Protohistoric stone disks from entrances and cemeteries of north-eastern Adriatic hill forts

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ABSTRACT – *The paper presents a group of four, approximately 0.5m large, stone disks from entrances or cemeteries of two protohistoric hill forts of north-eastern Adriatic. The disks, having a sparse chronology with the exception of one dated to the Middle Bronze Age, show flat and plain surfaces or covered with sub-circular depressions. One disk shows two larger cup-marks at the centre of both faces. They are interpreted as ritual artefacts based on the association with sacred settlement locations and comparisons with similar coeval stones found mainly close to citadel entrances, burials and thresholds in the Aegean area and Anatolia.*

KEY WORDS – *north-eastern Adriatic; hill forts; stone disks; cup-marks; SfM photogrammetry; Bronze Age religion*

IZVLEČEK –

KLJUČNE BESEDE –

DOI: 10.4312/dp.49.7

Introduction

The Karst plateau and Istrian peninsula at the north-eastern shore of the Adriatic Sea (Fig. 1) are marked by the presence of hundreds of protohistoric settlements, generally located on hilltops. These sites, protected by dry-stone walls, locally called *castellieri, gradine* or *gradišča*, featured clear originality and cultural unity in pottery production, architectural models, defensive systems and funerary practices. They were settled for a very long time, spanning from the late Early Bronze Age (EBA), approximately between 1800 and 1650 BC, to the late Iron Age (IA; *Mihovilić 2013; Borgna* et al. *2018*). The formation and rising of *castellieri* chronologically corresponds to the EBA II in the Italian relative chronological system (*Cardarelli 2009*) and to the BZ A2 in the Central-Europe Reinecke's system (*Hänsel 2009*). Their origin is still debated. The complex fortified entrances, the inner-space subdivision and settlement layout of some of them, *e.g.*, Monkodonja/Moncodogno (hereafter just Monkodonja) hill fort in Istria, together with some peculiar ceramic and metal artefacts, such as pottery tripods and bronze knives with two rivet holes, suggest that the first Istrian settlements had direct contacts with the eastern Mediterranean (*Hänsel* et al. *2015*). However, other archaeological artefacts, such as the so-called enigmatic tablets, defined also as *Brotlaibidole*, and some types of pottery vessels, show that Istria was also connected to the Pannonian-Carpathian area (*Hänsel* et al. *2015; Borgna* et al. *2018*). Other pottery materials suggest connections with northern Italy and Apulia, too (*Hänsel* et al. *2015*).

Considering the funerary practices, small cemeteries close to or within the hill fort fortifications and burial mounds are the main funerary contexts at least from the EBA to the later Bronze Age phases. In more detail, single or small groups of burials have been identified next to the gates of settlements and/or within the ramparts. Recent radiocarbon dates obtained from two individuals buried in a small monumental cemetery found next to the main fortified entrance at Vrčin/Mt. Orcino (hereafter just Vrčin) in southern Istria (the so-called *sepolcreto gentilizio*, consisting of about 20 cist tombs) point to a time span approximately between about 1700 and 1200 BC (*Battaglia 1958; Cupitò* et al. *2018*). Cist tombs included within stone platforms very similar to those from Vrčin are known from the Gradina hill fort on Veliki Brijun/Brioni Maggiore island (hereafter just Veliki Brijun; *Vitasović 2002; 2005; Buršić-Matijašić, Žerić 2013*). At the Monkodonja hill fort, two cist tombs of similar chronology have been identified next to the western entrance (*Hänsel* et al. *2015*). The radiocarbon dating of some of the human remains from Monkodonja covers approximately the period between 1900 and 1600 BC (*Hänsel* et al. *2015*). A similar cist tomb has been discovered at the Gradac-Turan hill fort located along the eastern Istrian coast (*Mihovilić 1997; Buršić-Matijašić, Žerić 2013*).

Burial mounds have been found in the Karst and Istria in the surroundings of several hill forts, such as the tumuli of Mušego near the settlement of Monkodonja (*Mihovilić* et al. *2012*), those close to the Vrčin hill fort (*Battaglia 1958*) or the one excavated close to Barbariga (*Codacci-Terlević 2012*). Generally, as for burial mounds excavated in other part of Istria, they feature one or more depositions within stone cists covered by a stone slab and an earth or stone cap.

In this contribution, using structure from motion photogrammetric techniques, we present a group of four stone disks associated with entrances or Bronze Age cemeteries of two hill forts, Rupinpiccolo and Gradina, on Veliki Brijun, located in the Trieste Karst (Italy) and in the Brijuni/Brioni islands facing the southern Istria (Croatia), respectively (Fig. 1).

Rupinpiccolo/Repnič hill fort

The Rupinpiccolo/Repnič hill fort is located in the southern side of the central Karst ridge, which develops through the Karst plateau with a Dinaric orientation and approximately marks the border between Italy and Slovenia (Fig. 1). The area belongs to the Cenomanian to Turonian Repen Formation consisting of bedded and massive, partly re-crystallized, limestone containing chert and with displaced, locally broken and rounded rudist shells (*Jurkovšek* et al. *2016*).

