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The Monumental Grave Mound Yığma Tepe – Results of the Geophysical-archaeological Cooperation

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The Monumental Grave Mound Yığma Tepe – Results of the Geophysical-archaeological Cooperation

Matthias Meinecke – Rebekka Mecking – Wolfgang Rabbel – Ercan Erkul – Anneke Keweloh-Kaletta – Felix Pirson

1. Introduction

With a diameter of 158 m, the Yığma Tepe (Turkish: artificially raised mound) is the largest of the tumuli in the southern plain of Pergamon (Türkiye) and part of the UNESCO World Heritage. It is 32 m high, surrounded by a large ditch of 62 m in width and 11,4 m in depth, and lies in a central and dominant position directly opposite the city hill (see fig. 1 in the contribution of F. Pirson in this volume). Thought to be the grave of an Attalid king, early on it attracted travellers and scholars[1] but also pre-modern treasure hunters as the huge trench in its north-western flank and its flattened top with two summits indicate[2]. Nevertheless, the monument still reaches a height of 34 m over the current surface of the fluvial plain of the Bakır Çayı (ancient Kaikos). First scientific excavations were carried out from 1905 to 1909 by Wilhelm Dörpfeld and the German Archaeological Institute[3]. He excavated the large circular wall (*krepis*) at the base of the tumulus completely in search of an entrance or dromos to a grave chamber. As this was unsuccessful, he dug a radial trench from the perimeter using the pre-existent depression in its north-western flank and later a tunnel to the centre of the tumulus at ground level (fig. 1). Despite additional transversal tunnels and extensive search drillings, which were driven from the centre of the mound in every direction, no evidence for a burial could be found and the excavation was abandoned.

Over one hundred years later, in 2014, the monument again became the target of field work with the start of the new interdisciplinary geophysical-archaeological project in the context of NekroPergEol. Every year until 2019, with the exception of 2016, extensive geophysical prospections were carried out by the Christian-Albrechts-Universität zu Kiel (Germany) and the Kocaeli Üniversitesi (Türkiye) as partners of the Pergamon Excavation of the German Archaeological Institute. In order to gain the most comprehensive understanding of the construction of the Yığma Tepe, this work was complemented by small-scale excavations in 2015, 2017 and 2019 by the Pergamon Excavation Team. Additionally, the re-evaluation of Dörpfeld's excavation results, started in 2010 by Ute Kelp, was completed[4].

The aims of the geophysical project were (i) to clarify the structural composition of the burial mound and (ii) to find evidence for deep-set structures throughout the area without disturbing its surface. The complementary excavations were intended to (iii) clarify the origin and composition of some of the near-surface anomalies of the geophysical survey, (iv) deliver archaeological material for dating the con-

1 A report of these tumuli was first given by Cyriacus of Ancona 1431 and 1444 (Ziebarth 1902, 445), later by Smith 1678, 219; Dellaway 1797, 301 and Choiseul-Gouffier 1809, 31.

2 This cut was already mentioned by Choiseul-Gouffier 1809, 31.

3 His work was published in three short excavation reports: Dörpfeld 1907, Dörpfeld 1908a, Dörpfeld 1910 and summarised by Conze 1913, 240–242.

4 Project »Die Nekropolen von Pergamon« of the University of Cologne (Michael Heinzelmann) in cooperation with the German Archaeological Institute Istanbul (Felix Pirson) financed by the Deutsche Forschungsgemeinschaft between 2011 and 2013. Concerning the Yığma Tepe: Kelp 2011a, Kelp 2014, Kelp 2016. It was continued by Matthias Meinecke in his unpublished Master thesis at Leipzig University in 2016.

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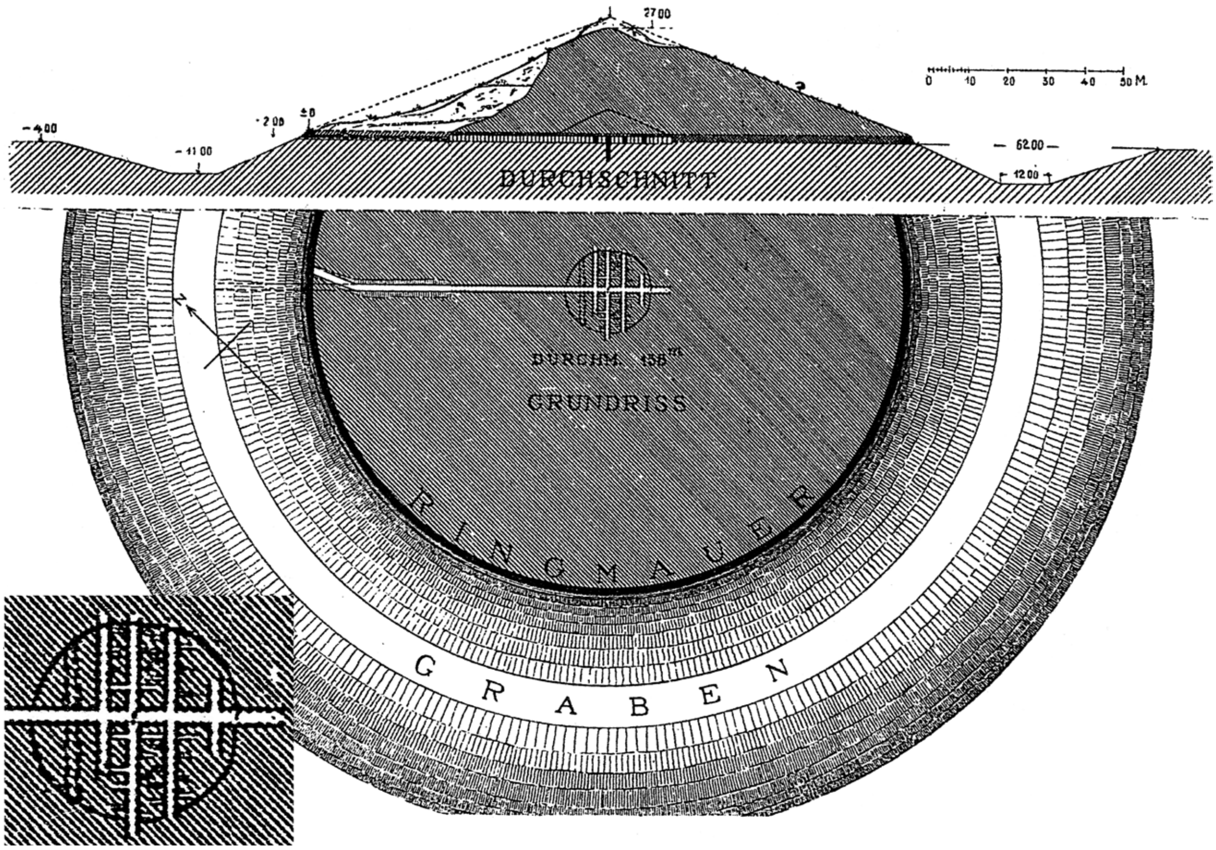


1 Yığma Tepe. Drawings of Dörpfeld's excavations (1905–1909). Core mound and three stratigraphic units of the embankment (top); magnified position of his tunnel system and central posts (bottom left)

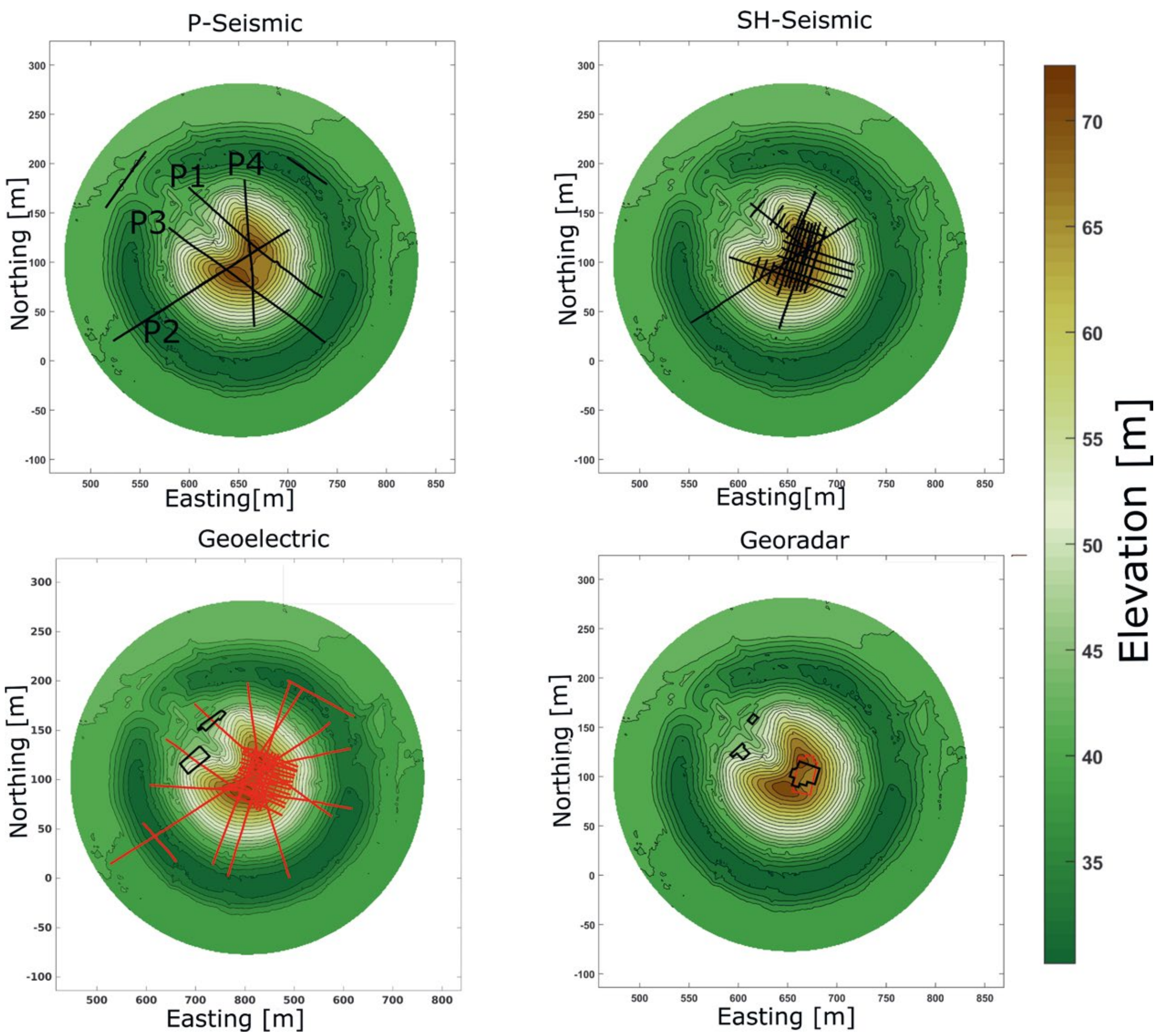
struction and use of the Yığma Tepe and (v) give further insights into its construction. In the interests of this interdisciplinary research design, the results of the prospection served as a basis for small, targeted excavations. Additional geophysical measurements close to the excavation trenches were implemented to improve the understanding of the excavated structures. As field work was carried out simultaneously, it allowed a continuous adjustment of the geophysical measurements on the basis of the excavation results. In this paper we want to present and discuss the major outcomes of the project in a summarised way[5].

