

# EVALUATION ON THE DISTRIBUTION OF BURIED STONE WALLS AND BANKING CONSTRUCTION OF THE FORMER OSAKA CASTLE WITH DRILLING DATA, CENTRAL JAPAN

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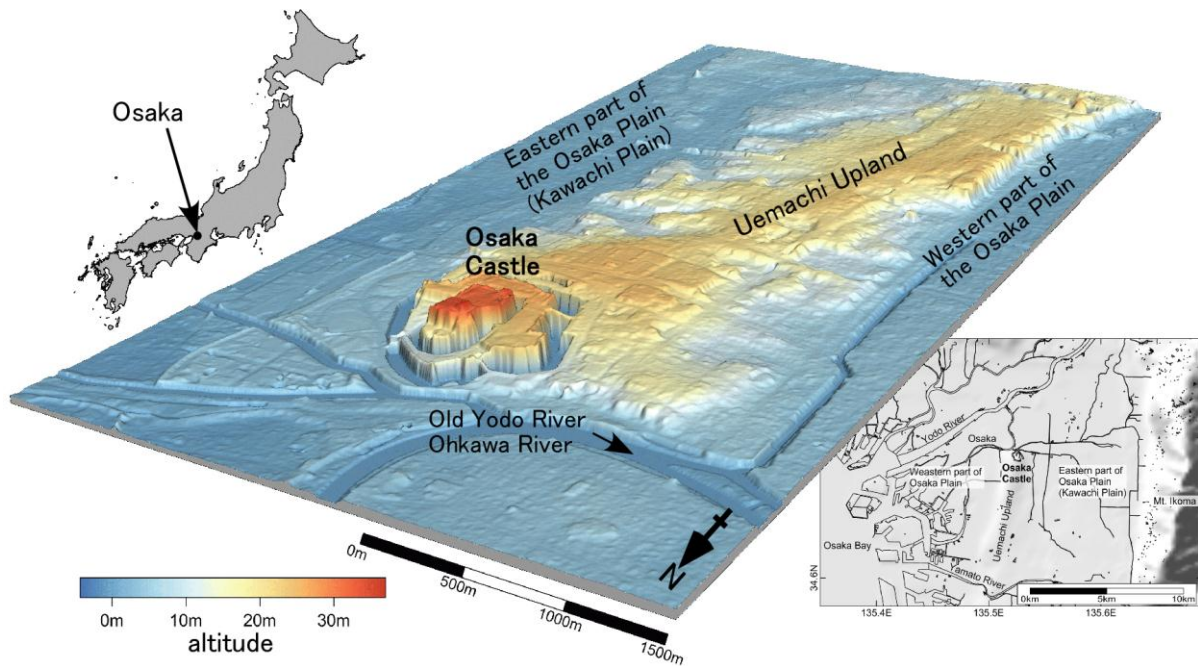
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## ABSTRACT

*The Osaka Castle which was built in the 17<sup>th</sup> century by Hideyoshi Toyotomi is one of the historical heritages in Osaka. The current main tower of castle is built in 1931 through destructions and constructions. On the other hand, the castle ground and stone walls reconstructed by Tokugawa shogunate are conserved till today. The Toyotomi-built castle stone walls buried under the current ground from 2 to 8 meters deep are found at several sites in the castle main area by academic investigation. There are more than 70 drilling site in the castle main area. These data has been used for the restoration of the Toyotomi-built castle and stone walls. In this paper, the drilling database with these drilling data and 3D surface models of natural layer and the Toyotomi-built castle ground are re-evaluated. These 3D surface models clarify the relation between former natural topography and the castle constructions.*

