SPARC Project Short Report

Project Name: Bosutswe Landscapes: Exploring early African towns through geophysics and photogrammetry

PI(s) and Institution(s): Carla Klehm (PI), Washington University in St. Louis; Eileen Ernenwein (co-PI), East Tennessee State University; Katie Simon, Center for Advanced Spatial Technologies, University of Arkansas

I. Summary of work undertaken in collaboration with SPARC

SPARC's Bosutswe Landscapes was part of a three-phase pilot project that utilized low-altitude aerial remote sensing thermography, RGB and NIR photography, and photogrammetry (as contributed by CAST) in conjunction with a ground-based geophysical survey to identify archaeological sites and features in east-central Botswana. The southern African (Botswana) Iron Age (900-1650 CE) was a period when Indian Ocean exchange in gold and ivory linked southern Africa to East Africa, the Middle East, China, India, and Indonesia. As southern Africa's role in this trade network became increasingly important, the local landscape was reimagined as large towns and city centers emerged along with material evidence for hereditary inequality. Bosutswe Landscapes was located near one of these major regional trade centers, Bosutswe (700-1700 CE), located on the eastern edge of the Kalahari Desert. However, these early African trading centers involve much more than the central sites: satellite communities also emerged in order to take advantage of new economic opportunities. Almost entirely ignored in earlier research, these smaller hilltop and ground sites would have been crucial to the development and sustainability of towns and cities living in the marginal environment of the African interior. Research at these sites is key to understanding the development of complexity and inequality during this period.

Bosutswe Landscapes 2014 concentrated on survey at three smaller, rural sites located within 5km of the Bosutswe: the hilltop of Mmadipudi Hill and two nearby "ground" sites located in the adjacent riverine basin, including Queen's Ground Site and Iron Furnace Site. The first phase involved the SPARC project, where PI Klehm and co-PI Ernenwein teamed up with Katie Simon, Center for Advanced Spatial Technologies, to conduct a low-altitude aerial survey using a CineStar Octocopter. The Octocopter platform is built to take digital stereo images that can be photogrammetrically processed to produce three-dimensional terrain models, as well as color and infrared photos that we will use to investigate vegetation patterns that reveal archaeological sites and features. This aerial phase attempted to characterize the landscape topographically and discover new sites. The second phase, led by Ernenwein (here, as PI; co-PI Klehm) surveyed the research areas with electromagnetic induction (EMI), magnetometry, and ground-penetrating radar (GPR) instruments to characterize the subsurface anomalies and study the spatial layout of the sites. This second phase was compared to the results from the aerial survey, to look for correlation between the two datasets. The third phase, still underway, involved excavations in the

features detected within sites through aerial photography and geophysical surveys. These units are used to address questions about the chronology and functions of these sites with respect to one another.

The major contributions of this project were two-fold: firstly, through its methodological contribution, and secondly, as a pilot project that provided the first evidence towards a major re-thinking of the development of complex societies in the African Interior. These spatial archaeometric approaches are not new, but they are rarely combined and none have been done in Botswana aside from our work in 2011. Bosutswe Landscapes is the initial phase of a project that posits a landscape approach to early African complexity. We believe these small sites, which the survey began to record, were crucial to the success of urban centers and, furthermore, integrally involved in how inequality first developed and was maintained. Building this mosaic of sites on the landscape will help to replace dated, oversimplified arguments that the first inequality in prehistoric Africa was a logical outcome of external trade driven by core urban centers.

II. Summary of Results

In June 2014, a pilot survey lead by Carla Klehm and Eileen Ernenwein, along with SPARC collaborators Katie Simon and Jeremy Menzer, was conducted near the site of Bosutswe in east-central Botswana ((21º57’8.4”S, 26º36’39.0”E on Cape Datum), at three of the surrounding settlements: Queen’s Ground Site (21º57’19.1”S 26º37’36.7”E), Iron Furnace Site (21º58’3.32”S 26º38’11.56”E), and Mmadipudi Hill (21º57’22.2”S 26º35’2.9”E). The research design of the survey was a three-phase design: photogrammetry and low altitude aerial survey with a UAV (“drone”) platform to do a thermography survey to see if archaeological sites have a heat signature and aerial photogrammetry of the sites (Phase One); followed by a near-surface geophysics survey to identify the extent of sites, their features, and the spatial layout (Phase Two); and test excavations to define the relationships between the remote sensing anomalies and subsurface features (Phase Three).

