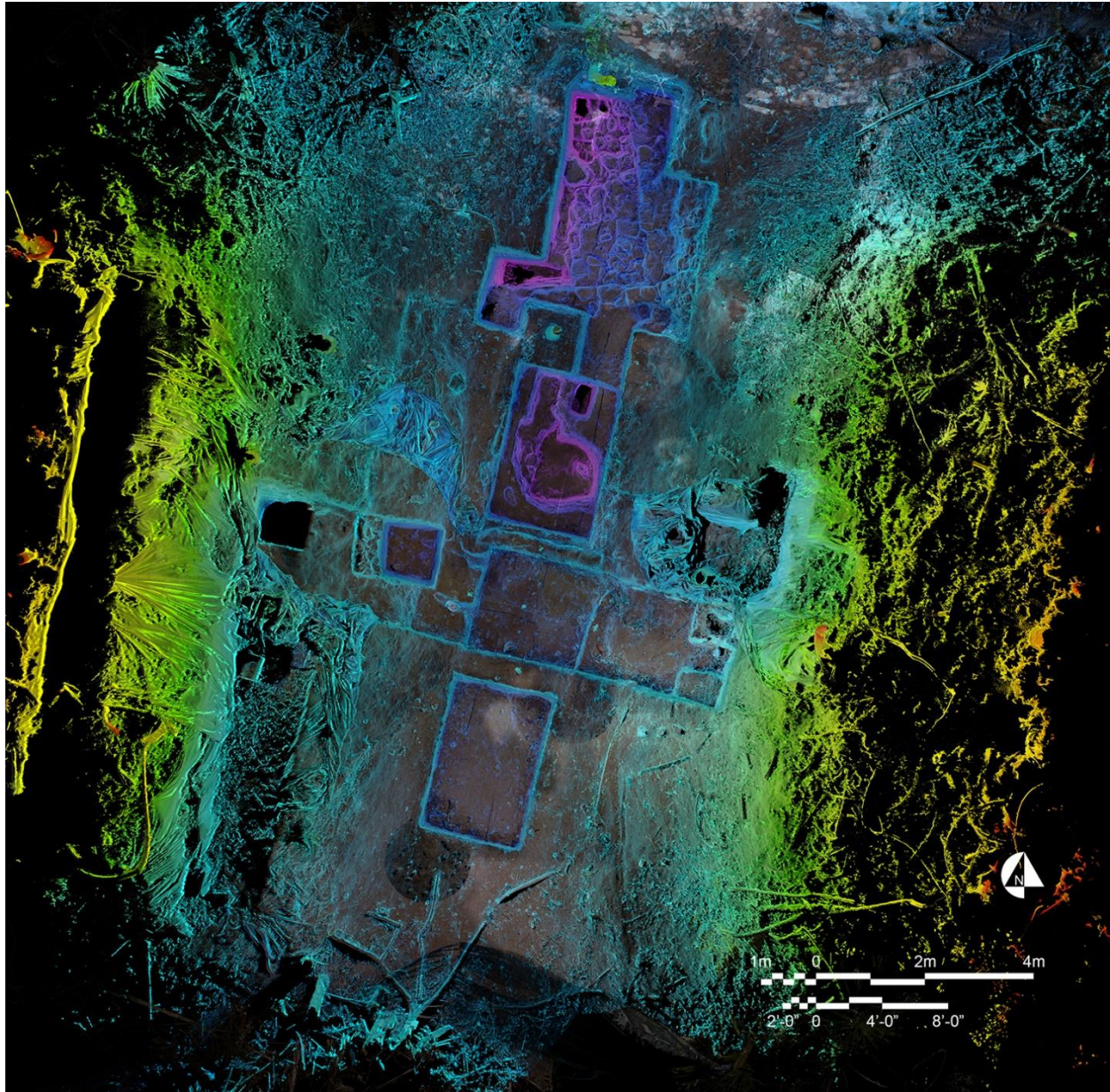


Figure 8. Plan (digital elevation map), Tz'unun, Structures 4 & 5, Sub-op H, Lot 53 [Laser scanning; FARO Scene registration; Autodesk ReCap + Adobe Photoshop post-processing].

Excavation and documentation continued at Structures 4 & 5, collectively called the “ballcourt”. Seven strata were recorded using photogrammetry, and two batch registrations were conducted using three and four lots. “Batch registrations” are what were discussed in the preceding paragraphs with using images from different lots in the same model registration in Agisoft Metashape. Laser scanning at the ballcourt required 11 scan positions, and was successfully registered using target-based auto registration in Scene. The latest lot at the time of scanning was Sub-op H, Lot 53. Mean point error was 2.2mm and maximum point error was 7.9mm; no overlap percentage is given since the auto registration was done using target-based registration. The project point cloud has 166.538 million points (a project point cloud for Structure 21 could not be done due to the size of the project i.e. 38 scan positions for Structure 21 versus 11 scan positions for Structures 4 & 5).