The ruins of its massive defensive structures were already noticed at the beginning of last century (*Marchesetti 1903*). The first archaeological investigations were carried out several decades later in 1965, 1970–1974, 1986 and 1988 (*Cannarella 1970; 1975; Maselli Scotti 1988*), making it possible to uncover the entire surviving fortification system. The site, built along the slope of a modest hill,

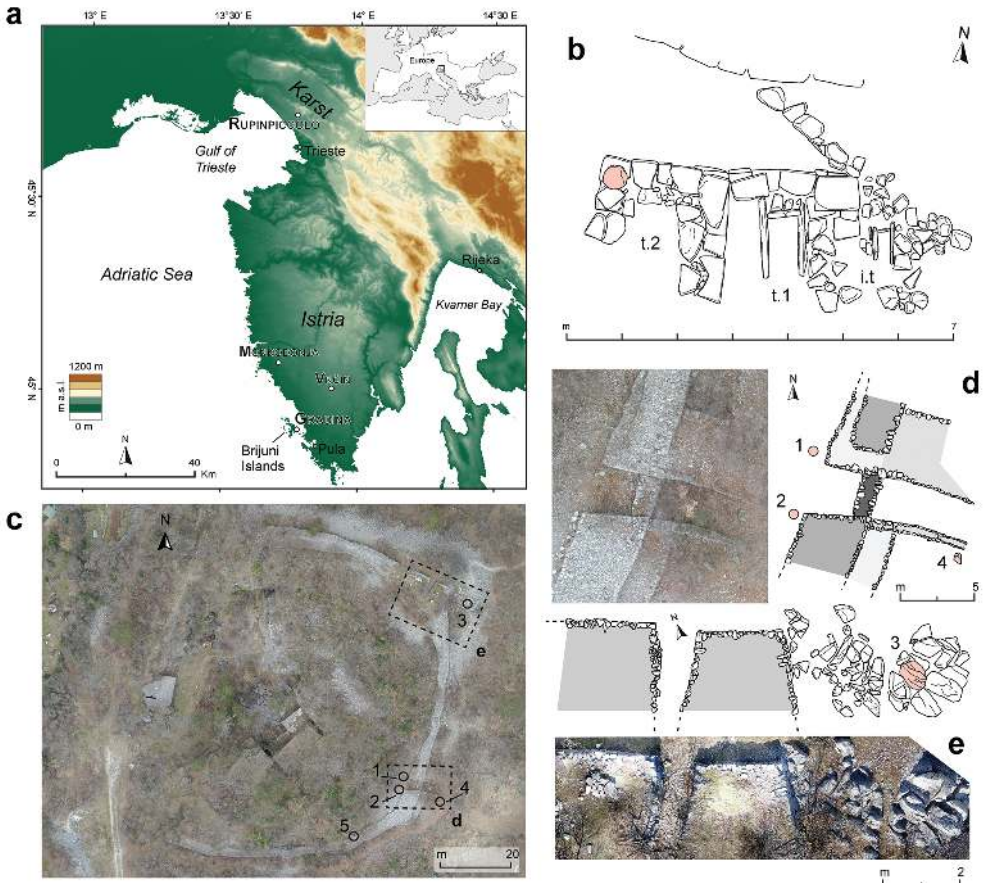

Fig. 1. The Rupinpiccolo and Gradina on Veliki Brijun hill forts. **a** ***Position of Rupinpiccolo and Gradina on Veliki Brijun hill forts and other main sites mentioned in the text.*** **b** ***Plan of the Bronze Age cemetery (t1-t.2: tombs 1-2; i.t.: infant tomb) of Gradina on Veliki Brijun hill fort with the Gradina disk 2 in light red.*** **c** ***Drone-derived orthophoto of the Rupinpiccolo hill fort with the position of the stone disks (1–2), ancient quarrying sites (3–4) and a block of the rampart with a wedge hole (5).*** **d-e** ***South-eastern and north-eastern gates of Rupinpiccolo, respectively.***

shows a sub-rectangular plan but its western side has been destroyed by a modern quarry. It was defended by a massive rampart, up to 7m tall, built with two main external stone alignments with the intervening space filled with smaller stones and partially supported by lower stone reinforcements. Two entrances have been discovered approximately at the north-eastern and south-eastern corners. The first one is located on the hilltop and is about 2m tall, while the southern one is larger, about 3.2 m, externally delimited by a corridor-like structure and walled up in ancient times. Remains of four inner transversal terraces, probably built to support the dwellings, have been identified.

According to available data, the stones used to build the fortification, including massive blocks up to about 3m wide, were taken from the local limestone outcrop which is broken in many parts, just outside the rampart. In addition, chisel marks and a wedge hole were identified a few meters east of the north-eastern corner of the fortification (*Priuli 1977*). The use of such huge blocks is not reported in other sites of the Trieste Karst, and makes Rupinpiccolo a unique context.

Based on the typology of ceramic finds, Rupinpiccolo was firstly dated to the IA (*Cannarella 1975*), then to a period spanning from the Late Bronze Age (LBA) to the advanced IA (*Maselli Scotti 1982; 1983*). However, Bronze Age materials were only partially published, and our revision of pottery finds has allowed us to identify pottery shards dating back to the EBA/initial Middle Bronze Age (MBA; see *infra*). No traces of a later Roman occupation of the site have been identified (*Cannarella 1975*). Archaeological survey (*Bernardini 2012*) and airborne laser scanner investigations (*Bernardini* et al. *2013; Vinci, Bernardini 2017*) have revealed that Rupinpiccolo is not isolated, but is part of a small-scale cluster of four hill forts.