## 1. INTRODUCTION

Osaka Castle is located northern end of the Uemachi Upland in the central Osaka Plain (Figure 1). The castle ground is constructed on the Pleistocene sedimentary layers by banking with earth materials of 5 to 20 meters in thickness. Osaka Castle is began the construction at the former site of Osaka Honganji Temple by Hideyoshi Toyotomi in 1583. The construction of the Main Area (Honmaru) and the Main Tower (Tenshu-kaku), it has taken a period of one and a half years. After Hideyoshi's death, Ieyasu Tokugawa ruined the Toyotomi family and destroyed Osaka Castle in 1615. After that, the Tokugawa shogunate reconstructed Osaka Castle in 1629. This castle ground was reconstructed on a larger scale with banking on the former ground of Toyotomi-built castle. The Tokugawa-built castle had been used until 1868, when the Tokugawa shogunate lost power and the castle fell. The current Main Tower was reconstructed with funds raised by the citizens in 1931. The remaining magnificent moats and the stone walls consisting of numbers of huge stones are constructed by the Tokugawa shogunate. The high stone wall along the Inner Moat is the greatest stone wall in Japan. The some stone walls constructed by Toyotomi are found from the depth of 1 to 8 meters underground in the main castle area. Several academic researchers have been carried out for the buried Toyotomi-built stone walls with drillings and excavations. The scientific investigation of Osaka Castle has been start from 1959. At the first investigation, a corner



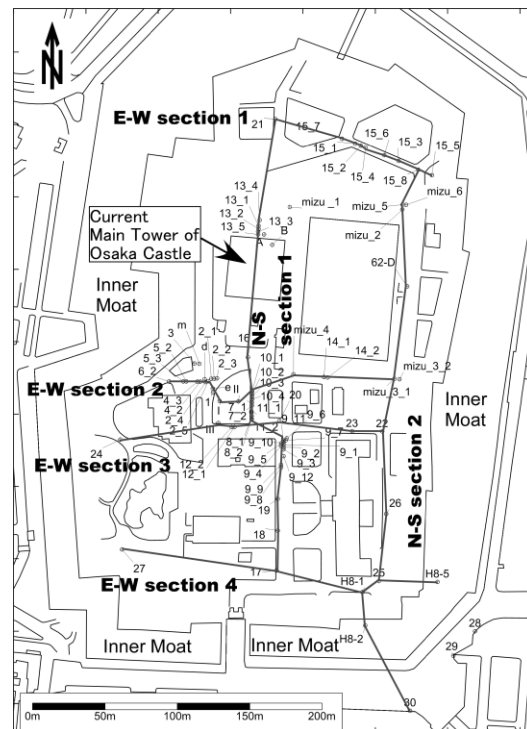
**Figure 1. Location Map and Topography around the Osaka Castle**

stone wall is found from 8 meters underground in the western part of the main castle area. Until today, drilling data at more than 70 sites in the main castle area are stored in the Osaka Castle Museum (Figure 2). Situations on subsurface ground in the main castle area, such as the depth on granitic rocks of the part of stone walls, lithology of earth fill, N-values of standard penetration tests, assumed boundary between fills and natural layer, etc., are described in documents of drilling.

In this study, the distribution of stone wall and the ground surface of the Toyotomi period are re-evaluated with stored drilling data.

## 2. GEOMORPHOLOGY AND GEOLOGY

The Osaka Castle is located in the northern margin of the Uemachi upland where ground surface ranges from 20 to 25 meters in altitude (Figure 1). The Upper Pleistocene terrace deposits ranging from several to 20 meters in thickness are widely distributed in the upland area. The middle part of the Upper Pleistocene deposit is called Ma12 bed which consists of marine clay. Under the Upper Pleistocene terrace deposits, The Middle to lower Pleistocene Deposits which are correlated with the Osaka Group and higher terrace deposits, are widely distributed. Toyotomi-built bank is constructed on these natural deposits. The Tokugawa shogunate-built bank covers also Toyotomi-built bank.