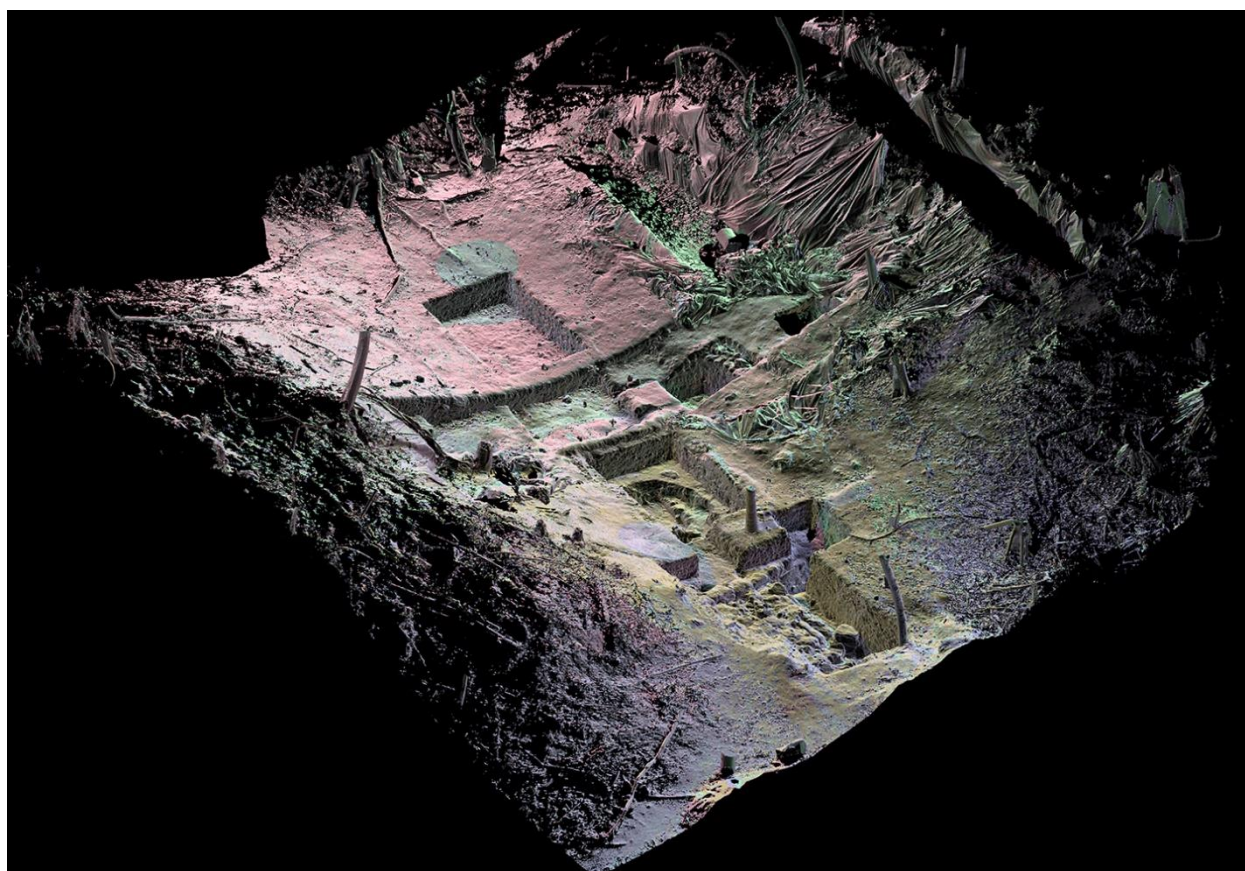


Figure 9. Northeast Isometric (scan location map), Tz'unun, Structures 4 & 5, Sub-op H, Lot 53 [Laser scanning; FARO Scene registration; Autodesk ReCap + Adobe Photoshop post-processing].

