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LiDAR Mapping of the Tsukuriyama Kofun Group: Research History of Three-Dimensional Surveys

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Located in Okayama City, Tsukuriyama Kofun is the fourth largest mounded tomb in Japan, measuring approximately 350 m in length. In addition to Tsukuriyama Kofun, the Tsukuriyama Kofun Group includes six smaller mounded tombs. These tombs are dated to the Middle Kofun period, or the early 5th century AD. Our project team will conduct three-dimensional surveys of the entire landscape surrounding the Tsukuriyama Kofun Group using UAV LiDAR (Light Detection and Ranging). Previously, Izumi Niiro and the Okayama University Department of Archaeology obtained three-dimensional data of the Tsukuriyama Kofun Group and its surroundings through direct measurement of the ground surface beginning in the 2005 fiscal year. Our project marks the first time UAV LiDAR has been used for a survey of this tomb group.

This paper is divided into three parts. First, I present an overview of the Tsukuriyama Kofun Group, touching upon the layout of the mounded tombs, their chronological positions, and the social structure as seen from the mounded tombs. Second, I introduce the research history of three-dimensional surveys of the tomb group and its environs. Third, I present our outlook for the LiDAR mapping project. I conclude that our LiDAR mapping project will provide detailed data in order to reconstruct the original mound shapes and the surrounding landscape and contribute to the field of LiDAR archaeology in Japan.

Localizada en la ciudad de Okayama, el Tsukuriyama Kofun es la cuarta tumba de montículo más grande de Japón, con una medida de aproximadamente 350 m de largo. Adicionalmente al Tsukuriyama Kofun, el complejo llamado Grupo Tsukuriyama Kofun, contiene seis pequeñas tumbas de montículo. Estas tumbas datan del periodo Kofun medio a principios del siglo V d.C. Nuestro equipo de proyecto realizará estudios tridimensionales de toda el área que rodea al Grupo Tsukuriyama Kofun utilizando UAV LiDAR (Detección de distancia mediante la luz). Anteriormente, Izumi Niiro y el Departamento de Arqueología de la Universidad de Okayama obtuvieron datos tridimensionales del Grupo Tsukuriyama Kofun y sus alrededores mediante la medición directa de la superficie del suelo a partir del año fiscal 2005. Nuestro proyecto es el primero que utiliza UAV LiDAR para el estudio de este complejo de tumbas.

Este artículo está divido en tres partes. En la primera Presento una descripción general del Grupo Tsukuriyama Kofun, haciendo referencia al diseño de las tumbas de montículo, sus posiciones cronológicas

y la estructura social desde el punto de vista de las tumbas de montículo. En la segunda present la historia de la investigación de los estudios tridimensionales del grupo de tumbas y sus alrededores. En la tercera parte present nuestra perspectiva del proyecto de mapeo LiDAR. Concluyo que nuestro proyecto de mapeo LiDAR proporcionará datos detallados para reconstruir las formas originales del montículo y el paisaje circundante, además de contribuir al campo de la arqueología LiDAR en Japón.

Tsukuriyama Kofun[1] (*kofun* is Japanese for "ancient mounded tomb") is the fourth largest mounded tomb in Japan, measuring approximately 350 m in length. Located in Okayama City in Western Japan, the Tsukuriyama Kofun Group is dated to the early 5th century AD and consists of Tsukuriyama Kofun and six smaller mounded tombs (Figures 4.1 and 4.2) Our project team plans to survey the group and surrounding area using UAV LiDAR in 2020. Okayama University previously conducted a digital survey of the Tsukuriyama Kofun Group from fiscal year 2005 to 2009. This pioneering work using 3D data is instructive when preparing our LiDAR mapping project of the mounded tomb group and its environs.

This paper consists of three parts. First, I will introduce the Tsukuriyama Kofun Group, including its location, the layout of its mounded tombs and their chronology, and the relationship between the mounded tombs and settlements. Second, I will provide an overview of research history on three-dimensional mapping of the tomb group. Third, I will present our research plan and outlook concerning the LiDAR mapping project.

1. Overview of the Tsukuriyama Kofun Group

Tsukuriyama Kofun is located at the end of a tongue-shaped plateau extending from the south. Located near the Ashimori River, it was made using the natural land. This area is considered to have been the traditional center of the Okayama Plain during the Yayoi and Kofun periods. The nearby Tatetsuki burial mound, measuring 80 m in length, is the largest mound of the Late Yayoi period, before the emergence of the standardized mounded tombs (*kofun*) of the following Kofun period (Kondō, ed., (*kofun*) of the

Figure 4.1.