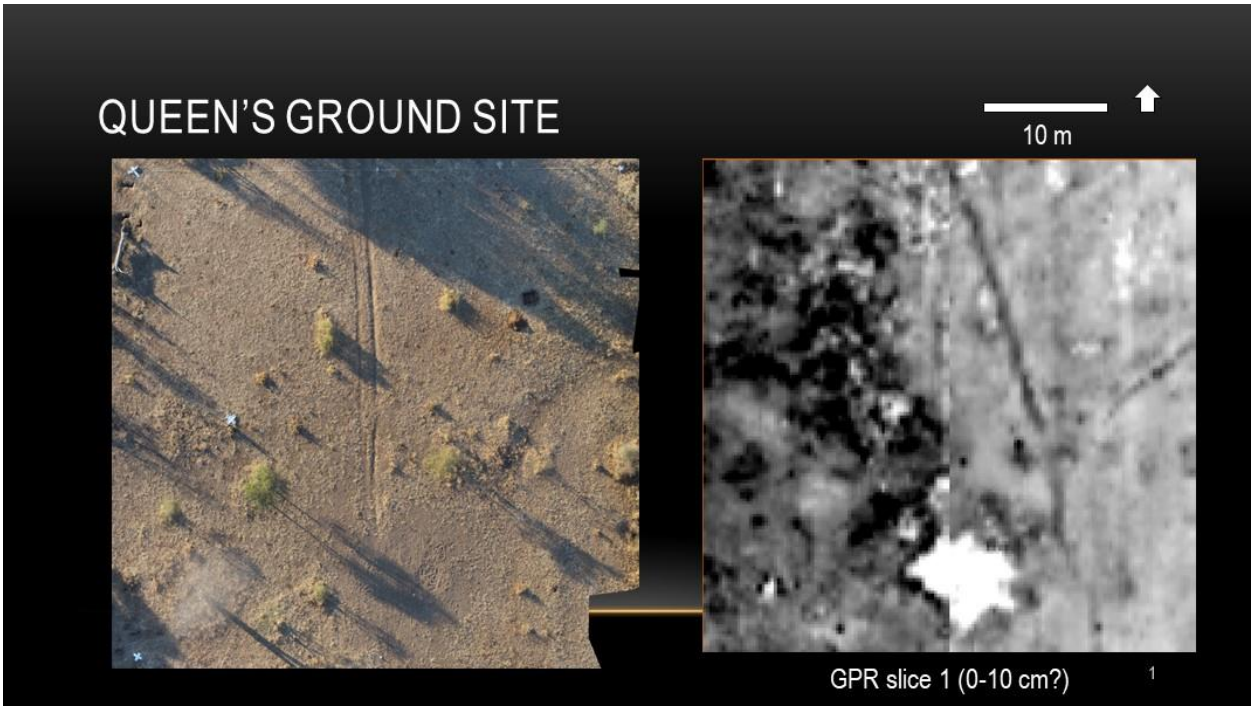
When we arrived in 2014, there were a number of unanticipated issues. The drone platform we hoped to have was unavailable, so a DJI Phantom 2 was used. The Phantom 2 had issues holding the thermal camera, a Tamarisk 320 Thermal, and instability was a major issue, as well as motor burnout. We attempted to do a thermography survey at the two sites: Iron Furnace Site (GPS) and Queen’s Ground Site (GPS). Katie Simon conducted the aerial survey, assisted by Mothusi Maeletsa.

Furthermore, the vegetation was also longer than expected, as the goats that had previously grazed on top of Mmadipudi Hill had been moved due to pythons, which made geosphysical survey difficult. Thus, the grass was knee-high or greater on the hilltop. We attempted to address the problem by hiring workers to hand-cut the grass with machetes.

Lastly, variable wind conditions made kite photogrammetry difficult.

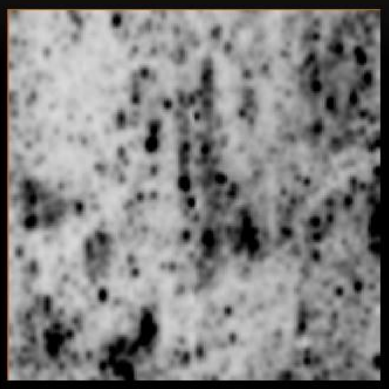
Thus, the SPARC component was ultimately unsuccessful. On the drone imagery: the 30,000+ images per flight from the thermal camera would not mosaic, as the imagery was too blurry: the drone platform was not sufficiently stable to hold the camera still while in flight. Individual inspection for archaeological features was difficult, given the volume of photographs and lack of reference points per B&W frame.