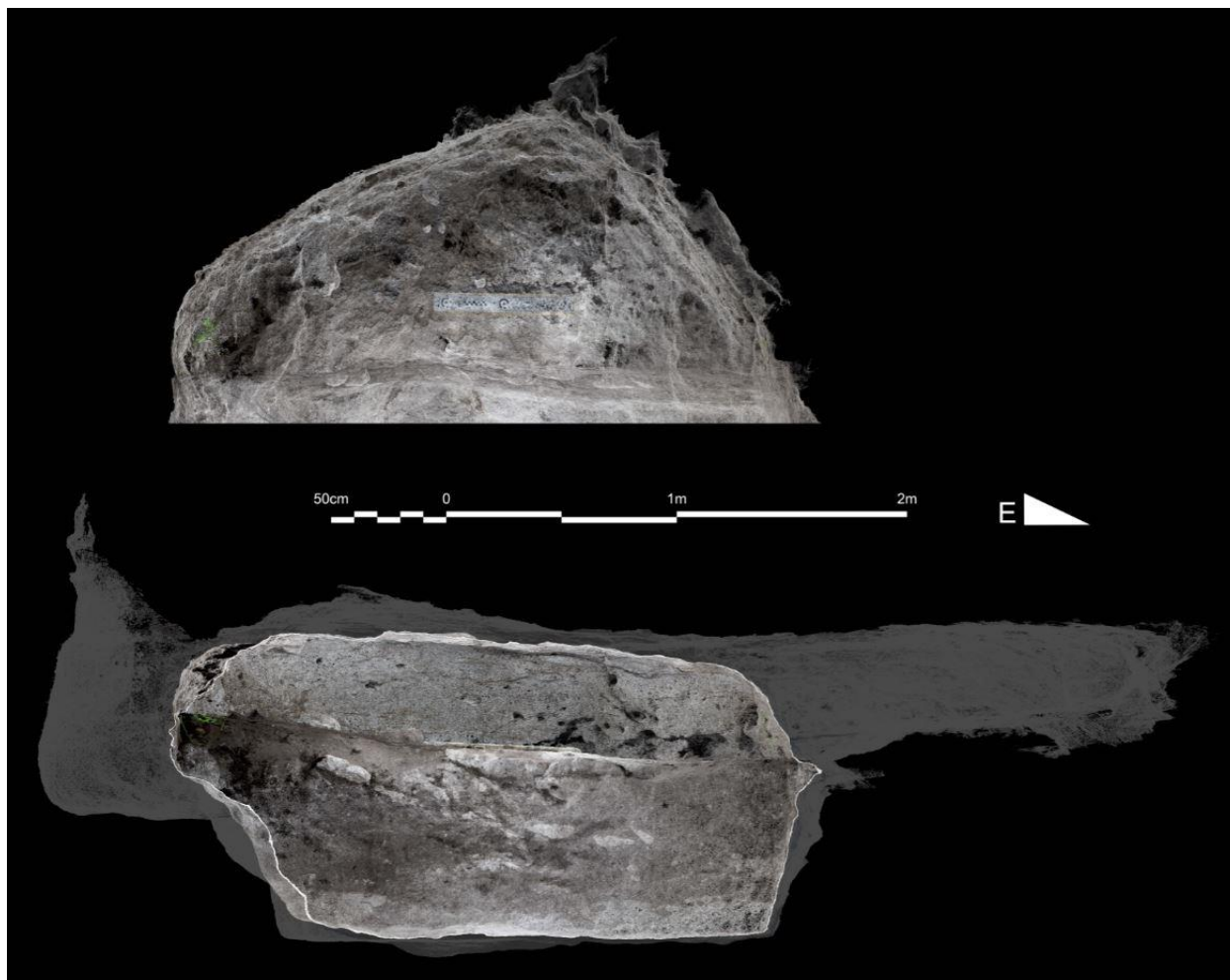


Figure 10. North Profile, Tz'unun, Chultun 18-05, Sub-op C, Lot 6 [Photogrammetry; Agisoft Metashape registration; FARO Scene + Adobe Photoshop post-processing].

Documentation of Chultun 18-05 in the Western Group (which consists of Structures 20, 21, and 22) continued and only used photogrammetry to document the feature. Chultun 18-05 is just west of Structure 22 (the eastern platform to a potential E-Group; Structure 20 being the radial pyramid). Unlike the documentation of chultun features at Xno'ha (Baaske and Warden 2017; Baaske and Warden 2018), this chultun at Tz'unun was documented at roughly mid-excavation and final phase of the excavation. No laser scanning was conducted on this chultun, as the operation closed (end of June) before the equipment made its way to Belize near the end of the field season (middle of July).