2. Geophysics

2.1 Geophysical measurements at the Yığma Tepe

The geophysical survey included seismic, geoelectric, magnetic and georadar measurements (see contribution by W. Rabbel – E. Erkul – R. Mecking – H. Stümpel). The geophysical prospection of the burial mound Yığma Tepe was divided into two parts (fig. 2): On the one hand, near-surface investigations with ground penetrating radar (GPR) and geoelectrics (ERT) were used, which allowed identification of building structures in the uppermost few metres. On the other hand, seismic measurements were applied for the in-

5 A more detailed monographic study of the interdisciplinary research project on the Yığma Tepe is part of the PhD project of Matthias Meinecke at Leipzig University (supervised by Felix Pirson and Ulrich Veit).



2 Maps showing the position of the profiles applying different geophysical methods

vestigation of the stratigraphy of the hill and the identification of possibly deep-lying building structures, as only this method is capable of surveying the entire hill.

2.1.1 Refraction seismic

During seismic measurements acoustic waves are generated by a hammer blow, which pass through the subsurface and are registered by seismic receivers along a profile. For a refraction seismic evaluation, the shortest propagation times of the seismic waves along a profile are used to create a model of the spatial distribution of the seismic wave velocities in the subsurface. By differentiating areas of varying seismic velocities, layer models of the subsurface can be generated.

P-wave seismic measurements were conducted along four long profiles crossing the entire diameter of the tumulus, two of them also reaching into the surrounding ditch (fig. 2). With a refraction seismic evaluation of these profiles, a 3D stratigraphic model of the hill was assessed. Additional shorter profiles outside the tumulus area and in the ditch were measured to get information about the original stratigraphy and the original depth of the ditch after the construction of the tumulus.

2.1.2 Reflection seismic

Reflection seismic measurements are based on the principle that acoustic waves generated from the earth's surface are reflected at boundary layers and return to the earth's surface, so that the ground vibration associated with the wave propagation can be registered by sensors (›geophones‹) as a function of the wave propagation time. The position of the reflecting body can be determined via the propagation time of the seismic wave.

Multiple shear-wave seismic profiles were measured at the top of the tumulus, reaching into the slopes if possible (fig. 2). With this method, small-scale objects with a diameter of a few metres, like fundaments or cavities, as well as extended layer boundaries can be detected.

2.1.3 Near-surface measurements

Geoelectric and GPR measurements were used to investigate the uppermost few metres of the subsurface. The former were executed along star-shaped profiles crossing the centre of the hill and as area measurements at the top and adjacent to the excavations at the crepis in the north-western sector (fig. 2). With the help of geoelectric measurements resistivities of the subsurface can be determined. Different resistivities stand for a change in material composition. This method makes it possible to explore the stratigraphic composition of the hill and to detect possible stone-built structures such as walls at depths of up to 10 m.

GPR measurements were carried out in the flat hilltop area and adjacent to the excavations at the crepis in the north-western sector (figs. 2, red; 15. 16). GPR measurements are based on electromagnetic waves that are reflected in the subsurface at discontinuities such as walls or stones. Therefore, this method is suitable for comprehensive mapping of structures in the uppermost 2 m.

The results of the geoelectric and GPR measurements were essential for the siting of several excavations and added further information to them. Hence, results will be shown together with results of the excavations (see section 4).

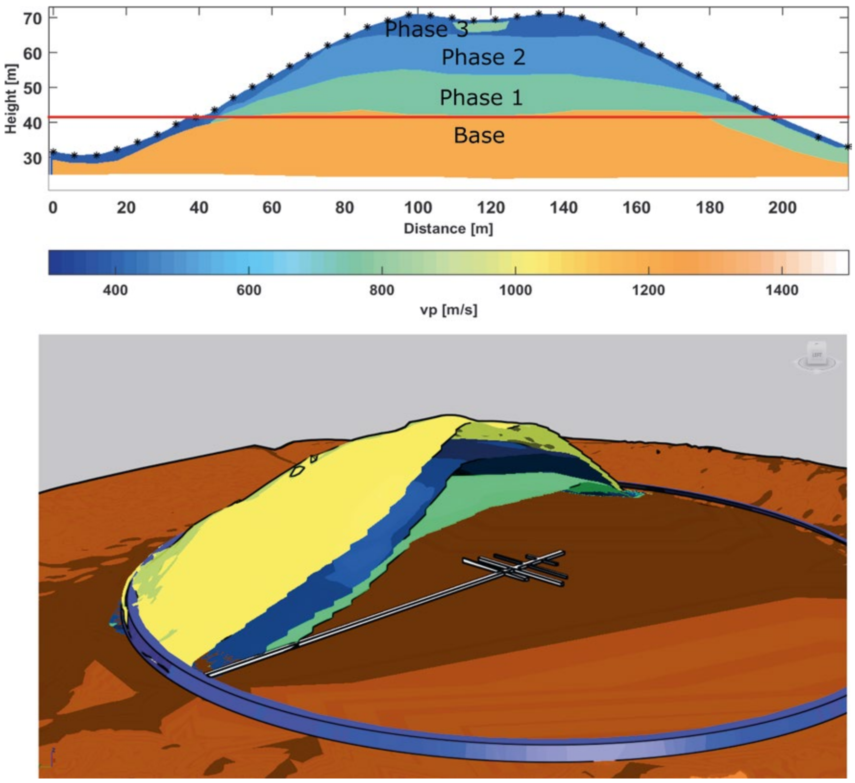
Method	**Number of profiles/ areas**	**Profile length**	**Max. depth**	**Equipment**
P-wave refraction seismic	10	36–216 m	50	Source: ELVIS-Vibration source (Geosym)/ Hammer blow Receiver 4.5 Hz vertical geophones Geometrics Geode
SH-wave reflection seismic	22	12–120 m	40	Hammer blow, 10 Hz horizontal geophones, Geometrics Geode
Geoelectric	21	12–120 m	10	RESECS 1-Channel unit (Geoserve)
GPR	5 profiles, 4 areas	10–60 m	2	GSSI SIR3000, 200/400 MHz Antenna

2.2 Results

2.2.1 Stratigraphy of the Yığma Tepe

The surrounding soil and the tumulus itself consist of river sediments (sandy gravels) from the rivers Bakır Çayı (ancient: Kaikos) and Bergama Çayı (ancient: Selinus). Refraction seismic measurements showed that two overlapping alluvial fans exist in the area of the Yığma Tepe, which can be distinguished by their P-wave velocity and composition[6]. In 2014, the multi-layered nature of the hill was determined by the refraction seismic evaluation of a single profile crossing the hill (P1, fig. 2)[7]. Three further profiles (P2–P4, fig. 2 a) were used to determine the course of the surface of these stratigraphic units[8]. Accordingly, the Yığma Tepe is divided into three stratigraphic units or phases above the ancient base level of ~ 41.5 m a.s.l.[9] (fig. 3), each about 10 m high, which could be distinguished by their P-seismic velocities[10]. Phase 1 located at the bottom shows significantly higher seismic velocities (ca. 800 m/s) than the two phases above it (~ 400 and 500 m/s). This implies an increased stability with growing depth due to higher

6 Mecking et al. 2020.
7 Mecking – Rabbel – Erkul 2015.
8 Mecking – Rabbel – Erkul 2018.
9 The height is given by the Pergamon measurement system (PerkSys) which does not give the exact height above sea level.
10 Mecking – Rabbel – Erkul 2015, Mecking – Rabbel – Erkul 2016, Mecking – Rabbel – Erkul 2018; The estimated layer elevations are connected to the estimated seismic velocities. Thus, the resolution of the layers is about 1–2 m at a velocity uncertainty of 5 %. See Mecking et al. 2020 for details.



3 Building phases of the Yiğma Tepe from refraction seismic; P-velocity model of profile P2 (top) showing three phases above a base level; interpolated layer-model from profiles P1–P4 (bottom)

compaction of the sediments. As the velocity difference between the first construction phase and second (~ 300 m/s) is significantly larger than the difference between the second and the third construction phase (~ 100–140 m/s) it is possible that the first construction phase was built from the material originating from the southern alluvial fan which showed higher P-wave velocities (1200 m/s) and the phases 2 and 3 were constructed from the material of the overlapping northern alluvial fan with lower seismic velocities (800 m/s) to the north-west of the mound. However, the refraction seismic could not distinguish if Phase 1 is homogeneously consolidated or if only its surface is compacted.

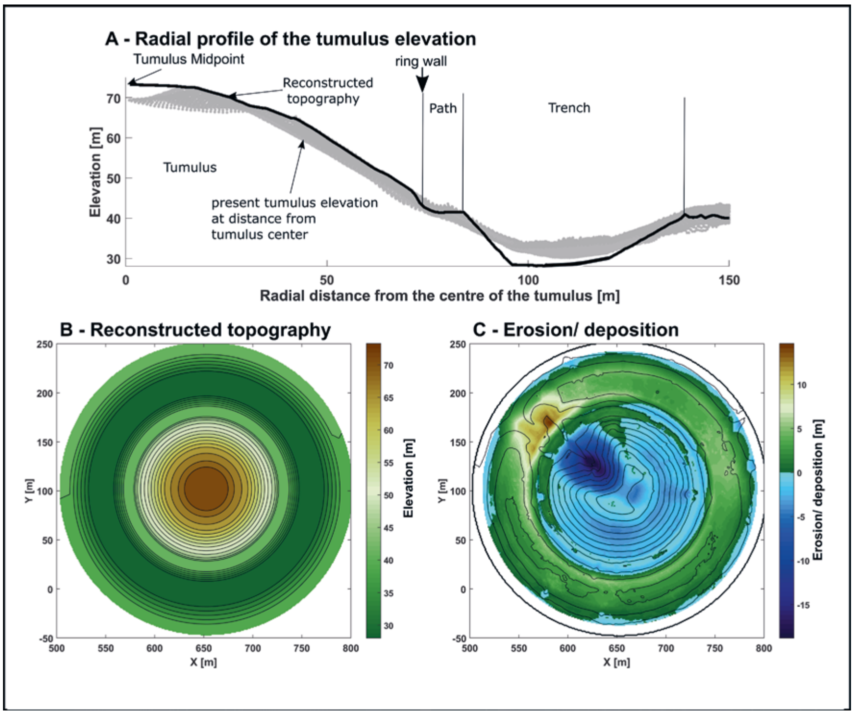
Using high-resolution, georeferenced aerial photographs, a digital terrain model of the Yığma Tepe and the surrounding ditch was created[11]. This terrain model was used to reconstruct the original topography of the hill by recalculating the ditch in the light of ancient robbery attempts as well as erosion and sedimentation (fig. 4). The results of the geoelectric and seismic measurements on profiles in the ditch were used to determine its original depth[12].