Gradina on Veliki Brijun/Brioni Maggiore

The Gradina hill fort, also known as Monte Castellier, is located on the eastern side of the Veliki Brijun island in front of southern Istria (Fig. 1). Veliki Brijun is part of the Upper Albian to Middle Cenomanian carbonate succession of southern Istria (*Tišljar* et al. *1998*).

The hill fort is composed of three concentric ramparts extending over a surface of more than seven hectares (*Vitasović 2002; 2005*). Already recognized more than a century ago (*Puschi 1898; Marchesetti 1903*), it was investigated by Gnirs (*1925*), who identified an entrance in the north-western part of the upper rampart and, later, by Boris Baćić and Anton Vitasović (*2002; 2005*). These last researchers excavated the entrance previously identified, revealing a complex structure designed to defend the access to the site. They also investigated other structures and a small cemetery next to the external side of the upper rampart, composed of a few cist tombs within platforms divided by low walls (Fig 1B; *Vitasović 2002; 2005; Buršić-Matijašić, Žerić 2013*). The Gradina entrance finds significant comparisons in Bronze Age hill forts of Istria, such as Monkodonja (*Hänsel* et al. *2015*), while the small cemetery is very similar to the Vrčin necropolis, recently radiocarbon dated to between about 1700 and 1200 BC (*Cupitò* et al. *2018*). The available data suggest that the Gradina on Veliki Brijun was settled for a long span time, at least from the late EBA and the IA (*Vitasović 2002; 2005*).

Materials and methods

Identification of the stone disks and related archaeological evidence

The stone disks 1 and 2 from Rupinpiccolo were uncovered during the excavations carried out in the 1970s close to the inner side of the south-eastern entrance (*Cannarella 1970; 1975*), but they were not recognized as valuable artefacts and were left on site (Fig. 1). Since the identification of the disks by Federico Bernardini, all the area has been carefully and repeatedly surveyed, in order to identify possible chisel marks and wedge holes on blocks of the rampart, similar to those identified on the disks (see *infra*) and on the karst outcrops just next to it. This research confirmed the presence of chisel marks and a wedge hole on the hilltop (*Priuli 1977*) (Fig. 1 and supporting Fig. 1A) and led to the identification of wedge hole remains on the karst outcrop next to the southern wall of the corridor-like structure in front of the south-eastern entrance (Fig. 1 and supporting Fig. 1B) and on a block of the rampart (Fig. 1 and supporting Fig. 2). The outcropping rocks with traces of wedge holes and chisel marks on the hilltop and close to the entrance were buried under the ruins of the rampart and brought to light by the archaeological excavations (*Priuli 1977*).

Stone disk 1 from Gradina on Veliki Brijun was discovered during the excavation of the entrance of the upper rampart and was preliminarily described and recognized as an artefact with a probable ritual value (*Vitasović 2005*). Stone disk 2 was identified during a visit to the small Bronze Age cemetery of the hill fort in 2019 by Bernardini. It lies on the eastern side of the low wall that delimits a tomb (Fig. 1B).

Drone structure from motion photogrammetry

A drone survey of the whole Rupinpiccolo site was performed in order to produce orthophotos and plans of the site, taking advantage of the low and sparse vegetation (*Eltner* et al. *2016*). Two separate flights, with the camera aligned perpendicular to the flight path and with a tilt angle of 45 degrees, respectively, were planned with FlightPlanner software (AeroScientific, Blackwood, Australia) to maintain a constant ground sample resolution (GSR) and optimize the area coverage. Drone pictures were taken using a DJI Mavic drone (DJI, Nanchan District, Shenzen, China) capable of providing 12Mp files with a zoom lens equivalent to 24–48mm. Working with a medium-long focal lens instead of a wide angle allowed us to perform higher flights above the vegetation and maintain a high ground resolution (12.7mm/pixel) over an area of 46 953m^2. In order to reduce the flight time, jpeg files were saved, cloudy days were preferred and almost no shadows were registered. A total of 414 orthogonal images and another series of 94 images with the same focal length but different angulations and ground resolutions were taken and processed using Agisoft Metashape (Agisoft LLC, St. Petersburg, Russia, 2019). The images were aligned, and a sparse point cloud generated using high quality settings. Thickening the cloud was done using the Dense Cloud algorithm, which was run at high resolution to provide a large number of points, suitable for DEM generation.

Such an approach was not applied at Gradina on Veliki Brijun because the area is covered by dense

evergreen vegetation.

Terrestrial structure from motion photogrammetry

The terrestrial structure from motion (SfM) approach was applied to produce a plan of the Gradina on Veliki Brijun cemetery and high-resolution 3D models of the stone disks (*Verma* et al. *2019; Porter* et al. *2016*), a Rupinpiccolo rampart block with wedge-hole remains, the Rupinpiccolo quarrying sites and a block from the Bronze Age Vrčin cemetery in Istria (Croatia). A full frame 21 megapixel camera was used with a 17mm lens, and raw format images were taken in order to produce files with low contrast capable of generating point clouds of even dark spots.