**Figure 2. Location map of drilling site and profile lines**

### **3. DRILLING DATABASE AND PROFILE SECTIONS**

#### **3.1 Database System**

Drilling data at more than 70 sites are summarized as drilling database. This database is constructed with the original database software on the Microsoft Visual Basic. Each drilling data consists of lithology and N values of standard penetration tests. The distribution of the natural sedimentary layer and lithology of banked materials, and the location of the buried stone wall are evaluated by drawing cross sections with this database software.

#### **3.2 Profile Sections and Lithological Distribution**

Figure 3.4 are shows typical profile sections in the main area of the Osaka Castle. In the western part of the main castle area, the natural sedimentary layers consisting of the Middle Pleistocene sandy alternation are mainly distributed under the artificial banked layers. On the other hand, the Upper Pleistocene marine clay bed and sandy layers distributes under the artificial banked layers in the southeastern part. The boundary between the natural and artificial layers is gently dips to northward from 24.5 to 7.5 meters in altitude. Valleys are respectively observed on east and west part of former natural ground surface.

### **4. DISTRIBUTION OF BURIED TOYOTOMI-BUILT STONE WALL**

A pictorial figure of the Toyotomi-built castle is remained at the family related the re-construction of the castle by the Tokugawa shogunate. The location of the Toyotomi-built stone walls in this figure has been modified with the drilling data detected the stone wall rocks. The top levels of the Toyotomi-built stone walls are divided into 3 levels, such as 17-22, 24-25, over 26 meters in altitude (Figure 5). The altitude of the stone wall in northern part of main castle area is highest in the surrounding area. The Toyotomi-built ground formation level ranges from 24 to 28 meters in altitude. In the southern part of the main castle area, the ground formation level is concordant with the natural layer surface level. The northern part of this ground formation level, forming the Toyotomi's main castle area, is higher than the surrounding part, and ranges 27 to 28 meters in altitude. Therefore, the northern part of the Toyotomi-built castle mound, consisting of mainly clay materials and partly gravel materials over 15 meters thick, is thicker than the southern part. The southern shallow inner mort "Kara-Hori" was excavated to the upper surface level of the Upper Pleistocene marine clay bed. On the other hand, the eastern inner mort "Higasi-uchi-bori" was excavated to the base level of the marine clay bed.

The Tokugawa-built castle mound completely covers the Toyotomi-built castle mound with banked clayey materials of 5 to 8 meters thick. The thickness of filled up part of the Toyotomi-built mort ranges more than 15 meters thick. The ground surface restoration at the Toyotomi period is referring to the remaining pictorial diagram on the outline features of Toyotomi-built Osaka Castle.

### **5. 3D SURFACE MODEL**

The 3D surface models of the upper surface of natural layer and the ground surface of the main part of Toyotomi-built Osaka Castle are made as the result of the estimation (Figure

6). The recent surface model is made from 5 interval mesh DEM of Geospatial information