Comparisons of the volumes of the hill and the surrounding ditch showed that its material was sufficient for the construction of the tumulus and that no additional material had to be brought in. This was further proved by soil samples taken from the excavations of 2015–2019 which verify the similar grain-size distribution of the tumulus fill and the natural fluvial layers below it that were also situated originally in the ditch[13]. Comparisons of the volumes of the reconstructed original and present hill showed that the hill lost about 17 % of its material due to erosion and excavations, which was mainly deposited in the ditch. Approximately half of this volume was removed by the excavations of Dörpfeld and before from the large trench in the north-west.

11 Andreas Bolten, University of Cologne performed the flights and computed the DSM, which was later analysed by M. Herbrecht (Cologne) see Mecking et al. 2020.

12 Mecking – Rabbel – Erkul 2016, fig. 42.

13 Mecking et al. 2020; Meinecke 2020.s



4 Reconstruction of the original tumulus topography: present surface from DEM-Model; radially transformed topography (grey dots) and reconstructed radial topography profiles (black line); reconstructed surface (B); erosion/ sedimentation thickness (C)

2.2.2 Seismic structures inside the tumulus

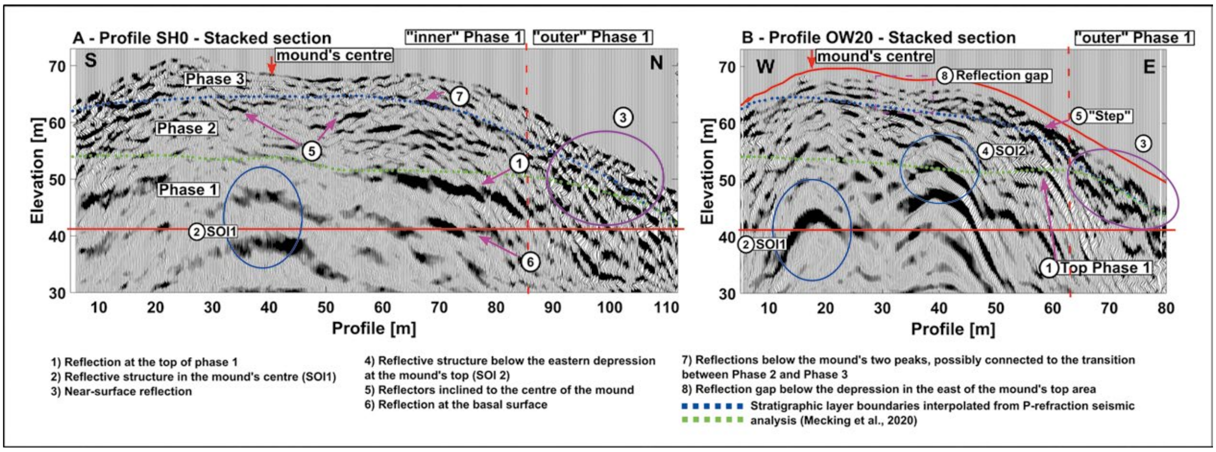
Using reflection seismic measurements, it was possible to localise structures of a few metres in diameter at different depths down to the base of the tumulus[14]. Structures that could be captured on multiple seismic profiles were abstracted as objects and inserted into the refraction seismic 3D layered model.

The stratigraphic phases identified by the refraction seismic analysis (see section 2.2.1) can be identified also by the changes in reflectivity. While the near-surface area (Phase 3) is characterised by strong and chaotic reflectivity, especially below the slopes of the mound (fig. 5, marker 3), the main structures identified by reflection seismics are found in Phase 2 (fig. 5, marker 7), on the surface of Phase 1 or embedded therein. Although the surface of Phase 1 shows strong reflectivity (fig. 5, marker 1) which might be attributed to the increase of the seismic velocities as well as artificial consolidation, the reflectivity inside Phase 1 is low compared to Phase 2 and 3. Phase 1 dips towards the basal surface at a distance of 40 to 50 m to the centre of the mound (fig. 5). However, the refraction seismic evaluation suggests that it spans nearly the entire diameter of the mound. Thus, we assume that Phase 1 might be subdivided into an inner and an outer Phase 1 and that only the inner Phase 1 is artificially hardened to generate the strong reflections. Below the reflection at the basal surface (marker 6) the reflectivity is very low, indicating undisturbed soil.

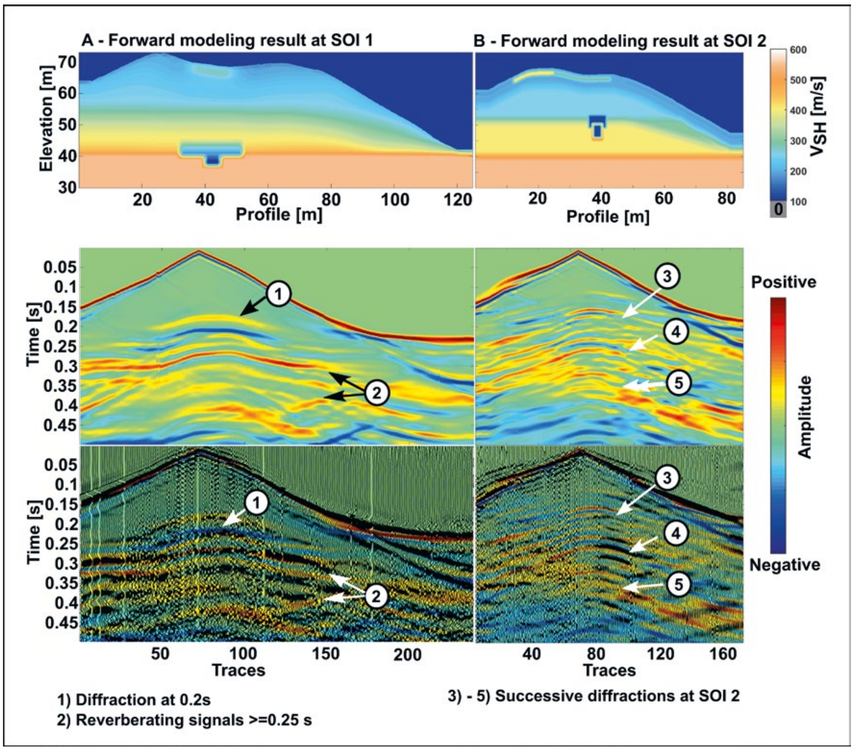
Dörpfeld's tunnel (fig. 1) was identified in the seismograms (fig. 5, marker 2)[15]. Notable, also, are reflections in the mound's interior above the tunnel system which are inclined towards the centre (marker 7). This implies subsidence due to a cave-in of the tunnel system. By numerical modelling of the measured seismic signal shapes and strengths it was determined that this tunnel system probably collapsed and created a loosened area of approx. 20 m in diameter (fig. 6, A). Additionally, an area that has deepened into the base level in the centre, which is filled with very loose material or contains a cavity, is suggested by the forward modelling tests to explain the observed seismic signals. This area of about five metres in diameter was probably created by Dörpfeld's test excavation below the base level, which was possibly only partially filled afterwards.

14 Mecking et al. 2021.

15 Mecking – Rabbel – Erkul 2018, fig. 8.

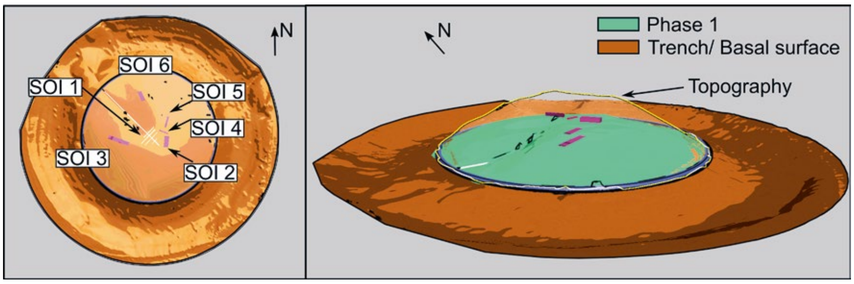


5 Processed reflection seismic sections for profile SH0 (left) and profile OW20 (right) (cf. fig. 2) revealing Dörpfeld's tunnel system (SOI 1, marker 2) and the north-south oriented structure SOI 2 below the eastern part of the mound's summit (marker 4)



6 Forward modeling on SH-wave profile SH0 of the Dörpfeld excavation (left) and on profile OW20 of SOI 2 (right); velocity model (top); forward modelled seismic shot (colour) and measured shot data (black) (centre); forward modelled shot (bottom)

All other reflective bodies are located inside the mound above the base level of the mound (fig. 7). The main structure identified by reflection seismic of archaeological interest (SOI 2) is an elongated north-south oriented object of about 15 m length which appears embedded into the surface of Phase 1 (fig. 5, marker 2). Forward modelling (fig. 6, B) suggests a collapsed walled cavity filled with loose soil which is embedded into Phase 1. Its floor lies about 5 m over the base level. Above lies an area of loosened soil which might have been loosened by the collapse of the structure below. Interestingly, SOI 2 coincides with a depression at the mound's surface and lowered seismic reflectivity below (fig. 5, marker 8). The explanation for this connection remains unsettled as the collapsed cavity is too small to be accountable for the depression.



7 Yığma Tepe, 3D-reconstruction. Top view (left) and perspective view (right). White: Dörpfeld tunnels; pink: structures identified by seismic measurements; green: construction phase 1; brown: trench; white/ partially transparent below yellow line: tumulus surface. Except for SOI 6 all identified structures lie above or embedded into phase 1

Additional objects identified by reflection seismic have been found adjacent to SOI 2 to the north, situated slightly higher inside Phase 2. The structures SOI 4 and SOI 5 appear as strong double reflections of about 10 m length and 4 m height (fig. 7). They lie below the northern peak of the mound. Their nature could not be determined but an electrical profile[16] shows highly increased electrical resistances in the area above the structures. Increased resistivities could be explained by stone accumulations[17]. The combination of the augmented shear wave reflectivity below the northern peak, the two identified SOIs and the high resistivity anomaly in the electrical resistivity tomography (ERT) may indicate increased construction activity in this area.

The placement of the seismic profiles focused mainly on the centre of the tumulus. However, on some profiles reaching down the slopes of the mound additional features could be observed. SOI 3 in the western slope of the mound is a flat double reflector which appears similar to the steps observed often near the surface in the slopes of the mound (fig. 5, marker 5) and which probably served for stabilising the mound's flanks. It reaches very close to the mound's surface but continues also about 30 m inside the mound. Its nature as well as its extension perpendicular to the profile where it was observed remains unclear.

SOI 6 is a small elongated structure which appears as a double diffraction on two short profiles in the northern slope. As such, it is of interest as it appears comparable to SOI 2 but does not show the reverberating behaviour which would indicate a loosened area. Its depth is near the base level of the mound and its distance to the centre of the mound places it in the transition of the inner Phase 1 to the outer Phase 1.