A total of 56 images of the Gradina on Veliki Brijun burial site, 270 images of the Rupinpiccolo quarrying site east of the north-eastern gate, 91 images of the Rupinpiccolo rampart block with two symmetrical half-wedge holes and 65 images of the block from Vrčin cemetery were acquired.

For the stone disks, two series of pictures representing both sides of the artefacts and their edges were taken to ensure the correct alignment. When necessary, a flashlight was used to achieve better visibility in the shadows and avoid uneven lighting (*Menna* et al. *2016*). Finally, a colour reference was used to calibrate colours during postproduction and to scale the model. A total of 98 and 96 images of Rupinpiccolo stone disk 1 faces, 104 and 125 images of Rupinpiccolo stone disk 2 faces, 113 and 134 images of Gradina on Veliki Brijun stone disk 1 faces and 38 and 82 images of Gradina on Veliki Brijun stone disk 2 faces were taken.

All the acquired images were processed using Agisoft Metashape (Agisoft LLC, St. Petersburg, Russia, 2019), as described for the drone photogrammetry of Rupinpiccolo. In addition, to remove outliers and improve the overall quality of the models, after sparse cloud generation the gradual selection tool was applied to remove non-correctly aligned pictures. After separating the sparse and dense cloud generation of the stone disk faces, manual alignment of the two clouds selecting homolog points along the stone edges was performed just before the mesh generation and texturing.

The large number of pixels and the high dimensionality of the CCD sensor used provided high resolution models: Gradina on Veliki Brijun cemetery: 10.7mm/pixel; Rupinpiccolo rampart block: 0.254mm/pixel; quarrying site: 12mm/pixel; Vrčin block: 1.68mm/pixel; Rupinpiccolo stone disks 1 and 2: 0.114 and 0.104mm/pixel, respectively; Gradina on Veliki Brijun stone disks 1 and 2: and 0.111 and 0.627mm/pixel, respectively.

Elaboration of 3D models

The obtained 3D models were visualized and rendered by using MeshLab 2020.03 (*Cignoni* et al. *2008*) in order to enhance artificial features, such as chisel marks and wedge traces, and bioerosional evidence detected on the frontal face of the disk 1 from the Gradina on Veliki Brijun hill fort. Surface features have been enhanced applying radiance scaling, and/or lattice plugins. The radiance scaling technique makes it possible to enhance shape details such as convexities and concavities (*e.g., Vergne* et al. *2012*), while the lattice shader makes it possible to detect surface details by removing the colour and regulating the light direction (*e.g., Cassen* et al. *2014*). In order to enhance the bottom of the chisel marks of stone disk 1 from Rupinpiccolo, the plugin Colorize curvature (APSS) was applied using the default parameters, with the exception of the filter scale which was set at 4.

Typological analysis of Bronze Age pottery and initial occupation of Rupinpiccolo

Bronze Age materials from Rupinpiccolo have only been partially published and, for this reason we have reviewed the pottery finds from the site kept in the Soprintendenza Archeologia Belle Arti e Paesaggio del Friuli Venezia Giulia.

Results

Rupinpiccolo stone disks

Two disks, carved from the local massive limestone belonging to the Repen Formation (*Jurkovšek* et al. *2016*), have been identified next to the south-eastern gate of the Rupinpiccolo hill fort (Trieste Karst, Italy; Fig. 1).

Rupinpiccolo stone disk 1

The Rupinpiccolo disk 1, about 50cm wide and 20cm thick, was carved by using a metal point chisel and a hammer. Producing a rounded disk from very massive and compact limestone is not a simple task, since advanced stone-working skills are required. The stone has a relatively flat upper face showing numerous chisel marks arranged in patterns (Figs. 2–3). The depth of the chisel marks ranges from about 20 to 1mm in those more seve-