Bird's-eye view of Tsukuriyama Kofun (provided by Izumi Niiro; Niiro ed., 2012).

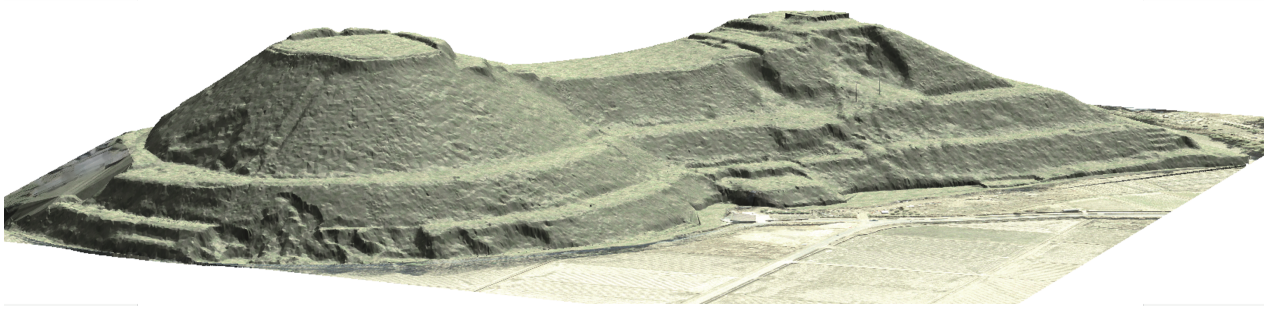
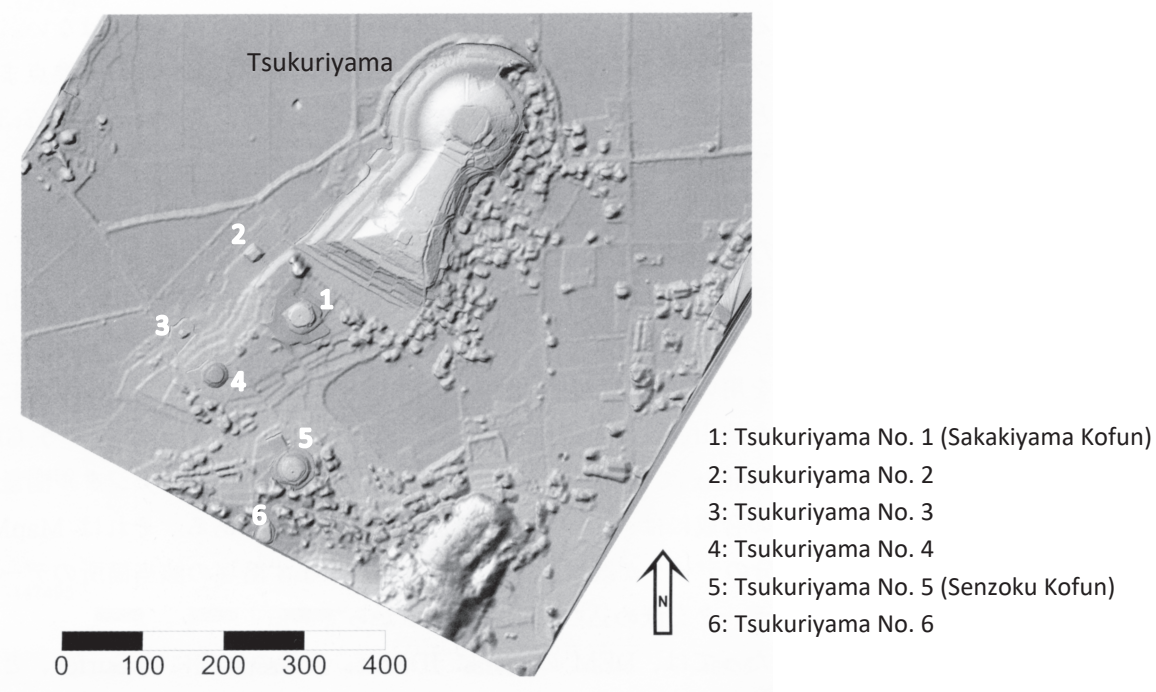


Figure 4.2.