3. Archaeology

In 2015 and 2017 six excavations were carried out on the crepis wall (PE15 So 01, 02, 04, PE15 Säu 01, PE17 So 03 and PE17 Säu 01/So 05) and one inside the surrounding ditch (PE15 So 03), all in the northern sector (fig. 8). Additionally, three excavations were executed on top of the mound (PE17 So 01, 02, 04)[18] and a smaller one in 2019 on the southern flank of the large robbery trench. All sondages had dimensions of 2 to 10 m in length and width and reached a depth of max. 2 m below the current surface[19]. The stratigraphy of the fill showed strong signs of disturbances, either by Dörpfeld's excavations, numerous ancient robbery attempts or other large-scale modifications as the tumulus had been used as a vineyard prior to Dörpfeld's excavations. Furthermore, the new project showed that large-scale stone robbery at the crepis must have occurred even after the old excavations as its current state of preservation is far worse than visible in Dörpfeld's documentation (fig. 9). One of the smaller

16 Mecking – Rabbel – Erkul 2015, fig. 61.
17 Mecking – Rabbel – Erkul 2016.
18 Pirson 2016; Meinecke 2018a.
19 After work was completed, all excavations were backfilled and crepis wall was covered with geotextile to preserve the monument and not further alter its appearance.

illicit excavations (further explored in PE15 Säu 01) there can even be dated to the 1980s by the presence of a Turkish coin.

3.1 Crepis

The monumental crepis at the base of the tumulus is 2.6 to 3 m wide and still preserved up to 1.8 m in height over five courses in the north-eastern sector (figs. 9–11), whereas it is almost completely destroyed in the east. In the northern half it is set in a deeper foundation trench and in the southern part a lower foundation layer had been added to compensate for the slope of the original surface (~ 1.5 m). New measurements prove that it has an almost perfect circular layout with an outer diameter of 158.4 m. Interestingly, the crepis of the Kastas tumulus at Amphipolis (Greece) has the same diameter[20] and the circumference of the surrounding wall of the at so-called Heroon at Pella (Greece) is comparable at 158.5 m[21].

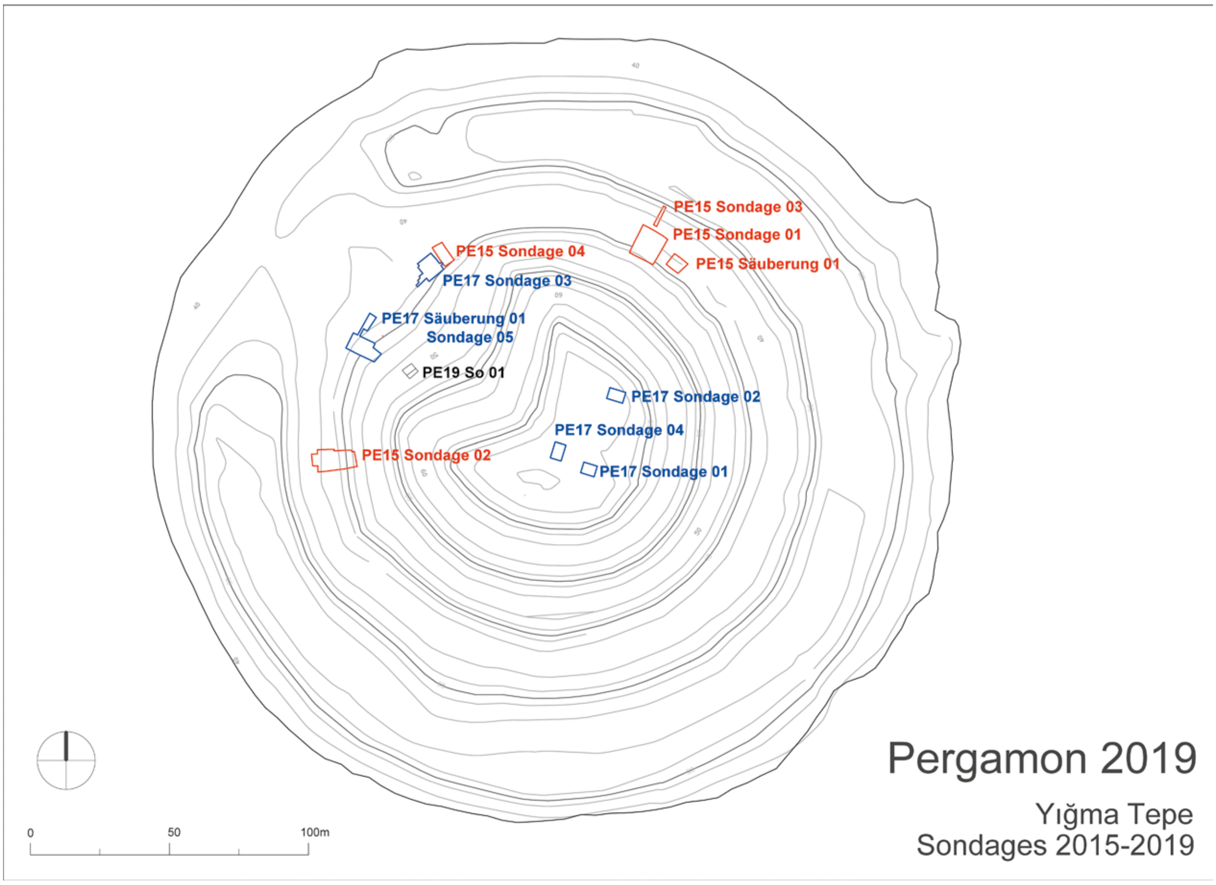
The crepis of the Yığma Tepe was built of large ashlar blocks of a soft, yellowish tuff of 0.33–0.45 m in height, 0.5–0.7 m in width and up to 1.6 m in length. These were set without mortar, clamps or dowels as headers in two rows in almost every course; only in one spot (PE15 So 04) do headers and stretchers alternate regularly. Due to destruction, its original appearance can only be determined through the old excavation's photographs: Over a two-stepped base crowned by a large half round or torus, the wall zone follows with a slightly protruding fifth course (fig. 9)[22]. A flat sixth course was assumed by Dörpfeld because of pry holes on the underlying blocks and the stratigraphy of the backfill that shows construction debris layers separated by rubble strata in correspondence with each course of the wall[23]. However, without further evidence its appearance remains unclear[24]. Single large tori as base-moulding of crepis walls are rare in Asia Minor[25], but more common in Etruscan tumuli, but without stepped bases[26]. In Pergamon, the crepis of the tumulus on the *via tecta* close to the Asklepieion has also a three-stepped base, but with a more complex moulding and a much higher wall zone[27]. Overall, the relatively low height of the crepis of Yığma Tepe is striking, especially if one considers its width, the massive construction with headers and the dimensions of the tumulus[28].

3.2 Platform and Ramp

In the north-western sector, south of the huge robbery trench, a slightly protruding platform adjacent to the crepis was found (PE17 Säu 01/So 05). Unfortunately, this structure is now almost completely destroyed, and its original dimensions are unclear (fig. 9). It was probably about 4.12 m long, 0.6 m wide and 0.5 m high[29]. It is composed of one course of similar ashlar blocks covered by thinner slabs that are also lying on the first course of the wall. As the crepis deviates here from its circular layout and runs straight, this feature was probably part of its original plan and is not a later addition.

Dörpfeld interpreted it as a part of a staircase due to a very hard-packed earth layer that he recorded here directly behind the crepis and which he thought

20 Peristeri 2016, 164. Mavrojannis calls this unit an »Alexandrian stadium« (Mavrojannis 2016, 646). However, such a stade has never been proposed before and Lehmann-Haupt has given different values for the different Greek stadia known so far (Lehmann-Haupt 1929).
21 Chrysotomou 1987, 154. Recently, this observation has been stated in the publication of the early Hellenistic Documaci tumulus in Kallatis (Romania) where the crepis has a diameter of 52.8 m, which is exactly a third of 158.4 m (Sîrbu – Ştefan 2019, 71–73).
22 See the section by Dörpfeld 1908a, fig. 8.
23 Dörpfeld 1908a, 366–368. These layers prove the dressing of the blocks in place and that the backfill was used as a working platform.
24 Although no evidence was found, Dörpfeld assumed a lower plate-like course (Dörpfeld 1910, 367), while Conze suspected another half round (Conze 1913, 242).
25 Only the crepis of the archaic Karnyıarık Tepe at Bin Tepe at Sardis is crowned by a three-quarters round (Ratté 1994).
26 Here single half rounds are used as mouldings in the archaic tumuli I, II at Banditaccia necropolis and tumulus Sorbo at Cerveteri, Caere (Naso 2016, 18).
27 It is now dated to the 2nd half of the 1st cent. BC (Berns 2003, 245).
28 The crepis of the Kastas tumulus is 3 m high and only 1.6 m wide (Peristeri 2016 164), that of the Chentinyova tumulus at Starosel, Bulgaria (diameter: 80 m) was about 5.5 m high (Kitov 2003b, 11). Only the very poorly published crepis of the Mal Tepe at Mezek had comparable dimensions (Stoyanov 2015). Furthermore, crepides are often built of stretchers and not headers as in the Yığma Tepe.
29 Dörpfeld does not give any measurements. In the excavations of 2017 only one part of a block was still in situ; its length can only be estimated through the historic photographs and the better-preserved wall faces here (Meinecke 2018a). However, the photographs show irregularities at the northern and southern end. This could indicate that it had been already partly destroyed before 1907 and was even larger.



8 Map of the Yığma Tepe with the location of excavations undertaken in 2015 (red), 2017 (blue) and 2019 (black)

9 Crepis with annex in a photograph of the old excavations of 1907 (left) and actual state of preservation in 2017 (right)

was a foundation of a staircase or path leading up to the top of the tumulus[30]. The new excavation revealed that this layer is the filling of a ramp of 3.6 m in width, consisting of tuff flakes and gravel and flanked by two retaining walls (fig. 10). Those are at least 1 m high, inclined towards each other and constructed of irregular dry rubble masonry with tuff flakes and even ashlar blocks of tuff. The ramp is roughly

30 Conze 1913, 242.

10 Photograph of the crepis, annex and ramp behind the crepis in the north-western sector (trench PE17 Säu 01/So 05), uncovered in 2017

11 Rubble walls in trench PE15 So 01 in 2015 near the crepis, while excavation was still ongoing and differing inclination of the segments of the different construction stages can be seen (left) and after excavation where their radial alignment is visible (right)

12 Photograph of the rubble walls on the top of the tumulus in excavation trench PE17 So 01 in 2017. In the upper left part the later pit filled with ashes and rubble can be seen

aligned east-west but seems to turn slightly to the south-east while running uphill. It ends after 7 m at a modern trench where it is completely destroyed. Some fragments of tuff slabs might indicate that it was once covered with stairs. Due to Dörpfeld's large excavations, the stratigraphic relationship between ramp and crepis is unclear but they seem to be contemporary as the same building material occurs. Only the lower part of the ramp is preserved and lies roughly 1 to 3 m below the ancient tumulus surface. The continuation of this structure further uphill is unclear (see section 4). The coexistence of these two features at this location is striking; however they differ in width and alignment as the ramp is displaced more to the south but the platform might have been longer as recorded in the old excavations because the zone of well-preserved wall faces and straighter course of the wall is larger (figs. 10. 16). Furthermore, the platform seems to be too narrow for bearing a staircase as known examples from the Etruscan tumuli protrude further from the walls[31]. A good comparison might be found in the small tumulus near the Asklepieion in Pergamon, where a 6.43 m wide but only less than 2 m projecting staircase in front of the entrance to the Dromos was found; this structure was planned from the beginning as it is interconnected with the crepis[32]. However, this is not the case in the Yığma Tepe as the platform was set in front of the finished wall face with its half-round here and would have covered it. As all known examples of stairs or paths run straight uphill on the ancient surface and are orthogonal to the crepis[33] and staircases inside the embankment that are connected to grave complexes are much more elaborate[34], it is more probable that the ramp of the Yığma Tepe served as a temporary way used for construction and that it may not be connected with the built structure in front of the crepis. This explains its unsophisticated design and its curvy course, which one would expect for transporting heavy construction materials uphill[35]. Therefore, the platform could have had a different function and may have served as a podium for receiving a grave stele, as pointed out by U. Kelp[36], or may have been some sort of altar[37].