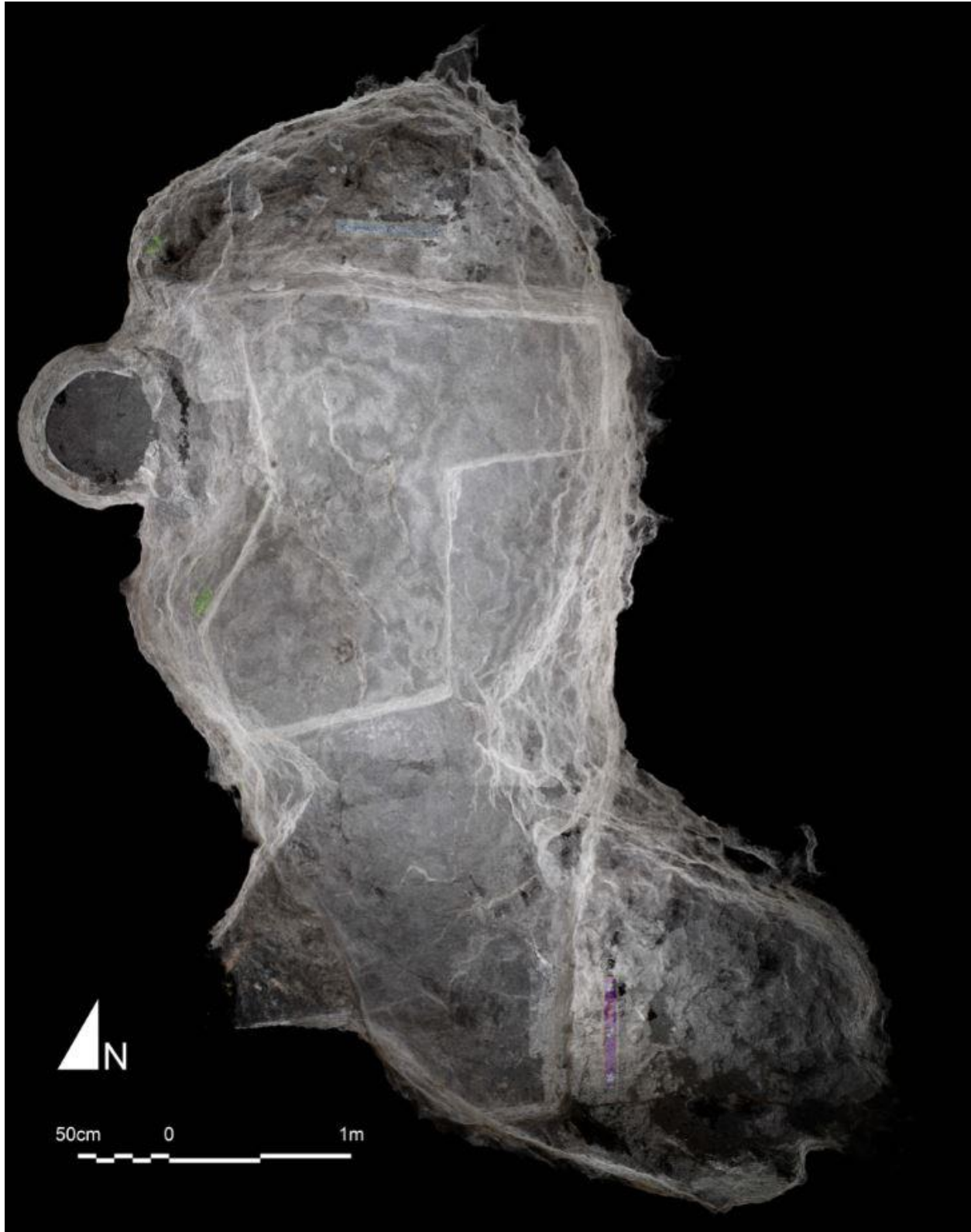


Figure 11. Plan, Tz'unun, Chultun 18-05, Sub-op C, Lot 6 [Photogrammetry; Agisoft Metashape registration; FARO Scene + Adobe Photoshop post-processing].

At Structure 9 (just south of the ballcourt and Structure 1, the main pyramid in the Eastern Group), documentation continued with photogrammetry as well as laser scanning. Six strata were documented using photogrammetry, with one batch registration using four archaeological strata. Laser scanning at Structure 9 required 13 scan positions, and used top-view-and-cloud-to-cloud auto registration. The latest lot at the time of scanning was Sub-op G, Lot 36. Mean point error was 7.1mm; maximum point error was 11.3mm; and the minimum overlap was 65.4% (which is relatively very high; this is due to the small scale of the structure and the resultant visibility between scan positions). The project point cloud consisted of 183.414 million points.

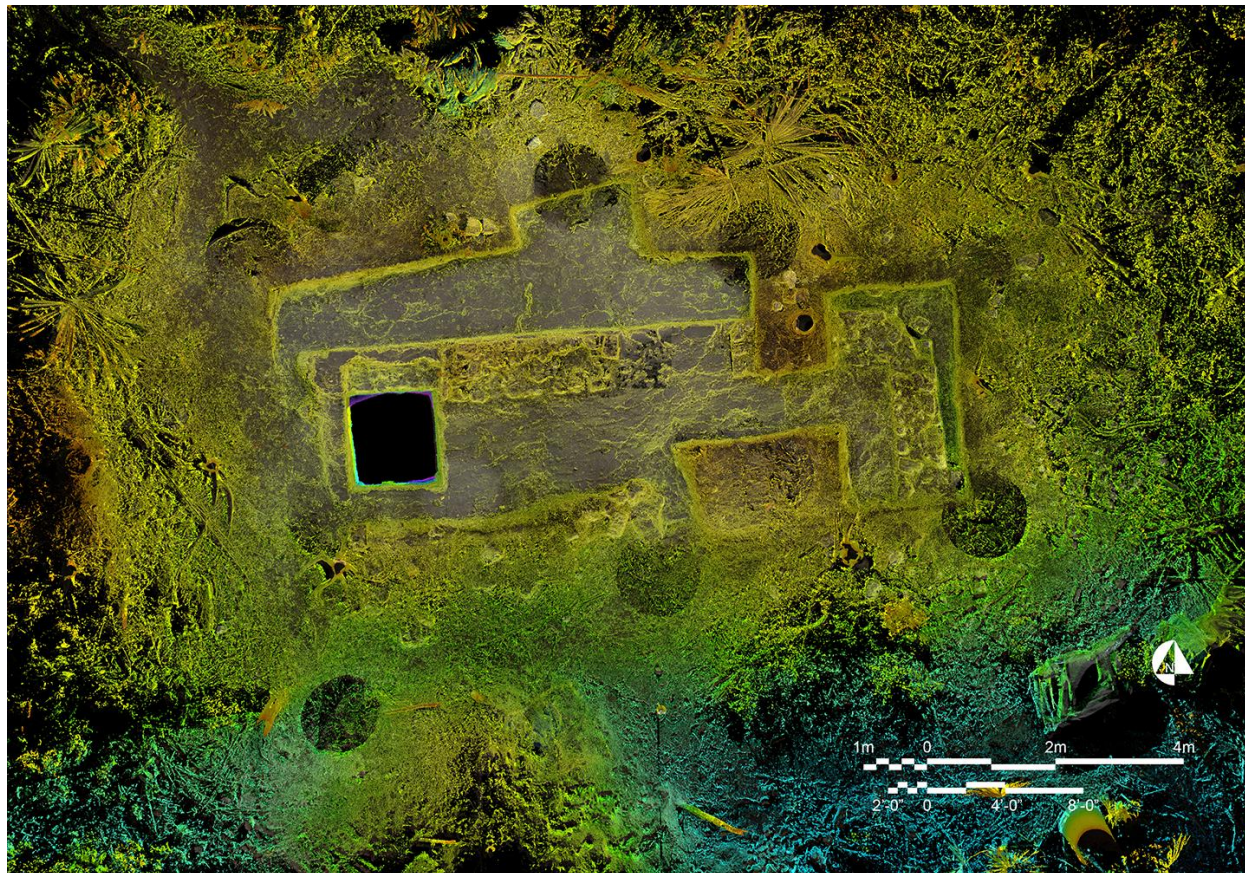


Figure 12. Plan (digital elevation map), Tz'unun, Structures 9, Sub-op G, Lot 36 [Laser scanning; FARO Scene registration; Autodesk ReCap + Adobe Photoshop post-processing].