Map of the area surrounding the Tsukuriyama Kofun Group (Teramura, 2012).



following Kofun period (Kondō, ed., 1992), and the nearby Tsudera site is one of the main settlements and rice paddy field sites on the Okayama Plain (Kameyama, 1996).

The location of the 5th-century Tsukuriyama Kofun Group suggests that its construction may have been related to the economy in the area. The San'yōdō, an ancient highway built around the late 7th century AD as a national project, ran between mounded tombs No. 5 and 6 at the southern end of the tomb group. The three major mounded tombs in Okayama Prefecture, namely Tsukuriyama (Zōzan), Tsukuriyama (Sakuzan), and Ryōgūzan, which all belong to the 5th century AD, are all also distributed along this ancient thoroughfare. It can therefore be assumed that this ancient highway played an important role as a traditional traffic route as far back as the 5th century.

As mentioned above, the Tsukuriyama Kofun Group is dated to the first half of the Middle Kofun period, or the early 5th century AD. The latest chronology suggests that it belongs to Phase 6, with some differences in construction period between each tomb within this phase (Yasukawa, 2020). According to the chronology of cylindrical haniwa, Tsukuriyama Kofun and two mounded tombs at the southern end of the group (Nos. 4 and 5) were built first, followed by the two mounded tombs in the northern part (Nos. 1 and 2). The detailed chronological positions of mounded tombs No. 3 and 6 are not clear.

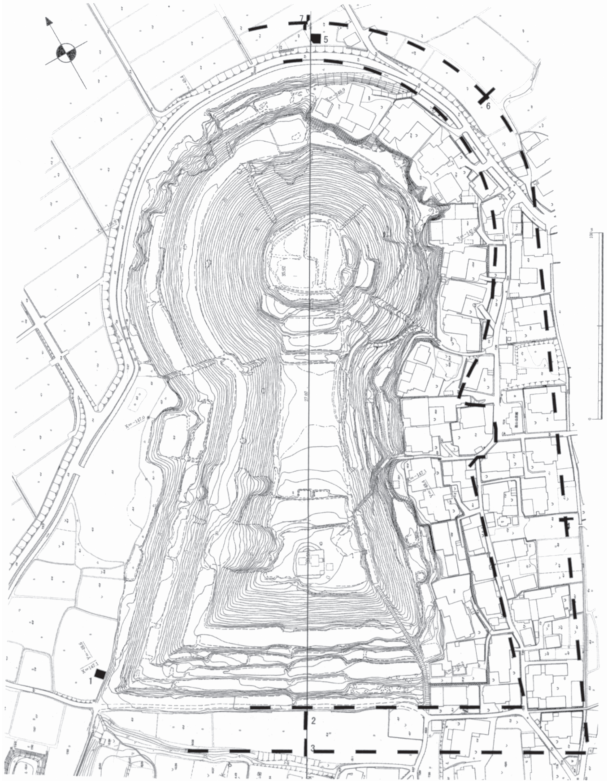
The layout of the *kofun* group is characteristic of the Middle Kofun period, with a main mounded tomb surrounded by several subsidiary tombs located on an open plain. During the preceding Early Kofun period, on the other hand, mounded tombs were generally built atop hills, tucked away within nature. Symbolic meaning associated

with mounded-tomb building may have changed between the Early and Middle Kofun period.

While the burial facility of Tsukuriyama Kofun has not been excavated by archaeologists, the mound was excavated by the Archaeology Department of Okayama University and the Okayama City Board of Education. Excavations carried out by the Okayama University team revealed a surrounding moat (Figure 4.3; Niiro ed., 2012), the existence of which previous scholars had suggested based on the current topography, in particular the rounded shape of the surrounding paddy field.

Figure 4.3.

Reconstruction of the surrounding moat of Tsukuriyama Kofun (Niiro ed., 2012).



Some artifacts found from the Tsukuriyama Kofun Group originated from distant areas. For example, the stone coffin said to be from Tsukuriyama Kofun was made from the tuff of Mt. Aso in Kumamoto Prefecture, Kyūshū (Takagi & Watanabe, 1990). By sea, the distance traveled measures over 600 km. Additionally, the stone chamber of Tsukuriyama No. 5 (also known as Senzoku Kofun) also displays ties to Kumamoto Prefecture and the horse-shaped belt buckle said to be from Tsukuriyama No. 1 (Sakakiyama Kofun) was imported from the Korean Peninsula (Nishikawa, 1986). In this manner, I consider mounded tomb construction to have been a system in which the external was transformed into the internal through the interaction of nature, artifacts, and humans.