3.3 Stratigraphy and Construction process

The old and new excavations revealed that the ancient hard-packed loamy topsoil (at about 41.5–41.9 m a.s.l.) was well preserved underneath the embankment of the Yığma Tepe which still reaches a height of 32 m over this base layer. Apart from the geophysical measurements, only Dörpfeld's excavation results provide further insight into the deeper internal structure of the tumulus. He found the remains of two wooden posts in the geometric centre of the tumulus which must have been erected first. As new calculations prove, those served for determining the circular layout of the crepis and helped in visualising the centre during the construction process[38]. After this, a small core mound of 20–30 m in diameter and about 7 m in height was piled up around them. It consisted of the loamy topsoil excavated first in the ditch (fig. 1). Over this core mound very different loose sandy-gravelly material was added, as Dörpfeld observed in his tunnels[39]. However, he subdivided this upper fill in three different thick stratigraphic units or phases that were separated by thinner, almost horizontal layers of a different material, maybe rubble or loamy material as the drawings might suggest (fig. 1)[40]. In the new excavations a more sophisticated stratification of layers of rubble alternating with layers of sandy gravel and hard packed loam was observed[41]. It probably served to stabilise and drain the tumulus fill as has been proposed for several other tumuli where regular changes between coarser and finer materials are recorded[42].

31 See Prayon 1975, 81–84.
32 Ziegenaus 1975, 46–50.
33 E. g. the complex of an altar-like staircase in front of the crepis that continues behind it uphill in the tumulus Sodo at Cortona (Zamarchi Grassi 2006, 142) or in several tumuli in Cerveteri-Banditaccia, e. g. archaic tumulus II.
34 E. g. in the Thracian tumulus Chetinyova at Starosel (Kitov 2003b, 11).
35 A comparable structure might be the one inside the tumulus at Nemrud Daği that was interpreted as a ramp or path used for construction (Sanders 1996, 97).
36 Kelp 2016, 603.
37 Small altars adjacent to the crepis have been recorded in tumuli in the western Black Sea region at Kallatis (Sîrbu – Ştefan 2019, 63).
38 Central posts were often found in the centres of tumuli, e. g. in Gordion (Young 1981, 139) but also close to Pergamon in the Seç Tepe tumulus of Elaia (Gaitzsch et al. 1985, 141).
39 Dörpfeld 1910, 390 f.
40 However, Dörpfeld never mentioned these layers or stratigraphic units.
41 Meinecke 2018b, 143.
42 Vokotopoulou 1990, 15; Schmidt-Dounas 2016, 105. In Asia Minor a good comparison can be found in the tumulus Beşik-Sivritepe (Korfmann 1985).

13 Stone walls and hard-packed layer (top left) in trench PE17 So 04 in the centre of the top of Yığma Tepe that could represent the possible last remnants of the foundation of a sema

Additionally, the new excavations revealed that almost the whole embankment was segmented by wall-like structures (fig. 11)[43]. Those are poorly constructed of mid-sized rubble (0.1 to 0.4 m) with lots of earth between the semi-continuous courses and are often strongly inclined. Therefore, they must have been built together with the fill. They appear on different levels at regular distances of roughly 1 or 2 m and are vertically divided into segments of 0.5–1.3 m height. These are inclined in the same direction on one level, whereas on the next one the inclination is often reversed to the opposite direction while the alignment of the previous segments is kept. Thus, they represent different construction stages. The inclination of the walls suggests that the earth was maybe heaped up counter-clockwise in one stage and clockwise in the next one to better interlock the segmented fill (fig. 11). The rubble walls close to the crepis are arranged radially, whereas on top of the tumulus they are arranged also circumferentially (figs. 12. 13. 15). Despite the heavy later disturbances it can be deduced that the alignment changes in every construction stage; thus radial and concentric walls are set on each other, but sometimes they seem to be contemporary and form almost rectangular structures (see section 4). In 2019, the same arrangement was recorded for the lower and inner fill of the tumulus on the flanks of Dörpfeld's large excavation trench[44].

In the Phrygian burial mounds of Gordion and Ankara (Turkey) similar rubble walls appear sporadically, are directed towards the centre and renewed at different construction stages. Therefore, they are interpreted as »guiding walls« for keeping a regular shape of the tumulus in the process of construction and for separating work zones but they are not conducive to statics[45]. A more regular arrangement has

43 Pirson 2016, 162–164; Meinecke 2018b, 144–147. Those were visible in Dörpfeld's excavations as photographs and the drawing (fig. 1) prove. However, he never mentioned them.
44 Meinecke 2020.
45 Gordion, tumuli B, S1 and H (Young 1951; Kohler 1995, 180); Beştepler near Ankara, Macridy II (von der Osten 1929, 49; Schede 1930, 479).

been observed in the archaic tumulus 3 at Salamis (Cyprus). Therefore, a static purpose was assumed[46]. The regular system of orthogonal and radial walls in the Hellenistic Great Tumulus of Vergina (Greece) is even more elaborated. Here, it probably served to stabilise the fill against erosion[47]. In the Hellenistic tumulus 77 of Salamis (Cyprus) a system of concentric walls on different terraces that were connected to each other by radial stone alignments was recorded and gave this mound its perfect conical form[48]. As some of the radially arranged walls in the Yığma Tepe point to the centre of the mound and the same alignments are constantly reproduced, they probably served to give the tumulus a regular shape and to organise the building process. Additionally, they could have had a static function – temporarily in the process of construction and later against erosion – as they constitute the ›skeleton‹ of the mound with its comparably steep slopes (25–35°).

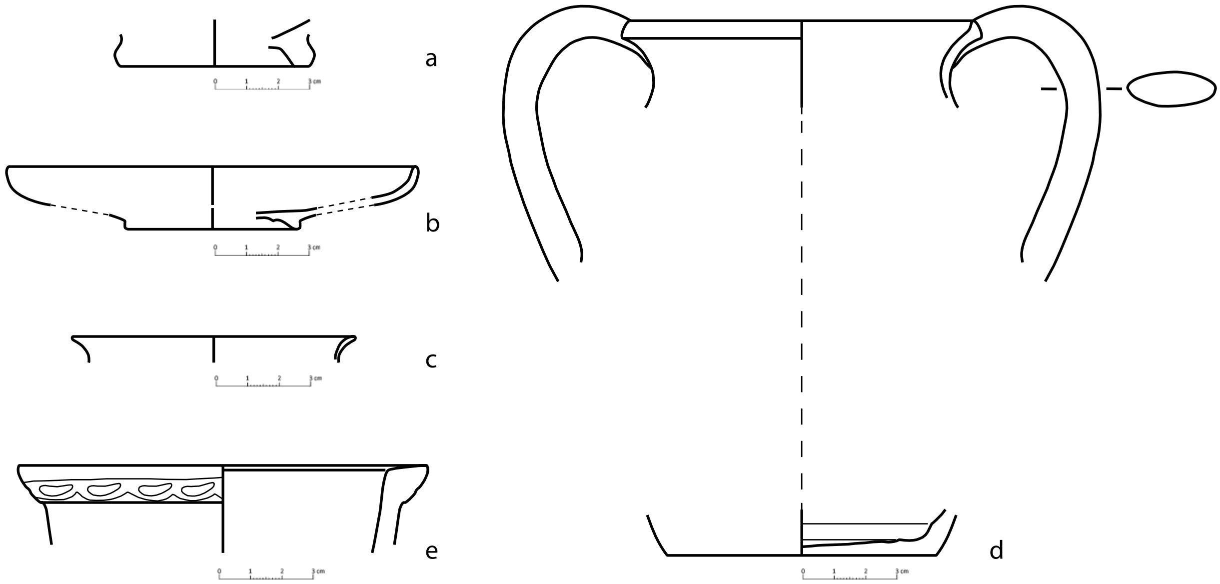
3.4 Finds and Dating

Traditionally, the tumulus was dated to the reign of the Attalid rulers (3rd–2nd century BC)[49]. For Dörpfeld the use of tuff for the crepis and its building technique pointed to the Hellenistic period[50], but this material was also used later till the 1st century BC in different buildings in Pergamon[51]. Furthermore, the old excavations have not revealed much archaeological evidence for dating. Only the foot of an unguentarium found below the crepis can be dated to the late 3rd or early 2nd century BC and gives a *terminus post quem* for its construction[52]. Consequently, a preliminary dating to the 2nd century BC was proposed[53]. Additionally, a coin with unknown stratigraphic position was found in 1905 close to the crepis[54]. It bears the inscription Ε-ΠΙ / Σ-Ω / Κ-ΡΑ / [ΤΟΥ] and the head of Demeter with a wreath of wheat on the obverse and probably the inscription [Ε-ΛΑ] / ΙΤ-ΩΝ and a torch in a wreath on the reverse, and could be dated to the late Hellenistic or early Imperial period[55].

Unfortunately, the new excavations have also not provided much datable material from original building contexts of the Yığma Tepe. Only very small pieces of pottery with heavily weathered surfaces were recovered, which are not suitable for dating its construction. The only diagnostic pottery fragment in the filling of the foundation trench of the crepis (PE15 So 04, 017) is a chronologically insignificant simple unslipped stand (PE15, So 04,017 K1; fig. 14 a) made of local fabric that belongs most probably to a partially slipped Hellenistic bowl (or plate), of a type which was in use from the 3rd till the 1st century BC[56]. A body fragment with a dull dark-brown slip on the interior (PE15 Säu 01, 020 K1) from the ancient topsoil (PE15 Säu 01, 020) below the tumulus, made of local fabric, might belong to such a partially slipped Echinus bowl as well, dating to the 3rd to 1st century BC.

In the upper and disturbed layers close to the crepis, small pieces of pottery vessels were recovered that can be vaguely dated to the 2nd and 1st century BC. A hard layer (PE15 So 02, 017) below a rubble stratum contained several small heavily worn body sherds, which belong to at least four vessels, but allow no closer chronological classification. Three of the vessels have a badly preserved dull creamy wash on the exterior, which speaks in favour of (Hellenistic?) jugs / table amphoras. One body sherd of the much more thin-walled fourth vessel shows remainders of a small strapped handle, which could support an interpretation as a Hellenistic Skyphos. However, these pieces are not enough to suggest another construction phase or enlargement of the tumulus, let alone to date it.