Documentation of Structure 13 (just northwest of Structure 9 and southwest of the ballcourt) captured five archaeological strata using photogrammetry, as well as the final phase of excavation using laser scanning. No batch registrations have yet been done with the strata from photogrammetry at Structure 13. Laser scanning at Structure 13 required 20 scan positions, and used top-view-and-cloud-to-cloud auto registration. The latest lot at the time of scanning was Sub-op E, Lot 36. Mean point error was 5.2mm; maximum point error was 13.5mm; and the minimum overlap was 16.3%. The project point cloud consisted of 240.597 million points.

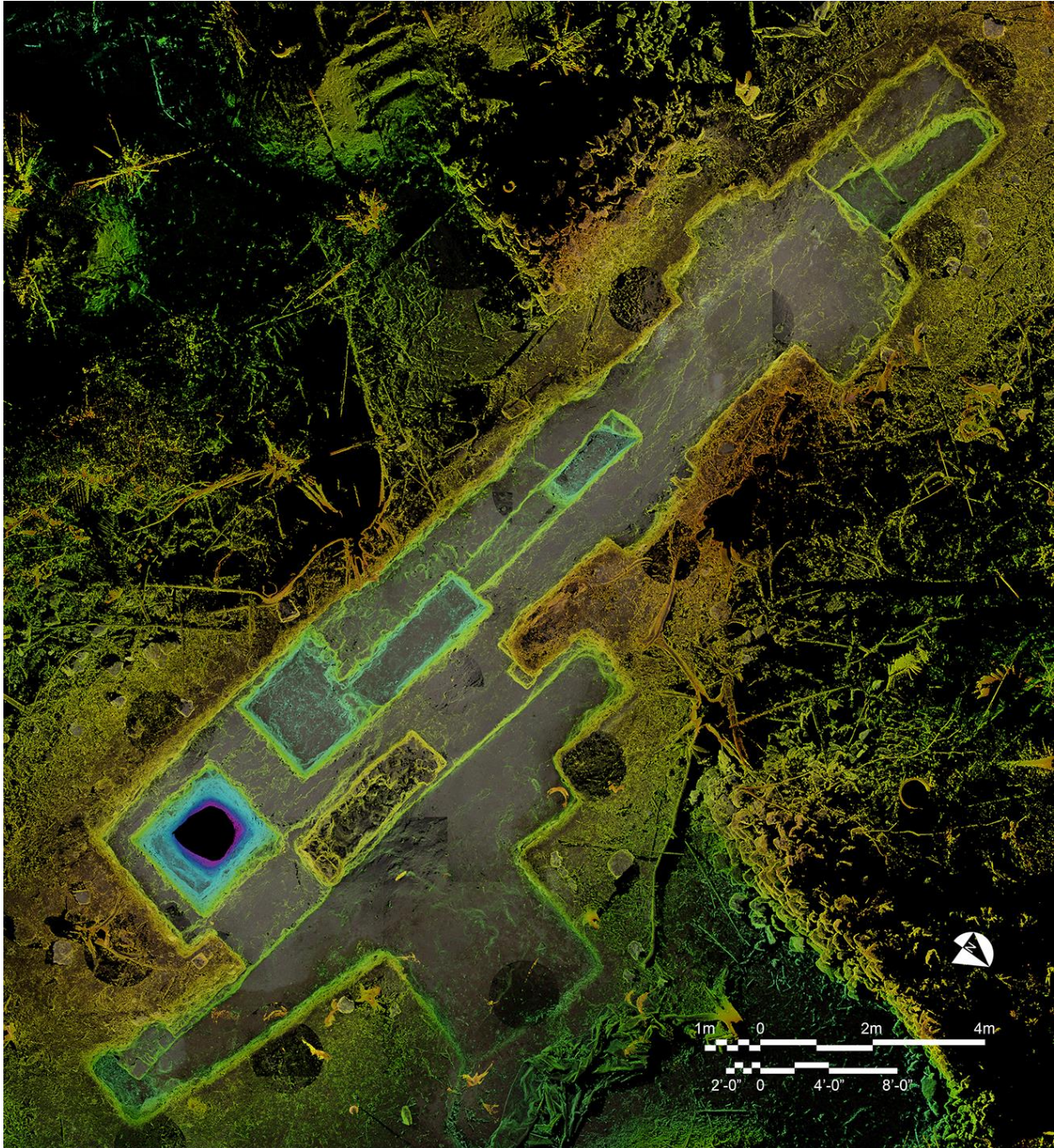


Figure 13. Plan (digital elevation map), Tz'unun, Structures 13, Sub-op E, Lot 36 [Laser scanning; FARO Scene registration; Autodesk ReCap + Adobe Photoshop post-processing].