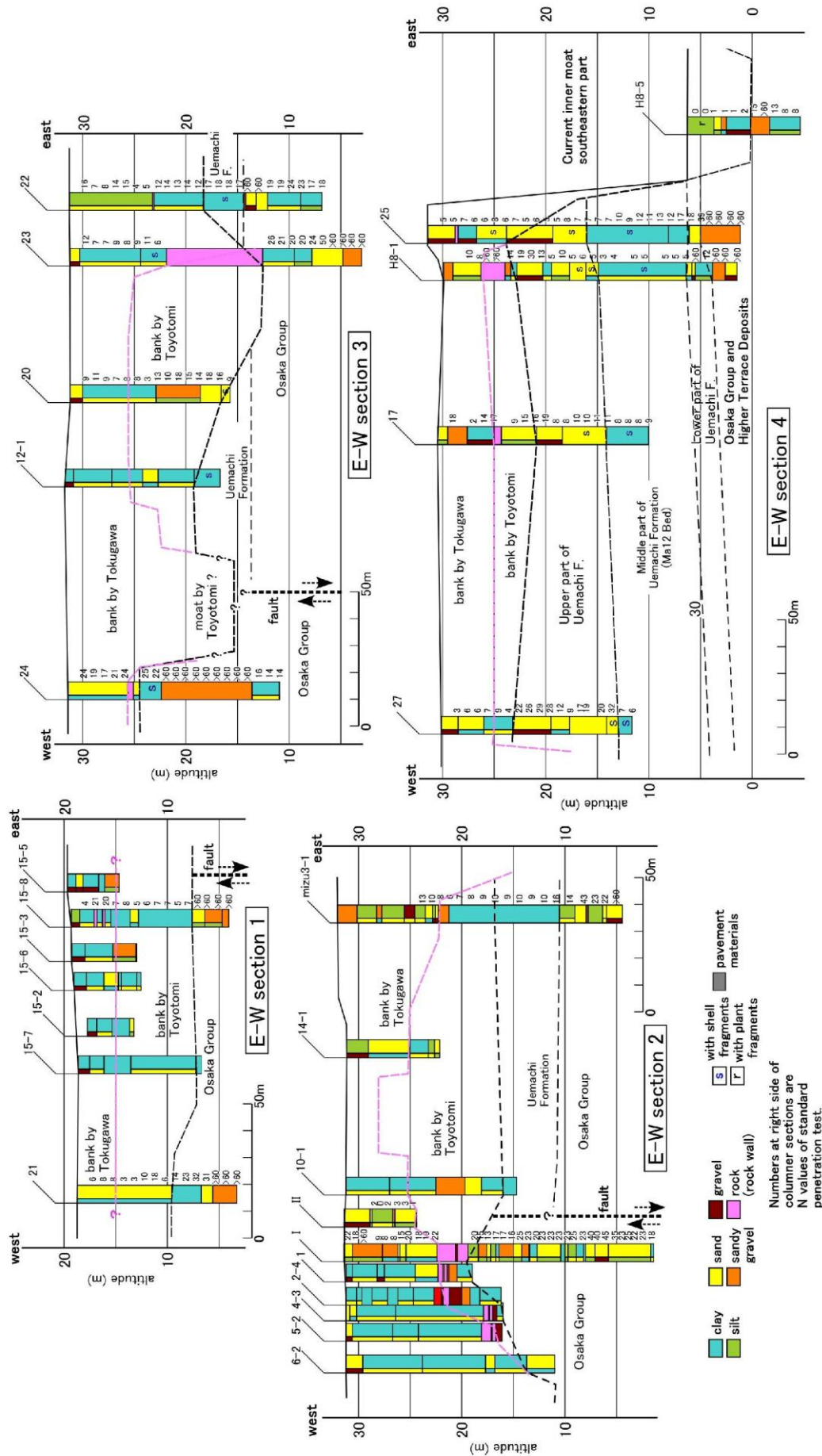


Figure 3. East-West profile sections in the main area (Hon-maru) of the Osaka Castle.