46 Karageorghis 1966, 234. On the Ceç tumulus of Avanos in Cappadocia several radially arranged walls that run straight uphill were recorded on its surface but interpreted as staircases by the excavator (Coindoz 1985, 3).
47 Saatsoglou-Paliadeli 1984, 8–10.
48 Karageorghis 1973/1974, 130. Very elaborated systems of radial and concentric walls with a statical purpose due to high crepides are found in Roman tumuli of the late Republican and early Imperial age (Clapham 1922; Schwarz 2002, 28). Such systems can also be found in earlier tumuli of Asia Minor like the so-called grave of Tantalos, Smyrna (Miltner – Miltner 1932, 151) and Basmacı Tumulus, Güre (Akbıyıkoğlu 1991, 3) and in Italy in the Montariolo di Covaro, Borgorose (Alvino 1990, 321).
49 Conze 1913, 240; Radt 2016, 268.
50 Dörpfeld 1907, 238.
51 Filgis – Radt 1986, 37.
52 Kelp 2014, 365. – Rotroff dates this form rather to the start of the 2nd cent. BC (Rotroff 2006, 152 f.).
53 Pirson 2016, 164.
54 It was found in 1905 »at a relatively great depth close to the surrounding wall« and was briefly described and drawn by H. Hepding in the unpublished lists of finds in 1905, 37 no. 267. Dörpfeld never mentioned this find in his excavation journal or the preliminary reports.
55 Similar coins found in the city excavation at Pergamon were dated from the 1st cent. BC to the 1st cent. AD (Voegtli 1993, 36 nos. 438–448 pl. 4). Other specimens are dated »maybe Augustean«: BMC Troas, Aeolis, Lesbos, 127, nos. 28. 29 pl. XXV 12; RPC I, 409 no. 2410 pl. 107. J. Chameroy (RGZM), whom we thank very much for his help, dates these coins still to the 1st cent. BC. (pers. comm.).
56 For the general development of the (deep) echinus bowls in Hellenistic times: Rotroff 1997, 161–164. For Pergamon: De Luca – Radt 1999, 30.



14 Pottery from the excavations at the Yiğma Tepe in 2015 and 2017. – a: Unslipped stand of an Echinus bowl (PE15 So 04,017 K1) from the filling of the foundation trench. – b. c: Eastern Sigillata C plate (PE15 So 01, 011 K1); thin-walled beaker (PE15 So 01, 011 K2) deposited on the sandy layer in front of the crepis. – d. e: Cooking pot (PE17 So 01,003 K3); byzantine jug (PE17 So 01,003 K2=PE17 So 01,008 K2=PE17 So 01,004 K3)

That the tumulus played an important role also in the Early Imperial period is further attested by small pottery fragments which belonged mainly to two small Early Roman vessels that seemed to be deposited – maybe as a kind of offering – not earlier than the second part of the 1st century AD in the sandy layer/ancient surface directly in front of the crepis (PE15 So 01, 011). Six rim fragments, ten body sherds and four bottom sherds belong to a small specimen of a regionally produced red slipped Eastern Sigillata C plate (PE15 So 01, 011 K1; fig. 14 b) with upturned, slightly incurved rim (Loeschke Çandarlı type L 6) with a diameter of 12 centimetres[57]. Two rim fragments and five body sherds belong to a thin-walled beaker (PE15 So 01, 011 K2; fig. 14 c) with a slightly concave curved rim made of a local fabric as well. Due to its preservation, it cannot be decided with certainty if the beaker belongs to the very typical Pergamenian type with an offset shoulder (Japp Typus X, similar to Atlante Typ I/37), well known from contexts of the late 1st century BC and most common in contexts of the 1st century AD, or to the rare, very thin-walled type with s-shaped profile, which has a similar datation span[58].

On the top of the tumulus, recovered ceramic fragments dating from the 2nd century BC to the 3rd century AD illustrate the large disturbances of the monument. The earlier phase is, for example, represented by a cooking pot (Chytra) with outturned, triangular rim with flat bottom (PE 17 So 01, 003 K3; fig. 14 d), which is well known from Pergamene contexts from the 2nd and especially the 1st centuries BC[59]. An ongoing usage or at least perturbation of the Yığma Tepe in the 2nd or even 3rd century AD is suggested by a fragment of an Ephesian amphora from the top of the monument and a body sherd of an amphora with a dull dark-red wash with distinctive turning marks with a very micaceous fabric, which suggests a provenance from the Meander valley (PE 17 So 02, 007)[60]. Large-scale modifications and partial destruction of the Yığma Tepe occurred in Late Antiquity and

57 This predecessor of Çandarlı Hayes type 4 can be dated from the middle to the late 1st cent. AD (Hayes 1985, 75 f.; Hayes 2008, cat. 766 [P 22136] fig. 24).

58 Ricci 1985, 241 f. For the thin-walled pottery in Pergamon: Japp 1999, 301–331; Japp 2003, 245 with fig. 2, 8. 9 (type with offset shoulder = Typus Japp X) and fig. 2, 12 (with s-shaped profile).

59 For comparison: Nohlen – Radt 1978, 49 K 192–194 pl. 32; Raeck 2000, 358 cat. 12.5 fig. 25; 363 cat. 16.2.3 fig. 28. In small quantity this chytra type is still present in Pergamene settlement contexts of the 1st cent. AD, for example in building T on the eastern slope of the settlement hill: Engels – Japp – Keweloh 2014, 148 f. with fig. 57 c.

60 Fabric and surface treatment are typical for the later variants of the Ephesian amphoras of the 2nd and 3rd cent. AD, for example the one of type Kapitän 2 (Bezeczky 2013, 149–151). A foot of an Ephesian hollow-foot amphora type Agora M 45 has been found as well in a layer in front of the crepis (PE 15 So 02, 011 K1). For datation: Bezeczky 2013, 70 f.

the Early Byzantine period, as indicated by several pottery fragments like for example a body sherd with dark-green glaze, by fabric most probably Byzantine (PE17 So 01, 003 K1), a jug or handled pot with offset, triangular undercut rim with waveband on the exterior rim and horizontal incised lines on the body represented in fragments in three different contexts (PE17 So 01, 003 K2 = PE17 So 01, 008 K2 = PE17 So 01, 004 K3; fig. 14 e) with Middle Byzantine parallels[61] as well as a large amount of brownish friable tile fragments on top of the tumulus and in the huge ancient robbery trench.

Although the finds from the new excavations were not conclusive for dating the construction of the Yığma Tepe, it was possible to date a piece of charcoal via C^{14}-AMS that has been found in the uppermost construction debris layer (PE15 So 02, 007) behind the crepis in a small fireplace. It delivered a date of 370–195 BC (93.8 % probability) and 186–178 BC (1.6 %)[62]. As this context was undisturbed and is closely related to this wall (see section 3.1), its construction could be dated – keeping in mind that the evidence comes from only one sample – to the late 3rd or early 2nd century BC, especially if one considers the unguentarium as well.

4. Combined Archaeological and Geophysical Work

Geophysical measurements played an important role in the positioning of excavation trenches. In 2015, ERT and GPR measurements were carried out on a rectangular surface on top of the Yığma Tepe and showed coinciding areas of increased reflectivity and electric resistances[63]. Two of those were further explored by archaeological excavations in 2017 (PE17 So 01, 02). They have not revealed any evidence of building structures but layers of densely packed rubble near the surface that might have belonged to the original tumulus fill but were later disturbed, as a pit filled with rubble and ashes (PE17 So 01, 003) indicates (fig. 12). Zones of increased resistance were also observed in the star-shaped profiles around the tumulus and are – as one excavation trench of 2015 (PE 15 So 02) revealed – likewise caused by rubble accumulations or layers[64]. In contrast, the monumental crepis was not visible in the profiles as it does not show significantly increased or decreased electric resistances compared to the surrounding material.

In the central part of the top, a spatially extended zone of strongly increased seismic velocities was found near the surface – comparable with those from the lower construction Phase 1 (see section 2.2.1). This zone lies only ~ 1 m below the surface (figs. 3. 13). In 2017, an excavation (PE17 So 04) was placed over its edge and showed a hard-packed layer of sandy gravel with a small amount of clay and tuff particles at a depth of 1 m. As it lies in the geometric centre of the mound and is extremely consolidated it could represent the single remnant of a foundation for an architectural feature or grave sign (*sema*) which has been completely destroyed. Apart from one small piece of burnt marble in the later pit mentioned above, which is not enough to assume a marble architecture or sculpture, no further evidence of it has been found in the excavations.

As the small excavations on top of the Yığma Tepe delivered only limited insights into the system of stone alignments, a denser profile mesh using GPR was applied between them (fig. 15). It shows a very complex picture of many concentrically and radially arranged linear anomalies that can be probably interpreted as these rubble walls because they occur at the same depth as in the excavations. In a few cases, a correlation between the anomalies and the excavated structures may be possible. However, many irregularities and defects occur which may have been caused by the same later disturbances visible in the excavations or the collapse of an inner feature. Therefore, the system of rubble walls is still not completely clear and seems to be more complex than the one in tumulus 77 at Salamis (see section 3.3).

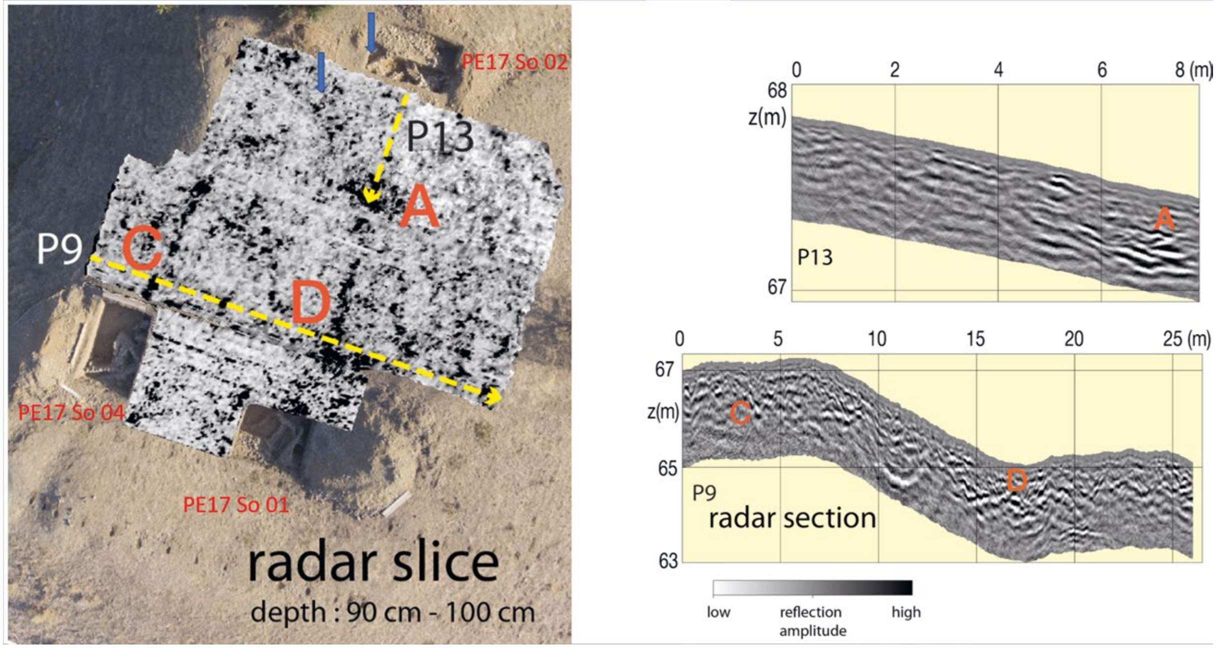
Finally, ERT and GPR measurements were also carried out to the east of the ramp (PE17 So 05) to determine if and how it continues. They delivered a co-

61 Parallels are known for example from Amorium from the 8th and 9th cent. AD, see: Böhlendorf-Arslan 2010, 352 f. with fig. 7.