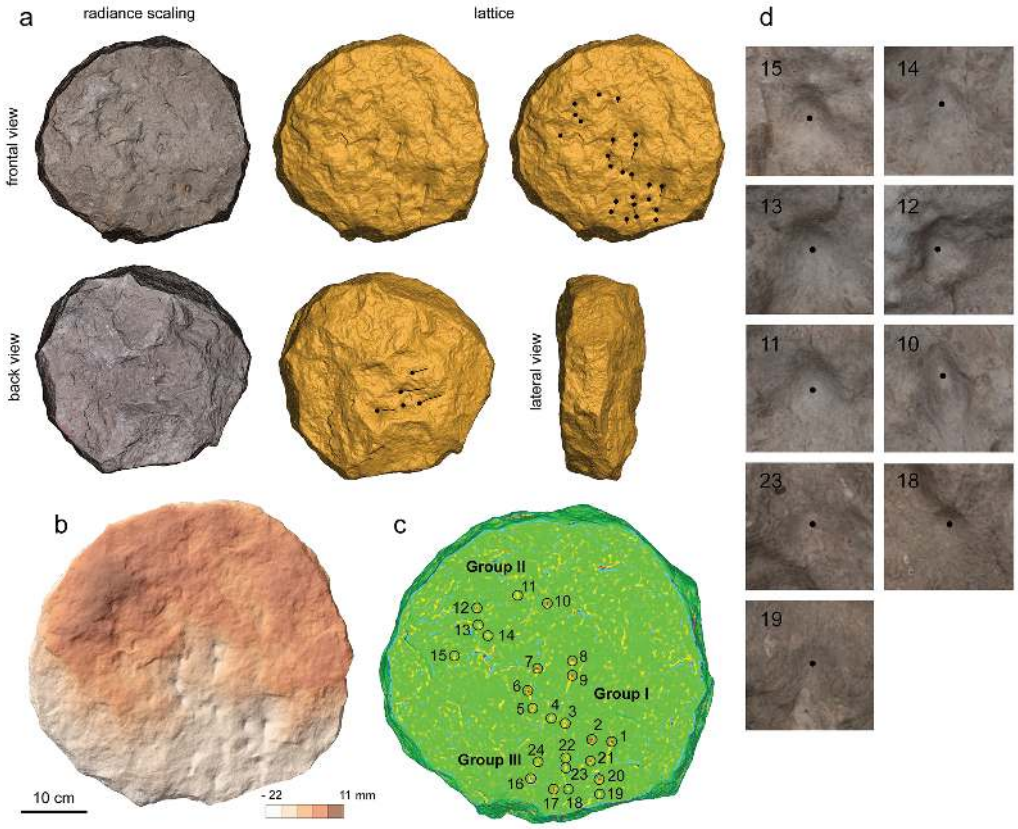

Fig. 2. Rupinpiccolo stone disk 1. **a** ***Radiance scaling and lattice visualizations of the disk with chisel marks highlighted in black (full circles correspond to the bottom of the chisel marks).*** **b** ***Digital elevation model of the frontal face of the disk.*** **c** ***Curvature map of the disk with chisel marks indicated by black circles and numbers. d Enlarged view of chisel marks 10–15, 18–19 and 23. The other chisel marks are clearly visible in Fig. 3.***

rely affected by weathering processes. The diameter of the chisel marks ranges from about 10 to 5mm with most of them being about 7mm. This suggests that the original point of the chisel was about 6–7mm in diameter.

The relatively flat morphology of the frontal surface of the disk 1 was probably achieved by centripetal flaking using a precursor. The position of the chisel marks corresponds to limited portions of the disk upper surface, suggesting they were not due to surface flattening processes. This is also shown by the digital elevation model of the frontal surface of the disk (Fig. 2B), where some marks were produced on the highest portion of the surface but without making it flatter, and the others, located at the lowest portion of the stone, have produced an irregular depression. Moreover, the very small distance between some marks (*i.e.* less than 2cm) further supports the idea that they were intentionally created to reproduce a pattern.

The chisel marks are highlighted in the curvature map of the disk due to their hemispherical shape, which separate them well from the other surfaces of the disk (Figs. 2C and 3). They are iso-oriented and were likely created by a right-handed person holding an oblique metal chisel with the left hand and a hammer with the right one.

Considering the north-eastern Adriatic region, the use of bronze tools to work limestone is already documented in the cemetery of Vrčin hill fort in Istria covering approximately a time span between 1700 and 1200 BC (*Battaglia 1958; Cupitò* et al. *2018*; see *infra*). Most of the cist tombs are included within platforms delimited by low walls made of well-shaped blocks which show clear marks produced by a metal point chisel (*Battaglia 1958*; supporting Fig. 3), similar to those found at Rupinpiccolo.

Rupinpiccolo stone disk 2

The Rupinpiccolo stone disk 2 was found close to stone disk 1 (Fig. 4). They share the same raw material, size (about 50cm large and 30cm thick) and shape, but its frontal surface is very flat and without any chisel marks (Fig. 4). To obtain such a flat