On the photogrammetry attempts: the kite photographs for Mmadipudi Hill were not sufficient for a product. The wind died down before we could get photos of the entire area and the ones we did get do not have sufficient overlap (unfortunately we did not have the luxury of previous experience with the kite on the site to avoid such issues). However, we 1) were able to get a decent photogrammetric RBG image of Queen's Ground Site, which is included below, and 2) the images from QGS and individual images from MH suggest future photogrammetry work will be useful in future survey.

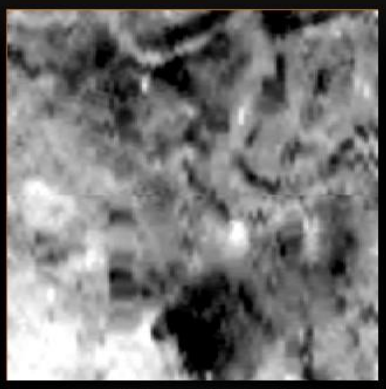


QUEEN'S GROUND SITE

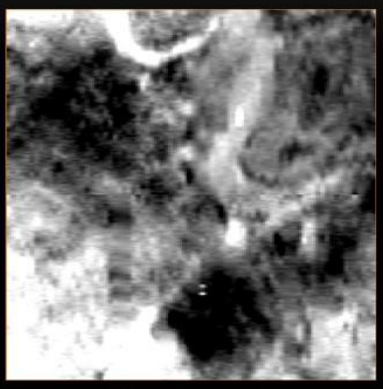
10 m



GPR slice 26 (est. 50 cm)

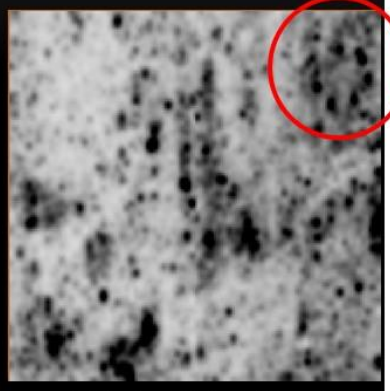


MS (50 cm coil spacing)

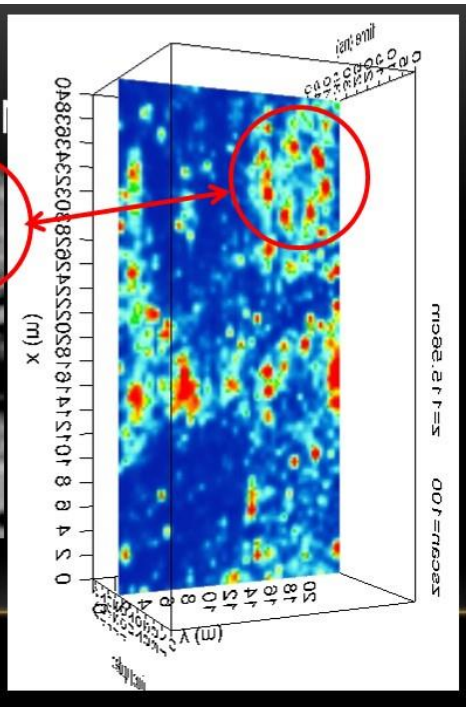


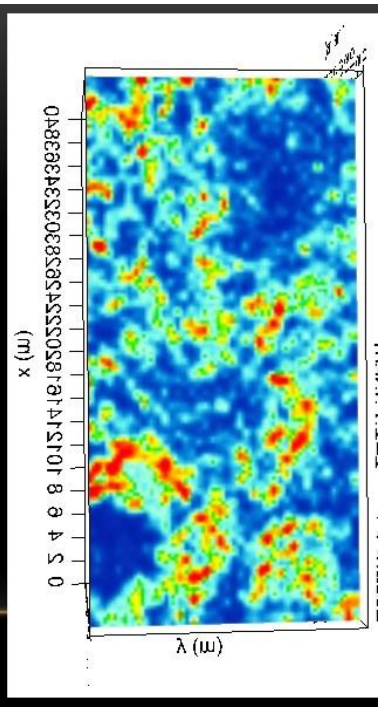
Conductivity (50 cm coil spacing)

QUEEN'S GROU



GPR slice 26 (est. 50 cm)





Presentations

2014. Ernenwein, Eileen, Simon, Katie, and Carla Klehm (Eileen, are these authors/order correct for the project?) Bosutswe Landscapes: Defining Early African Towns through Spatial Archaeometry. 5th International Conference on Remote Sensing in Archaeology. Duke University. October 13.

2015. Carla Klehm, Eileen Ernenwein, Katie Simon, Jeremy Menzer, and Mica Jones. Bosutswe Landscapes: Defining African Complexity through Spatial Archaeometry. Poster Submitted for the Annual Meeting for the Society for American Archaeology. San Francisco.