62 The analysis has been carried out on 10 g of charcoal in the Tübitak laboratory (Kocaeli, Turkey) and delivered an uncalibrated age of 2207 ± 25 years BP. Calibration was done with OxCal (IntCal20).

63 Mecking – Rabbel – Erkul 2016, see figs. 38. 39.

64 Pirson 2016, 164; Mecking – Rabbel – Erkul 2016. These accumulations seem to be remnants of rubble layers that belonged to the original layout of the tumulus.



15 GPR depth slice 90-100 cm (left) between the excavations PE17 SO 01, PE17 SO02 and PE17 SO 04 and two GPR sections (right) marked by yellow dotted line; strong signals, possibly connected with rubble accumulations, are marked A, C–D

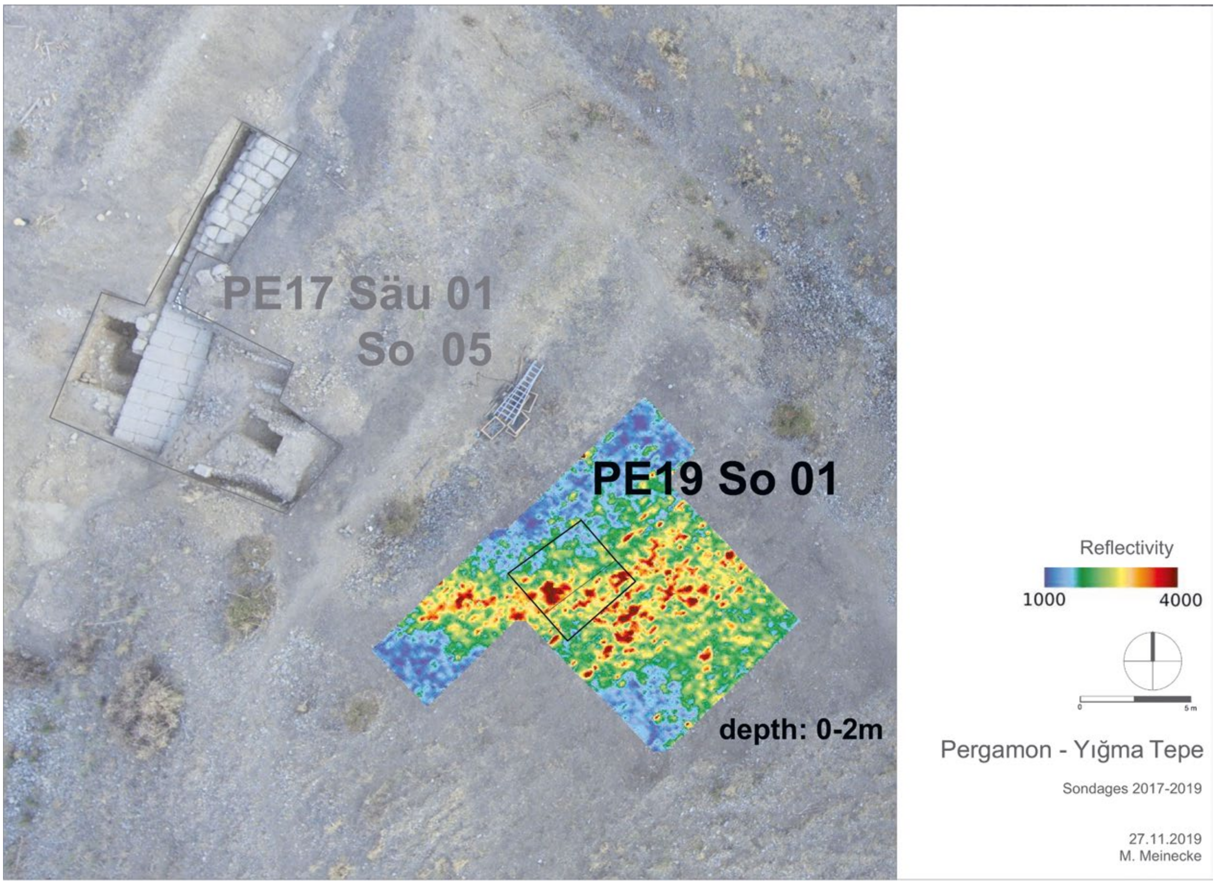
inciding rectangular zone of high reflectivity and electrical resistance 1 m below the current surface. It is about 3 m wide, continues 7 m uphill but turns hard to the northeast, where it becomes wider and ends at the large robbery trench (fig. 16). As this zone showed the same width as the ramp, it was thought to be its continuation[65]. However, it could not be reliably connected to the excavation due to non-measurable area, and its differing alignment with the archaeologically determined structure was conspicuous. Therefore, a small sondage (PE19 So 01) was placed over this area about 10 m east of PE17 So 05 and in alignment with the ramp. It revealed strong perturbations of the original fill made of densely packed gravel and rubble but no trace of the ramp. The observed anomalies were probably again caused by this material. Therefore, the ramp either ran on the original surface of the tumulus or not very deep below it and was not preserved due to the later large-scale perturbations, or it had a completely different course[66].

5. Discussion and Interpretation of the Results

At first glance, the three stratigraphic units determined by refraction seismics (fig. 3) with almost horizontal interfaces seem to be in accordance with Dörpfeld’s observations in his huge trench (fig. 1). Whereas his first interface layer ~ 5–6 m above the ancient ground surface is not visible in the reflection and refraction seismic, the second one at ~ 13 m height could coincide with the one between Phase 1 and 2. The upper boundary between Phases 2 and 3 could not have been recorded by Dörpfeld as his open trench did not reach this depth. The core mound might be visible in the geophysical data as well but is strongly biased by the reflections of his tunnel system (SOI 1). However, the further differentiation between an inner and outer part of Phase 1 through a hard-packed layer as assumed by the geophysics was not observed by Dörpfeld. The probably compacted surface of Phase 1 is of special interest as the reflective body SOI 4 lies on it and SOI 2 is embedded into it with its floor ~ 4–5 m above the ancient surface. Inter-

65 Mecking – Rabbel – Erkul 2018, 137–139 figs. 38. 40.

66 Meinecke 2020.



16 GPR depth slice near excavations PE17 So 05; The slice shows linear reflections pointing towards the centre of the tumulus with the possible connection to a ramp structure in PE17 So 05. This has been falsified by the test excavation PE19 So 01

estingly, the position of SOI 2 coincides with the lowest interphase layer drawn by Dörpfeld and could have been constructed on its surface or set in Phase 1 after some part of this fill was removed.

SOI 2 can be regarded as a major archaeological feature. Although its exact interpretation is not clear, judging by its size and proportions, it could represent a possible disturbed architectural tomb-structure with a grave chamber and a corridor (dromos)[67]. Some tuff blocks that were found in small excavations at the ancient robbery trench that do not belong to the crepis, and a larger andesite block in situ above the robbery trench below the top visible in 2017 might suggest such a built structure in a higher stratigraphic position. Additionally, the robbery trench itself seems to be oriented towards SOI 2 and 4. Furthermore, the eccentric location of SOI 2 coincides with the position of known grave chambers of smaller tumuli in the Pergamon area[68]. The distance (20 m) and direction (east) of the offset of SOI 2 are surprisingly similar to what is found at the Mal Tepe tumulus in Pergamon from the Roman period[69]. However, as is the case there, primary grave chambers are usually built on the original ancient surface or set in pits dug into the natural soil[70]. Dörpfeld already expected that a walled grave chamber would lie eccentrically

67 Mecking et al. 2021.
68 Such as the Taşdam Tepe (Stappmanns 2012), Ilyas Tepe (Pirson et al. 2011b) and Seç Tepe (Kasper 1966).
69 There the grave complex lies 21 m to the east of its centre (Dörpfeld 1907).
70 This applies especially to the barrel-vaulted Hellenistic chamber tombs of the so-called Macedonian type (von Mangoldt 2012). In Pergamon, this type is found at the Hellenistic tumulus on the İlyastepe (Pirson et al. 2011b) or in the 1st cent. BC tumulus near the Asklepieion in Pergamon (Ziegenaus 1966). Sometimes the whole chamber lies below the ancient surface as in the Hellenistic Naip tumulus of south-eastern Thrace (Delemen 2006).

only on the ancient surface as the freshly piled up earth would not be stable enough to support the weight of such an architectural structure. He concluded that only a smaller sarcophagus might be placed in such a stratigraphic position[71], but SOI 2 seems to be a larger built feature.

Only in very few cases have grave chambers been found at higher levels inside a tumulus. A prominent example is the Karakuş in east Anatolia where evidence of a chamber was found 8 m above ground in an eccentric position[72]. However, this tumulus is constructed on a steep hillside which is not comparable to the topographic situation of the Yığma Tepe. In the Askertepe tumulus near Tekirdağ in Ancient Thrace (northern Turkey) the architectural tomb complex of the second half of the 4th century BC lies ~ 3–4 m above the ancient surface in the tumulus fill in an eccentric position[73]. In both cases no other burial structures on the ancient base level are known as the tumuli have not been completely excavated. In Bulgaria, which also belonged to Ancient Thrace, some entirely excavated Hellenistic tumuli showed primary architectural grave complexes about 1.5 m over the ancient ground. Therefore, an artificial mound was piled up in a first construction stage, later some earth was removed for the construction of the chamber[74]. In the same region, more temple-like architectural structures have been recorded in the upper fill about 3 m over the ancient surface in the Ploskata tumulus or even to a height of 8 m in the Donkova Tumulus near Shipka[75]. Such structures, however, have never been observed in Hellenistic tumuli in Turkey and the region of Pergamon. In the Yığma Tepe there is no clear evidence in the geophysical data for another burial structure on the base layer inside Phase 1. This may be also due to the fact that the entire hill could not be investigated fully by geophysics and that small burial structures may not have been recognised due to the resolution limit of the applied methods. Dörpfeld reported only in his unpublished documentation that an almost complete pithos had been found in one of his tunnels, but without the mention of further finds this cannot be interpreted as the remnant of an older burial[76]. In the new excavations, a single rubble wall was found directly behind the crepis on the ancient surface in PE17 So 03, which was built much more carefully than the other segmented walls in the fill and might be vaguely interpreted as the beginning of a dromos[77]. Unfortunately, geophysical measurements behind this structure were inconclusive and a reflective body (SOI 6) that lies in the same sector on the base level cannot be characterised more precisely due to the low resolution of the seismic grid. Consequently, SOI 2 could represent either a primary or secondary tomb complex.