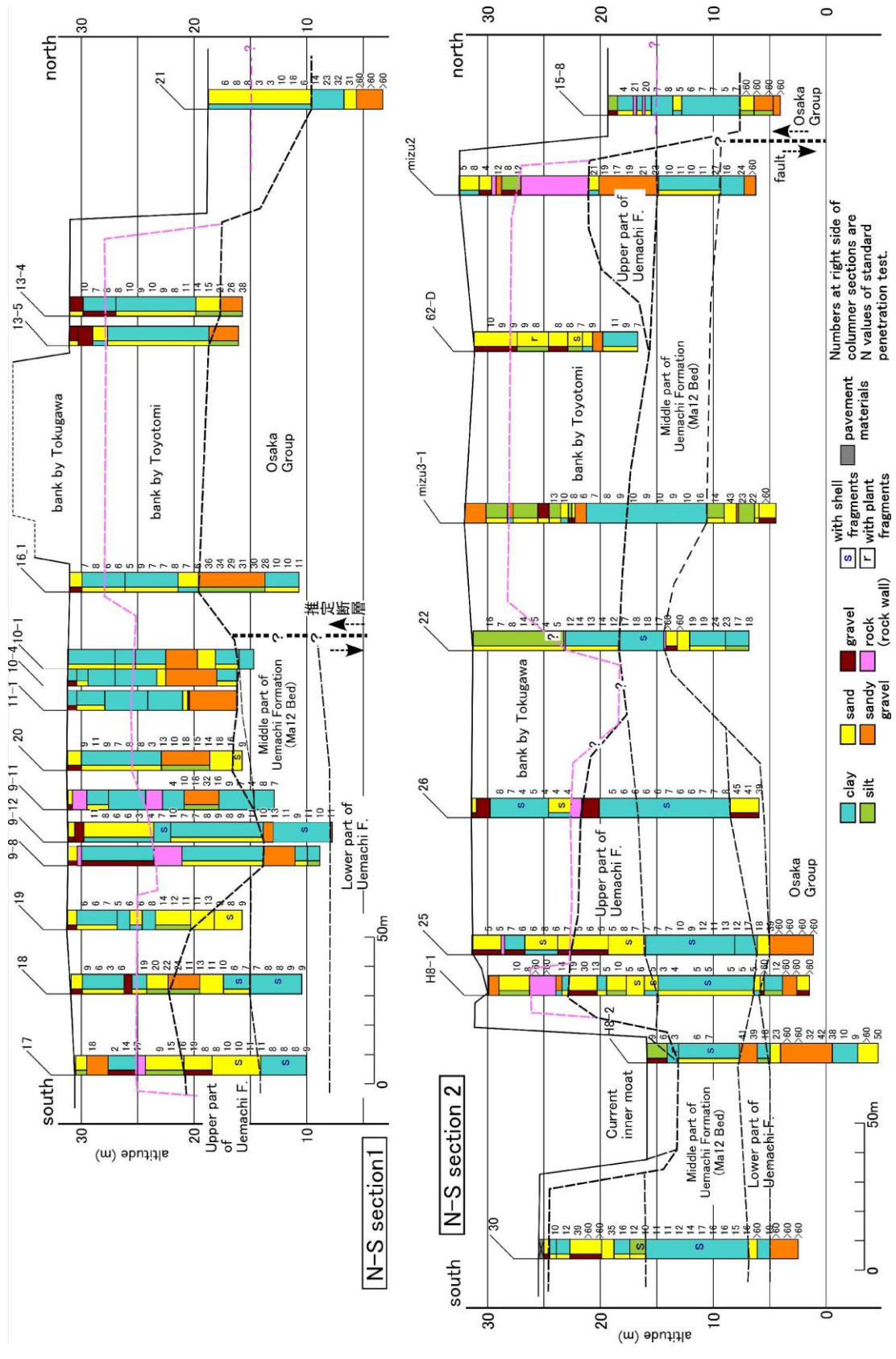
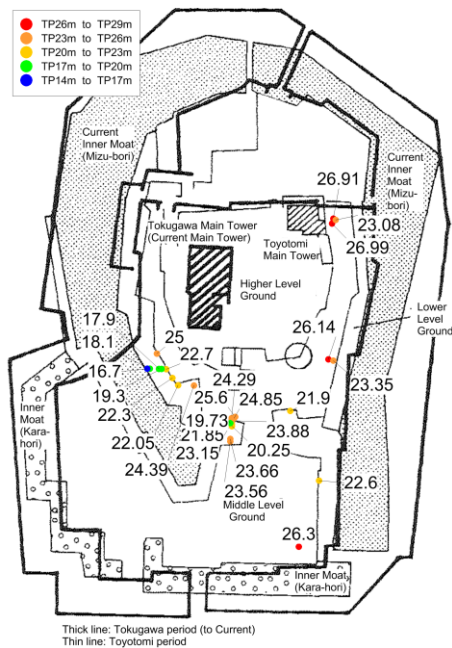


Figure 4. North-South profile sections in the main area (Hon-maru) of the Osaka Castle.