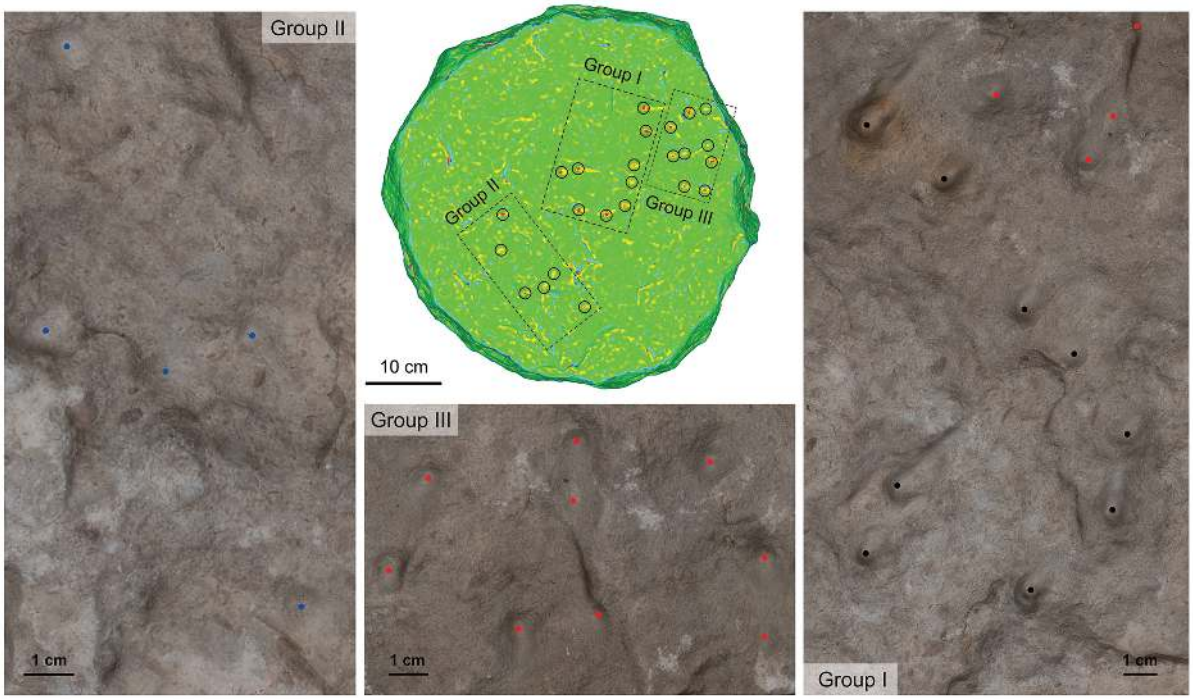

Fig. 3. Curvature map of the frontal face of the Rupinpiccolo stone disk 1 and enlarged views of the chisel marks divided in three groups (I-III). Chisel marks of Group I are indicated by black circles, those of group II (with the exception of one mark which is not shown) by blue circles and those of group III by red circles.

surface a rock with a very regular bedding plane was selected, extracted and carefully worked. Unlike the other stone, disk 2 still has the remains of two different half-wedge holes that made it possible to shape the artefact. One of them, originally part of a complete hole with a triangular cross-section, is about 12cm wide and 6cm deep and still preserves faint parallel and oblique chisel marks on its surface (Fig. 4, black arrows and lines). It develops on the lateral surface of the disk from the frontal surface towards the bottom of the disk. It was likely opened up to separate the block from the outcrop. The other half-wedge hole, about 15cm wide and 7cm deep, shares a similar cross-section and chisel marks but it is located on the bottom surface (Fig. 4, grey arrows and lines). It was opened to reduce the thickness of the disk. The presence of such wedge holes is significant, as it makes it possible to connect the disks with the quarrying sites used to build the rampart. After the production of the rough stone, it was carefully retouched by using a hammer to make the frontal surface round.

Typological analysis of Bronze Age pottery and initial occupation of Rupinpiccolo

Based on our review of the pottery assemblage from Rupinpiccolo, the initial occupation of the site is likely to be placed during the late EBA/MBA.

In particular, one elbow (*a piastra*) shaped handle with straight upper profile (Fig. 5.1), one fragment of handle with a large central impression (Fig. 5.2) and another a lingua pointing up handle (Fig. 5.3) all refer to typical *castellieri* types well attested in the Istrian peninsula, the Trieste Karst and Friuli between late EBA-initial MBA (*e.g., Urban 1993. Pl. 1.2–3; Mihovilić 1997.Pl. 1.1 and 10; Hellmuth Kramberger 2017.Pl. 100.8–10*).

The base of a bowl decorated with rectilinear furrows on the external side (Fig. 5.4) points to a similar chronological span. This decoration refers to a cruciform-like set of motifs, probably recalling the solar symbolism associated with pottery finds (generally to the external base of bowls and cups) widespread in several coeval contexts from the North Adriatic (Trieste Karst, Istria and Kvarner), the Po plain and the adjacent peri-Alpine zone and the Pannonian-Danubian region (*Hellmuth Kramberger 2017.161–168*). The best comparisons for the Rupinpiccolo base are found at the hill fort Gradac-Turan in Istria (*Mihovilić 1997.Pl. 1.3*).

A generic chronology pointing to the MBA can be proposed for some relatively small globular bowls

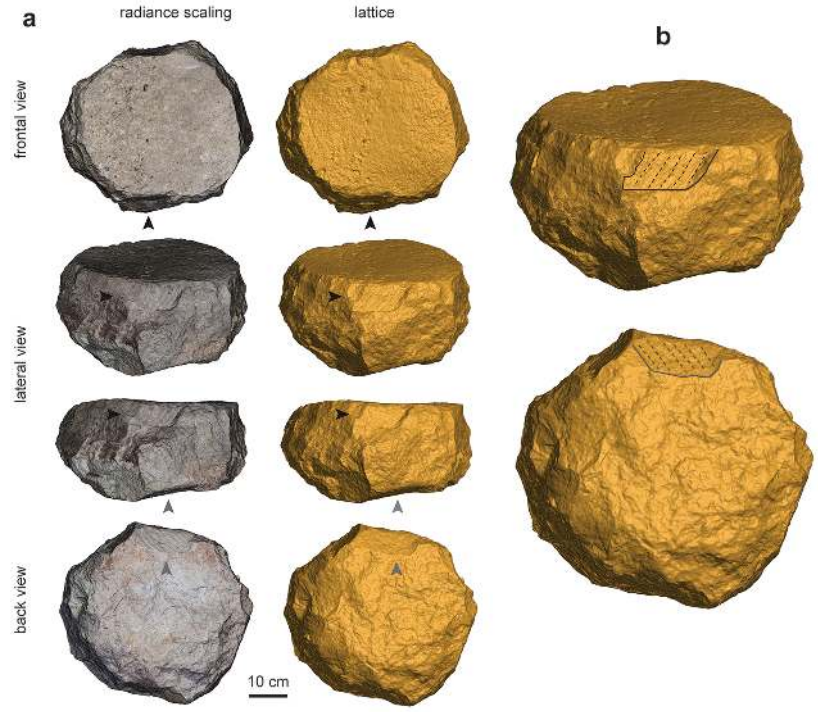

Fig. 4. Rupinpiccolo stone disk 2.* a *Radiance scaling and lattice visualizations of the disk with black and gray arrows showing lateral and bottom wedge hole traces, respectively.* b *Lateral and bottom lattice visualizations showing the wedge hole remains.