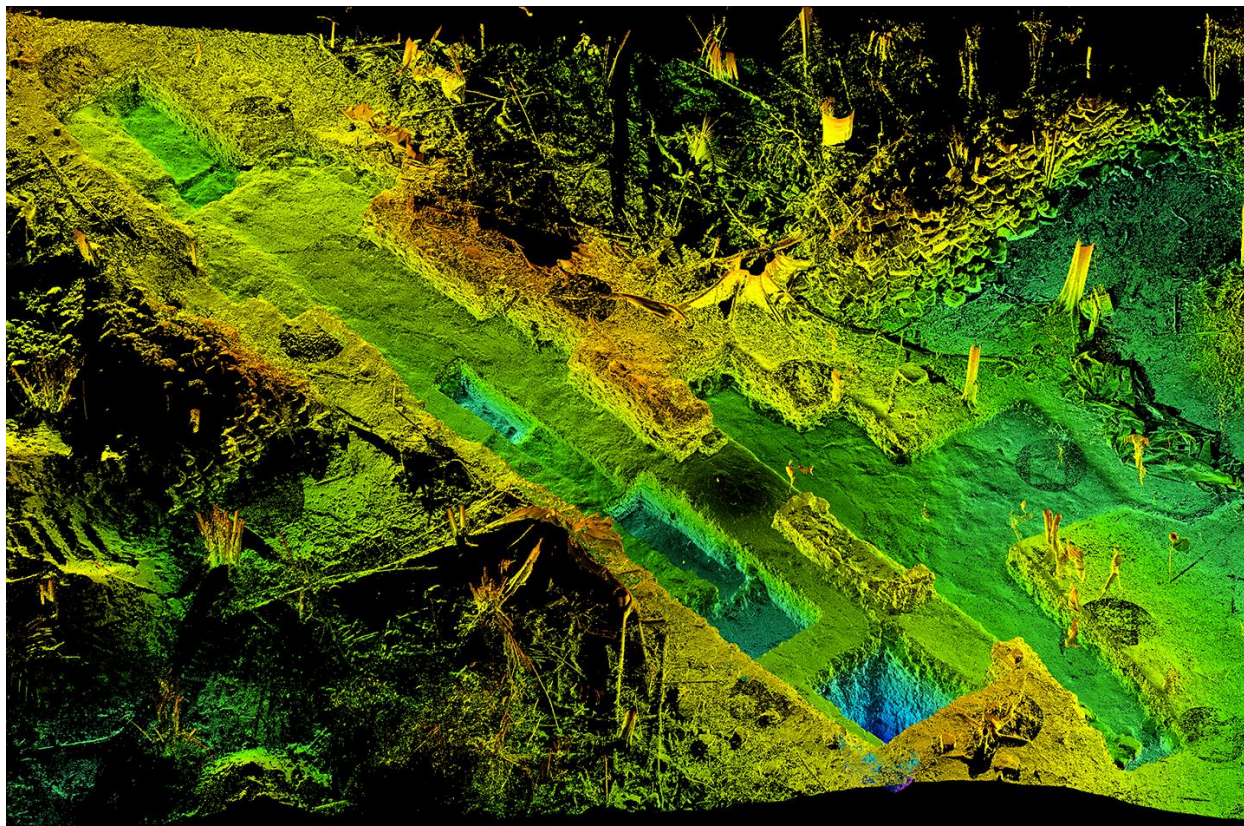


Figure 14. Southeast Isometric (digital elevation map), Tz'unun, Structures 13, Sub-op E, Lot 36 [Laser scanning; FARO Scene registration; Autodesk ReCap + Adobe Photoshop post-processing].

Documentation of Structure 20 (the radial pyramid of the E-Group on the west side of the Western Group) captured nine archaeological strata using photogrammetry, as well as the final phase of excavation using laser scanning. 2019 was the first season of excavation at this structure, and excavations will continue here in 2020. No batch registrations have yet been done with the strata from photogrammetry at Structure 20; all strata except for one have over 100 images, which takes longer to register with Agisoft Metashape and “current” hardware (2016 computer specs: i7 processor, NVIDIA GeForce GTX 960M [4G], 16G RAM). Laser scanning at Structure 20 required 43 scan positions, and used target-based auto registration and manual registration with target selection. Mean point error was 8.4mm; maximum point error was 32.3mm; and the minimum overlap was 8.0%. This high error and low overlap is likely due to the size of the structure, which is easily the most massive under excavation at Tz'unun so far. However, registration with survey points recording the checkerboard targets should help to reduce the point errors.