As there are no historical documents or findings of directly neighboring settlements, it is not clear who created the Tsukuriyama Kofun Group. A major settlement during the Middle Kofun period may have been located around the Takatsuka site, located approximately 1.4 km north. 38 dwellings have been found dating to the first half of the Middle Kofun period (Hirota, 2000). On the other hand, the area around the Tsudera site, located around 1.0 km to the northeast, was adversely affected by the flooding of the Ashimori River in the latter half of the Early Kofun period, before the construction of Tsukuriyama. At the Tsudera site, while 83 dwellings were uncovered belonging to the Early Kofun period, only one dwelling was found dating to the end of this phase, signaling a drastic decrease (Kameyama 1996). Additionally, only 19 dwellings were found from the entire Middle Kofun period, relegating the Tsudera site from its status as a central settlement to a normal village.

The archaeological data leads us to the following questions: Where did the individual buried in Tsukuriyama Kofun come from? Where did he live? Did he live locally? According to recent research on kinship during the Kofun period, male elite of the political center (the modern Nara

and Osaka Prefectures) were sometimes buried in distant, peripheral regions tied to their matrilineal side (Seike, 2018). The individual buried in Tsukuriyama Kofun, the fourth largest mounded tomb in Japan, may therefore not have lived in what is currently Okayama Prefecture, but rather may have been active in the political center. In such a case, familial ties to the ancient Okayama region would have made possible the construction of these mounded tombs on the Okayama Plain.

2. Research History of Three-Dimensional Surveys of the Tomb Group and its Environs

Professor Izumi Niiro and the Okayama University Department of Archaeology conducted digital surveys of the Tsukuriyama Kofun Group from fiscal year 2005 to 2009 (Niiro ed., 2008, 2012). They used a total station to calculate the XYZ coordinates of the mound surfaces at 50-cm intervals, taking care to accurately reflect subtle changes in topography, such as between the slopes and terraces. It took approximately 120 days for one team consisting of three to four people to calculate 120,000 points at Tsukuriyama Kofun (Niiro ed., 2008, p. 8). The team succeeded in producing a contour map and bird's eye view of Tsukuriyama Kofun. Additionally, using the same method, his team completed measurements on almost all surrounding smaller tombs (Table 4.1).

Hirofumi Teramura produced a digital elevation map for the Tsukuriyama Kofun Group and its environs based on aerial photographs and combined this with XYZ coordinates recorded for each mounded tomb (Teramura 2012).

While we can now utilize 3D laser measurements or photogrammetry to measure sites more easily and quickly, their team's research, based on systematically collected digital points with XYZ coordinates, was nevertheless pioneering. Their thorough recording of ground data ensured actual measurement of the mound surface. On the other hand, this method requires a considerable amount of time and the whole landscape surrounding the Tsukuriyama Kofun Group cannot be easily recorded.

Table 4.1.

Digital measurements of the Tsukuriyama Kofun Group (from fiscal 2005 to fiscal 2009).

Mounded tomb	Mound shape	Length (m)	Method	Measured points
Tsukuriyama Kofun	Keyhole	350	Total station	120,000
Tsukuriyama No. 1 (Sakakiyama Kofun)	Round?	35	Total station	12,025
Tsukuriyama No. 2	Square	40	Total station	2,649
Tsukuriyama No. 3	Round	30	Total station	2,248
Tsukuriyama No. 4	Scallop shell?	35	Total station	7,484
Tsukuriyama No. 5 (Senzoku Kofun)	Scallop shell	81	Total station	13,264
Tsukuriyama No. 6	Round	30	Total station	3,501

3. Outlook for LiDAR Mapping

LiDAR enables us to accurately map the mounded tomb group and surrounding terrain. Three academic questions inform our LiDAR mapping project. The first question is how we can reconstruct the original shape of the mounded tombs. For instance, the topographic data around Tsukuriyama Kofun will be highly instructive in reexamining the extent of the surrounding moat. We will be able to examine the shape of the moat based not only on its planar shape, but also its altitude. The shape of the surrounding moat is important when comparing Tsukuriyama Kofun with the royal tombs located in the Kinki region.