and jars with everted rims, sometimes decorated with a circular knob under the rim (Fig. 5.5–7), well attested in the *castellieri* assemblages (*Cardarelli 1983.Pl. 17, type 71 and Pl. 18, type 6*) and very common at several sites in the Trieste Karst and Istria (*e.g., Hellmuth Kramberger 2017.Pl. 32.2*).

Finally, a carinated bowl (Fig. 5.8), a jar with a thick crown-like rim (Fig. 5.9) and a handle with a deep circular impression (Fig. 5.10) find good comparisons with types in use between the final MBA and the first centuries of the LBA (*Cardarelli 1983.Pl. 18, type 97a and Pl. 19, type 14; Hellmuth Kramberger 2017.Pl. 20.1*).

Chronology of Rupinpiccolo disks

The pottery assemblage from Rupinpiccolo shows that the hill fort was probably in use from about 1800/1650 to 400 BC. The disks can only be safely referred to this long time-span (the original finding context was not recorded in detail during excavations), but several data suggest they can be lined to an early building phase of the rampart. The half-wedge holes on disk 2 and chisel marks on disk 1 can be associated with identical stone-cutting marks identified next to the external face of the rampart (Fig. 1.C, locations 3–4) and in one large block of the rampart itself (Fig. 1.C, location 5). These stone-cutting marks do seem to be related to the building of the rampart itself.

● Location 3 of Fig. 1. East of the north-eastern gate of the Rupinpiccolo hill fort, an area covering about 16 square meters, that before excavations was buried under the ruins of the rampart, is characterized by outcropping rocks showing numerous fractures produced by the extraction of blocks to build the rampart (Fig. 1.C,E, location 3). Chisel marks, interpreted as a representation of a halberd (*Priuli 1977*), and a wedge hole were already identified on the face of a large outcrop-

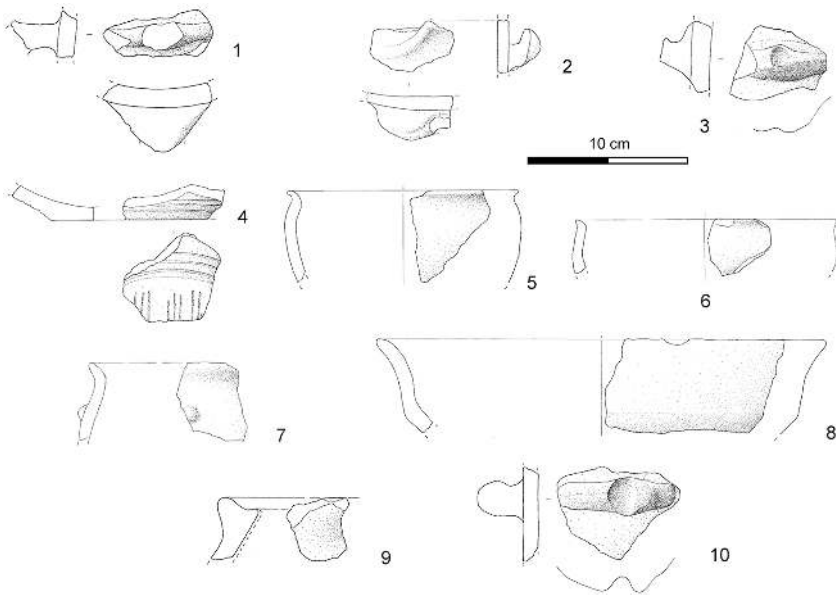

Fig. 5. Bronze Age selected pottery from Rupinpiccolo. Drawings by G. Vinci and A. Fragiacomo.

ping rock in the 1970s (supporting Fig. 1.A). An accurate re-examination of the rock and the elaboration of its 3D model have made it possible to identify a line of additional chisel marks parallel to the handle of the putative halberd and many other previously unreported marks on the adjacent eastern rock face. The wedge-hole is complete and is identical to those identified on stone disk 2, showing a triangular cross-section and similar dimensions (about 20cm wide and 7cm deep). The chisel marks present on both wedge-holes and the other surfaces of the rock are comparable to those identified on the stone disks, likely produced by a point chisel. The position of chisel marks and wedge-hole suggest that all of them are related to an aborted attempt to extract a stone block after a first block was successfully obtained. The putative halberd, located opposite to the wedge-hole, seems more likely a quarry mark related to the extraction activity.

● Location 4 of Fig. 1. An additional half-wedge hole has been identified on an outcrop next to the southern wall of the corridor-like structure in front of the south-eastern entrance (Fig 1.C,D, location 4 and supporting Fig. 1.B). It is also very similar to those present on stone disk 2. Originally part of a complete hole with a triangular cross-section, it is larger (about 40cm wide and 20cm deep) and still preserves faint parallel and oblique chisel marks on its surface. This area was completely buried under the ruin of the entrance, testifying to its ancient origin.