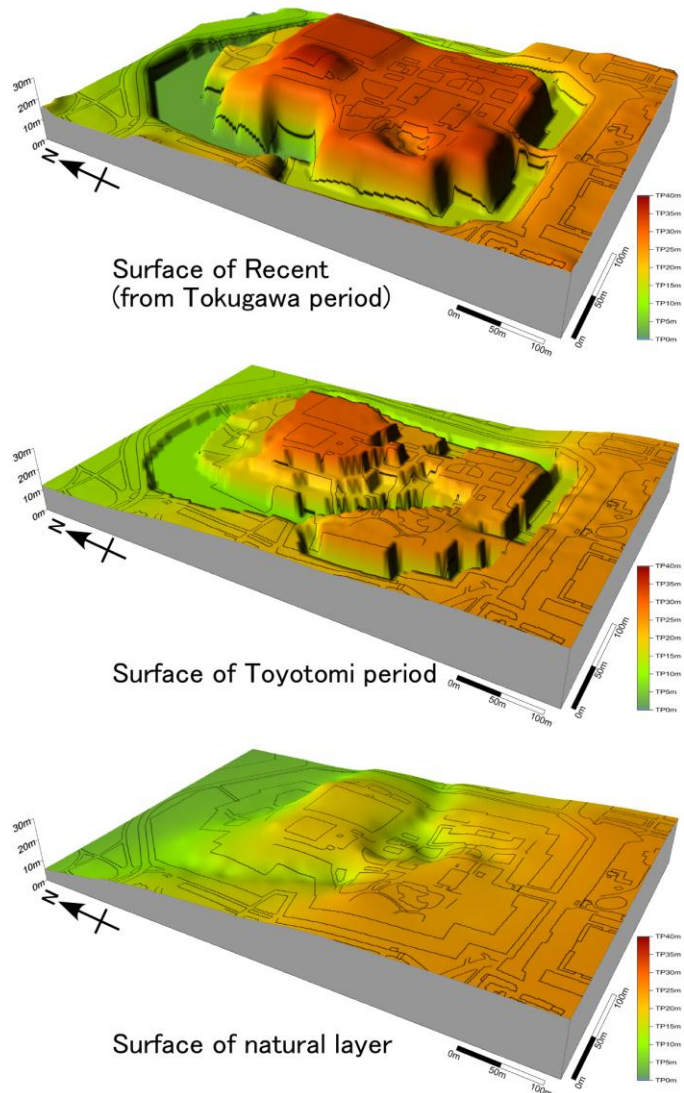


**Figure 5. Top level of detected buried stone wall site and the correlated Toyotomi-built stone wall line**

Authority of Japan. The Toyotomi-built Osaka Castle surface model is estimated from the upper level of the detected stone wall drilling sites and the modified pictorial diagram. As mentioned above, there are three levels, such as lower, middle, and upper level, in the main area of the Toyotomi-built Osaka Castle. The altitude of the each level is estimated the distribution of the top altitude of the detected the stone wall rocks. The surface model of the natural layer is also estimated from drilling data at sites detected natural layer. The surfaces, which are 10 meter interval DEMs of natural layer and the Toyotomi-built ground surface, are estimated by the Kirging method with the spatial data of drill sites.

## 5. CONCLUSION

In this study, the 3D surface model of the main area in Osaka Castle at each period with the results of the former academic survey. As the result of making of the 3D surface model, followings became clear. Because the Osaka Castle is located at the northern margin of the Uemachi upland, the surface altitude of the natural layer descends toward north. Two incised valleys of east and northwest direction erode the northern marginal slope. The Toyotomi-built Osaka Castle was constructed according to the terrain. On the other hand, the Tokugawa-built castle was constructed with filling up the area from the lower to middle level of the Toyotomi-built castle ground.



**Figure 6. 3D surface images of the Osaka Castle at each period**