The second question is why this location was chosen for the construction of the mounded tomb group. I view the construction of the Tsukuriyama Kofun Group as being connected to redevelopment activity following the flooding of the Ashimori River. The construction project of the mounded tomb group may have been closely related to the leveling of the tongue-shaped plateau attending the construction of the ancient thoroughfare. The construction process of Tsukuriyama Kofun and the two smaller mounds close to the road, which were built earliest in the tomb group, may have been intimately related to this development project.

The third question is how we can contribute to the field of LiDAR archaeology. Our project team will carry out LiDAR mapping of Tsukuriyama Kofun and its surroundings and analyze the data at our laboratory. In Japanese archaeology, while the entirety or parts of this process have normally been contracted out to surveying companies, we consider it important to conduct the whole process in order to achieve a greater understanding and further develop LiDar applications in archaeology.

We conducted a test flight at Tsukuriyama Kofun in the latter half of March 2020. In the near future, our team will conduct a full-scale mapping covering a 1 km square area over the mounded tomb group.

Note

1. There are two giant keyhole-shaped mounded tombs in Okayama Prefecture whose Chinese characters can be read as “Tsukuriyama”. In order to differentiate these two tombs, an additional reading of their characters is employed: Consequently, the Tsukuriyama Kofun of this paper is often called “Zōzan” Kofun and the other example “Sakuzan” Kofun.

References

Hirota, M. (2000). Kofun jidai no shūraku ni tsuite [On the settlements of the Kofun period]. In M. Emi (Ed.), *Takatsuka iseki, Mite iseki: 2* (pp. 1032–1037). Okayama Prefecture Board of Education.

Kameyama, Y. (1996). Kofun jidai [The Kofun period]. In Y. Kameyama (Ed.), *Tsudera iseki: 3* (pp. 187–190). Okayama Prefecture Board of Education.

Kondō, Y. (Ed.). (1992). *Tatetsuki Yayoi funkyūbo no kenkyū* [Research on the Tatetsuki Yayoi burial mound]. Tatetsuki kankōkai.

Niiro, I. (Ed.). (2008). *Okayama-shi Tsukuriyama Kofun sokuryō chōsa gaihō* [Preliminary report on the survey of Tsukuriyama Kofun in Okayama City]. Graduate School of Humanities and Social Sciences, Okayama University.

Niiro, I. (Ed.). (2012). *Okayama-shi Tsukuriyama Kofun-gun no chōsa gaihō* [Preliminary report on the survey of the Tsukuriyama Kofun Group in Okayama City]. Graduate School of Humanities and Social Sciences, Okayama University.

Nishikawa, H. (1986). *Sakakiyama Kofun*. In Okayama-ken-shi Henshū Iinkai (Ed.), Okayama-ken-shi, *Vol.18* (p. 344). Okayama Prefecture.

Seike, A. (2018). *Maisō kara mita Kofun jidai* [The Kofun period seen through burials]. Yoshikawa kobunkan.

Takagi, K., & Watanabe, K. (1990). Sekkan kenkyū e no ichi teigen: Aso-ishi no gonin to pinku-ishi sekkan no keifu [A suggestion for research on stone coffins: The misidentification of Aso stone and the lineage of pink-stone coffins]. *Kodai Bunka*, *42*(1), 21–32.

Teramura, H. (2012). Tsukuriyama kofun baichō no funkyū dejitaru sokuryō [Digital survey of the satellite tombs of Tsukuriyama Kofun]. In I. Niiro (Ed.), *Okayama-shi Tsukuriyama Kofun-gun no chōsa gaihō* (pp. 46–60). Graduate School of Humanities and Social Sciences, Okayama University.

Yasukawa, M. (2020). Okayama (Zōzan Kofun, Sakuzan Kofun, and Ryōgūzan Kofun): Kofun jidai chūki Kibi ōken no seikaku [Okayama (Zōzan Kofun, Sakuzan Kofun, and Ryōgūzan Kofun): The nature of the Kibi polity during the Middle Kofun period]. In Nihon Kōkogaku Kyōkai FY2019 Okayama Taikai Jikkō Iinkai (Ed.), Nihon Kōkogaku Kyōkai 2019 Okayama Taikai kenkyū happyō shiryōshū (pp. 143–154). Nihon Kōkogaku Kyōkai FY2019 Okayama Taikai Jikkō Iinkai.

This work was supported by Grant-in-Aid for Scientific Research on Innovative Areas JP19H05732 “Integrative Human Historical Science of "Out of Eurasia"”.