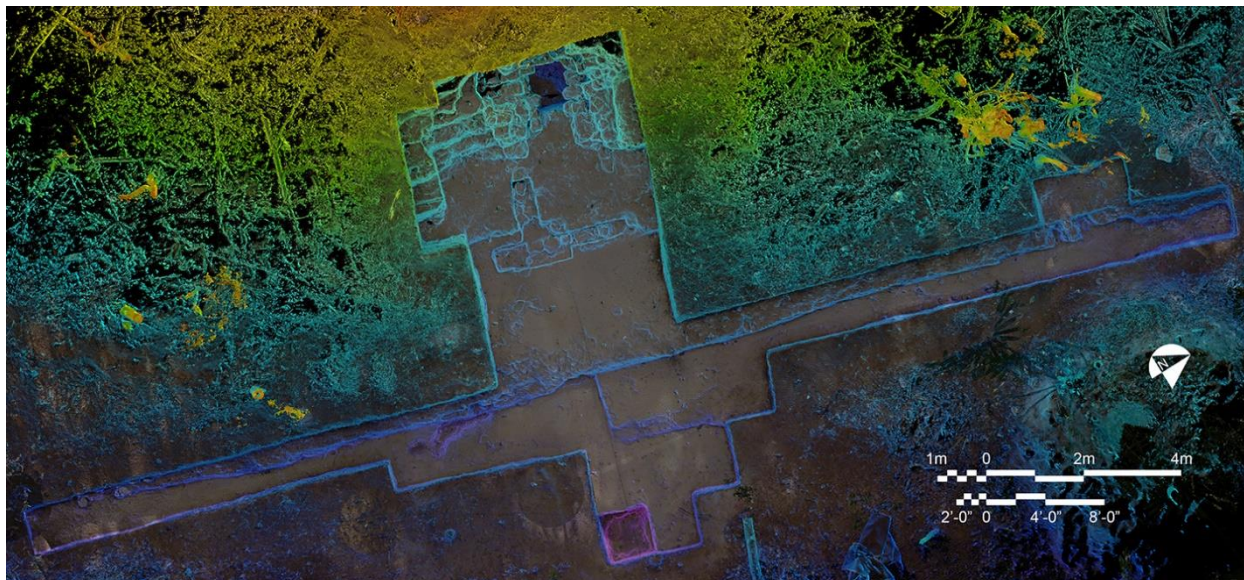


Figure 15. Plan (digital elevation map), Tz'unun, Structures 20 [Laser scanning; FARO Scene registration; Autodesk ReCap + Adobe Photoshop post-processing].

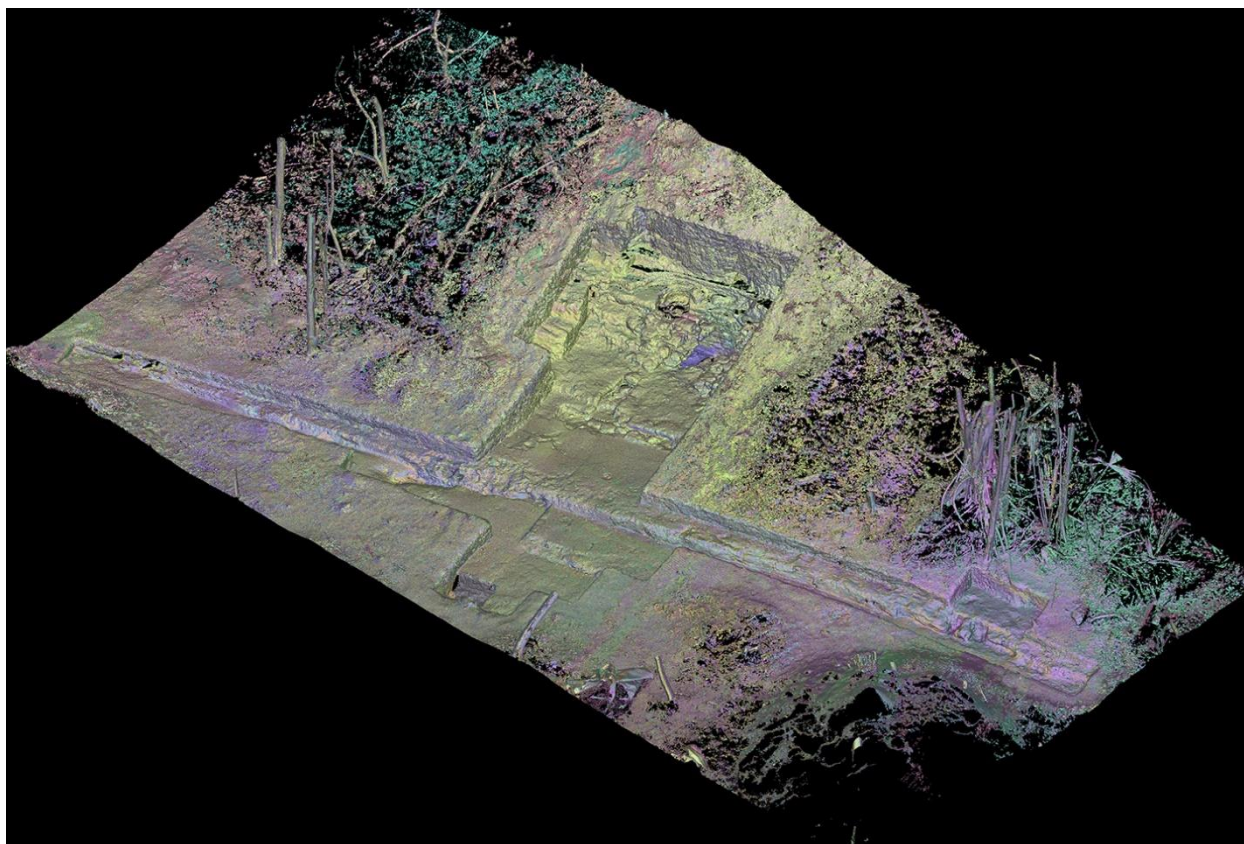


Figure 16. Northeast Isometric (scan location map), Tz'unun, Structures 20 [Laser scanning; FARO Scene registration; Autodesk ReCap + Adobe Photoshop post-processing].