From the geophysical and archaeological data, a multi-phased or multi-staged construction of the Yığma Tepe can be assumed and is illustrated by the different stratigraphic units and SOIs at different heights. The radiocarbon date suggests that the crepis was constructed in the late 3rd or early 2nd century BC and the scarce archaeological finds in the backfill of the wall do not contradict this (see section 3.4). As it is interlocked with the inner embankment of outer Phase 1, at least the lower part of the tumulus must have existed at this time. However, whether the core mound and the inner Phase 1 represent an older tumulus remains open, as there is no archaeological evidence for or against it. At first sight it appears to be more logical that SOI 2 was set into a pre-existing monument with an already naturally compacted older fill. But the examples mentioned above and other points might indicate the opposite: Firstly, this hypothetical tumulus would have had a diameter of already 96 m and a height of 10 m and was relatively low in comparison to other tumuli of Asia Minor where the ratio between height and diameter is usually 1 : 5–6.5. Secondly, a pit of 5 m depth or a large-scale levelling prior to its construction would have been necessary. Thirdly, the geometric centre of the crepis wall lies close to the central posts inside the core mound (offset: 0.2–0.5 m) which makes a joint planning of both features seem likely. Therefore, the construction phases were probably realised in quick succession without longer breaks as in the examples from Thrace[78]. The same might be true for the rest of

71 Dörpfeld 1910, 392. Sarcophagi burials that are set in the upper layers of tumuli almost always represent secondary or subsequent burials as is the case in the archaic tumuli of Demirağ and Akpınar D in ancient Lydia (Manisa district) where the fill covered also a primary architectural grave complex (Roosevelt 2003, 133) or in the tumulus ›Kizöldün‹ in the Troad where it was enlarged for another sarcophagus (Rose 2014, 104).

72 Dörner 1969/1970.

73 That is not mentioned in the excavation report (Yildirim 2010) but Şahin Yıldırım confirmed this assumption, for which we are very grateful.

74 E. g. the Slavchova tumulus near Rozovo, and Sarafova tumulus near Kazanlak. In the latter the earth had not been consolidated enough and the walls of the grave chamber subsided (Kitov 2003a).

75 Dimitrova 2007.

76 Furthermore, they only occur in the Troad and not in the Aeolis in Archaic times (Mohr 2015, 66).

77 Dromoi with only one wall were observed in tumuli of Daskyleion (Iren – Doğan – Atay 2014) or the Çataltepe tumulus in Ainos (Başaran 2007, 194).

78 Mecking et al. 2020.

the fill as it is not clear if Phases 2 and 3 as well as SOI 4 and 5 represent a later enlargement of the tumulus[79]. The scattered pieces of pottery found in the upper fill dating to the 2nd to 1st century BC till 1st century AD could point to the latter but are not conclusive (see section 3.4). Furthermore, all construction phases or stratigraphic units seem to be piled up horizontally and Phases 2 and 3 would have been an untypical enlargement of an older monument only in height which is not attested for other tumuli. A continuous building process is also supported by the hypothesis that Phase 1 was created out of the excavated material of the southern part of the surrounding ditch and Phases 2 and 3 from material of the northern part (see section 2.2.1), because one would expect an evenly excavated ditch if Phase 1 represented a finished monument.

The proposed dating of the Yığma Tepe (late 3rd/early 2nd century BC) is in accordance with the earlier consideration that it could be the burial place of the Attalid rulers[80]. W. Radt assumed that it was built by Eumenes II (197–159 BC), as he enlarged the city of Pergamon significantly[81]. The new proposed date could point to Attalos I (241–197 BC) as well who was the first Attalid to take the title of king[82]. However, the attribution to one or the other Attalid ruler is a highly problematic task, as the basis for dating is still contentious. An important role in the determination of the grave owner was played by the observation of V. Scully, that the position of the tumulus in the plain seems not to be random and that its centre lies on the prolonged axis starting from the western side of the Temple of Athena over the western front of the Great Altar on the city hill (see fig. 21 in the contribution by F. Pirson in this volume)[83]. Others have observed such a connection as well, however, here the central axe of the Temple was reconstructed as starting point[84]. Therefore, different propositions concerning the grave owner have been made[85]. As new measurements revealed, the western sides of the Temple and the Altar are aligned but the deviations between the centre of the tumulus and the prolonged axis of the stairway side of the Great Altar being around 25–30 m and to the Temple of Athena 45–52 m. This seems negligible if one considers the distance of 3 km. In order to perceive this spatial relationship, a viewpoint further south of the temple on the terrace of the sanctuary would be needed, and was maybe another reason why the southern stoa was shortened[86]. Interestingly, SOI 2 lies very close to the prolonged axis of the altar (offset of 2–7 m) and is roughly aligned with it. But it is not clear if this is by chance or if it indicates joint planning. As the proposed date of the tumulus is earlier than the construction of the Great Altar (180–160 BC)[87] the latter seems less probable because the altar must have been positioned on the pre-existent visual axis between the Sanctuary of Athena and the tumulus. Nevertheless, another connection between the altar and the tumulus exists inasmuch as the same tuff was used for the construction of the foundations of the altar and the crepis of the Yığma Tepe[88]. If this is taken into consideration, another possible nature of the tumulus might be proposed, given that the Telephos frieze in the court of the altar shows the mythical founding of Pergamon[89]. In fact, Pausanias (8, 4, 9) wrote that the tomb for Auge, mother of Telephos, still existed above the *Kaikos* at Pergamon, and described it as a mound of earth surrounded by a foundation of stone and surmounted by a statue of a naked woman in bronze. P. A. Webb already proposed that the Yığma Tepe could have been meant here and believed in an early Hellenistic date for its construction[90]. Unfortunately, this cannot be verified as the appearance of the *sema* of the Yığma Tepe is unknown.

79 Later enlargements of tumuli that comprise several burial complexes are well known from Hellenistic tumuli in Greece, e. g. in Vergina/Aigai. However, older and once separated tumuli were integrated into one monument and all grave complexes lie on the ancient surface (see Kyriakou 2016, appendix V).

80 Choiseul-Gouffier 1809, 31; Dörpfeld 1910, 392; Hoepfner 1990, 282.

81 Radt 2016, 268; Pirson 2017.

82 Gehrke 2011, 15.

83 Scully 1962, 195 f. fig. 377; F. Pirson (in this volume) p. 149.

84 Hoepfner 1990, 282; Wulf 1994, 158 n. 147.

85 A. Stewart proposed Philetairos and Attalos I due to the connection to the Temple of Athena or Eumenes II if the Great Altar is the point of reference (Stewart 2000, 36–40). F. Queyrel thought also of Eumenes II (Queyrel 2005, 122).

86 Pirson – Ludwig 2024, 45 fig. 8; 46–47.

87 De Luca – Radt 1999, 120–124.

88 The analysed samples show a similarity in chemical composition and texture. We thank Domenico Miriello and Raffaella De Luca of the University of Calabria who carried the analysis out in 2019.

89 Pirson 2017, 87; Pirson – Ludwig 2024, 41.

90 Webb 1998, 249. See also F. Pirson (in this volume) p. 148 note 101. Adler connected the tumulus to another part of Pausanias lore (1, 11, 2) where he wrote about a heroon for Andromache and a cult for Pergamos and concluded that the tumulus might be the heroon of both due to its appearance with two summits (Adler 1872, 55). This is of course hardly credible and was rejected by Curtius also because of its position far away from the ancient city (Curtius 1872, 53).

Conclusion

The interdisciplinary project has shown that a combination of archaeological and geophysical methods is necessary if a monument of this size is to be examined without further destruction. Many new insights into the construction of the tumulus Yığma Tepe have been gained. Geophysical investigations revealed that the mound consists of three different stratigraphic units or phases, the first one differing considerably from the second and third in terms of seismic velocities. The detection of Dörpfeld's tunnel system showed that the application of reflection seismic was able to locate deep-set structures inside the embankment. At least one reflective body (SOI 2) might be a grave complex, which is now destroyed. The combined archaeological and geophysical project proved that the fill was horizontally and vertically segmented and structured by a complex system of rubble walls for shaping and stabilising the embankment. Furthermore, a multi-staged or even multi-phased building process is probable, but the time spans involved cannot be determined due to the scarce archaeological finds. With the radiocarbon date, the unguentarium and new finds, it is now demonstrable that a large part of the tumulus existed in the early 2nd century BC. However, an earlier date for at least some parts of the tumulus is still possible and a later enlargement of the monument in the 1st century BC or 1st century AD cannot be excluded either, although both seem unlikely. Therefore, the Yığma Tepe can now be interpreted more convincingly as the burial place of one (or several?) of the Attalid kings, perhaps stylised as a dynastic monument with references to Telephos and his mother Auge[91].

Abstract

From 2014 to 2019 a new interdisciplinary research project was carried out on the Yığma Tepe tumulus of Pergamon (158 m diameter, 32 m height). Large-scale geophysical prospections by the universities of Kiel and Kocaeli (Geoelectrics, GPR, Seismics) were supplemented by small-scale excavations by the Pergamon Excavation of the German Archaeological Institute. They showed that the tumulus consists of three different stratigraphic units of about 10 m in height. Several deep-set structures were recorded inside the embankment (SOI 1–6). At least one large reflective body (SOI 2) lying 5 m above the ancient surface might be a grave complex. Excavations and near-surface geophysics showed a complex system of radially and concentrically arranged, segmented and poorly built rubble walls in the embankment. This reflects the construction process and might have served to regularise and stabilise the tumulus. The foot of an unguentarium (late 3rd or early 2nd cent. BC) found below the crepis gives a *terminus post quem* for its construction, which is further supported by a C^{14}-AMS dated piece of charcoal (370–195 BC) in its construction debris layer. Therefore, the tumulus was probably built in the Hellenistic period and might be the burial place of the Attalid king(s).

Keywords: tumulus, geophysical prospection, excavation, Pergamon, hellenistic

Illustration Credits

Fig. 1 Dörpfeld 1910, 389 fig. 9 (modified)
Figs. 2–7 R. Mecking, E. Erkul, W. Rabbel
Figs. 8. 9 b; 9. 11–13 M. Meinecke
Fig. 9 a D-DAI-ATH-1907.1529
Fig. 10 M. Meinecke, M. Lomp, I. Yeneroğlu
Fig. 14 A. Keweloh-Kaletta
Fig. 15 E. Erkul, M. Meinecke, I. Yeneroğlu, B. Ludwig
Fig. 16 E. Erkul, R. Mecking, M. Meinecke, I. Yeneroğlu

91 Cf. Pirson 2017, 87–89; Pirson – Ludwig 2024, 41.