Documentation of Structure 22 (the eastern platform of the E-Group on the east side of the Western Group) captured seven archaeological strata using photogrammetry, as well as the final phase of excavation using laser scanning. 2019 was the first season of excavation at this structure as well. Excavations will continue at Structure 22 in 2020. One batch registration using the first two strata at the structure produced a decent output. However, this test showed that while the individual strata registered coherent surface models, the composite model appears to strip points from one or the other model. This produces a gap in the surface model, dropping points from the earlier strata to the later strata. Laser scanning at Structure 22 required 25 scan positions, and used target-based auto registration. The latest lot at the time of scanning was Sub-op H, Lot 37. Mean point error was 4.9mm and maximum point error was 30.3mm. It is unclear why this max point error is so high, but this can be reduced by using the survey points recording the checkerboard targets. The project point cloud consisted of 414.260 million points.



Figure 17. Plan (digital elevation map), Tz'unun, Structures 22, Sub-op H, Lot 37 [Laser scanning; FARO Scene registration; Autodesk ReCap + Adobe Photoshop post-processing].

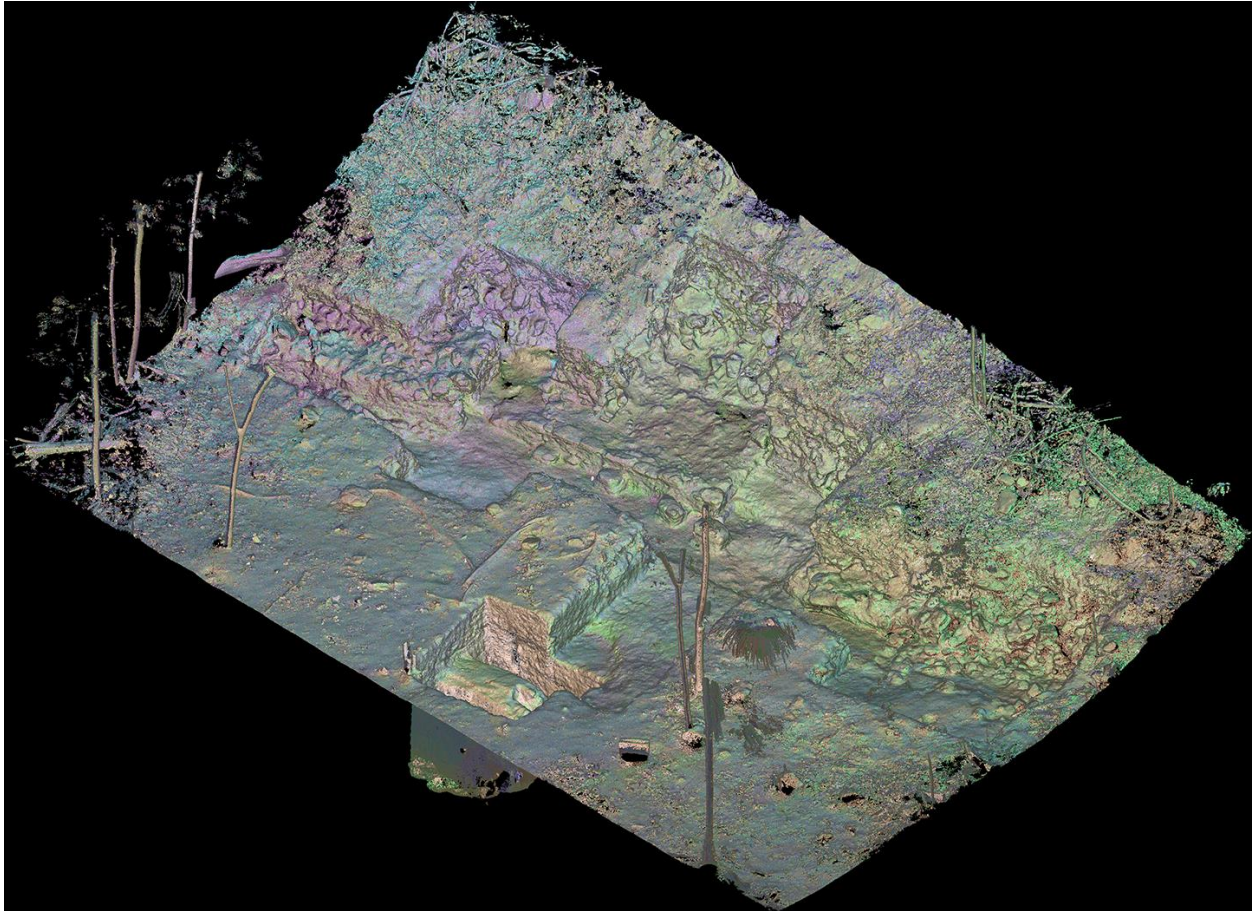


Figure 18. Southwest Isometric (scan location map), Tz'unun, Structures 22, Sub-op H, Lot 37 [Laser scanning; FARO Scene registration; Autodesk ReCap + Adobe Photoshop post-processing].

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