● Location 5 of Fig. 1. Finally, a wedge-hole divided in two symmetrical parts has been identified on a large block broken in three big pieces, which belongs to the inner stone alignment of the rampart of Rupinpiccolo (Fig 1.C, location 5 and supporting Fig. 2). Three chisel marks and half-wedge hole have been recognized on the southern fragment of the block (supporting Fig. 2, black arrows and lines). The chisel marks are probably related to the preliminary operations aimed at the production of the hole. Just in front of this first half-wedge hole, another one originally belonging to the same hole has been identified on the northern fragment of the block (supporting Fig. 2, white arrows and lines). The wedge-hole is about 18cm wide and 10cm deep and shows a triangular section but no parallel chisel marks, similar to those visible on the half-wedge holes of disk 2 and the outcropping rock close to the south-eastern entrance, are visible. This suggests that the block suffered higher levels of dissolution probably because it was not completely buried under the ruins of the rampart such as the stone disks and the outcropping rocks with quarrying traces.

At the macroscopic level, the original surfaces of the block and the wedge-hole faces appear much smoother than the fracture surfaces, suggesting the block was put in place after an aborted attempt to split it and broke up in recent times.

The ancient origin of the quarrying traces was ascertained based on the fact that they were covered by the massive ruins of the rampart and are located next to it. A possible later quarrying activity is unlikely, considering that the ruins of the rampart could easily provide abundant already extracted limestone blocks of different size. The identification of one of the newly identified wedge holes on one block of the rampart would further confirm such a hypothesis. Considering that the surviving rampart has been entirely excavated, and only one main building phase was recognized with some possible minor additions (*i.e.* rampart stone reinforcements and the corridor-like structure connected to the south-eastern gate; *Cannarella 1975*), its construction could have taken place during an early phase of the hillfort. Most of the large blocks used to build the Rupinpiccolo rampart were probably extracted levering along natural fractures in the local limestone outcrop, but, when necessary, wedge-holes produced by metal chisels were used to split the rock in absence of natural discontinuities by using wooden levers or wooden/stone wedges.

In Egypt, wedging was generally believed to be a quarry technique developed during the mid-1st millennium BC with the introduction of iron tools/wedges (*e.g., Harrel, Storemyr 2009*), but the identification of u-shaped holes in greywacke quarries of the Wadi Hammamat (eastern desert of Egypt) and stone wedges of the same rock type suggest that such technique was in use much earlier, probably since the Old Kingdom (mid-3rd millennium BC; *Bloxam 2015*).

Stone disks from Gradina on Veliki Brijun/Brioni Maggiore

The other pair of disks are from the Gradina hill fort (Veliki Brijun island, Croatia; Fig. 1), in use at least from the late EBA to IA.

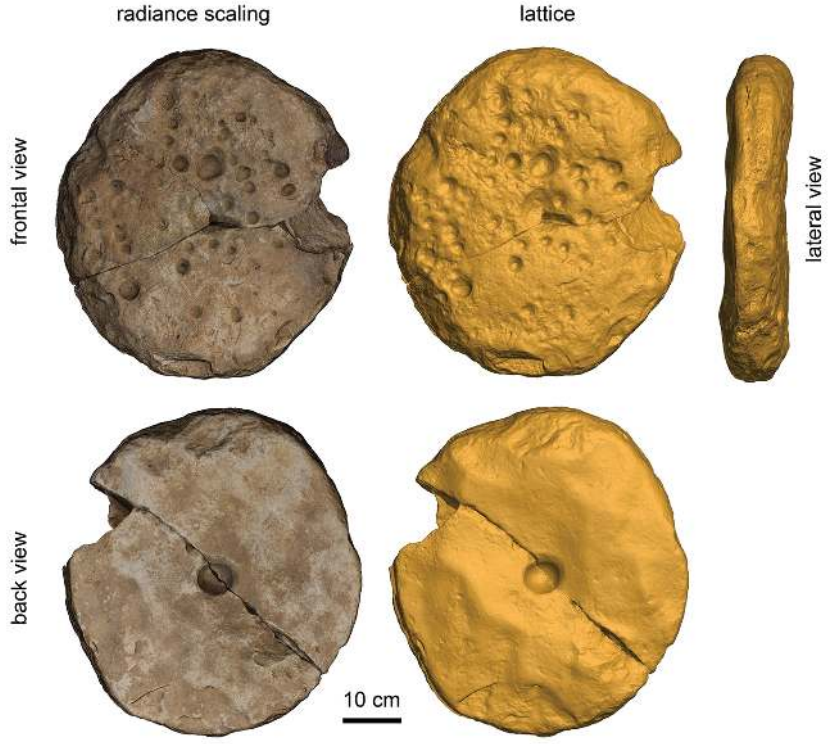

Fig. 6. The Gradina stone disk 1 from the upper entrance of Gradina on Veliki Brijun island (Croatia).

Stone disks 1–2 from Gradina on Veliki Brijun

Gradina 1 is about 50cm wide and 10cm thick and was found next to the entrance of the upper rampart (*Vitasović 2005*). Both faces show a central artificial cup mark, 6cm wide, but only one face is covered with shallow hemispherical depressions, likely produced by marine bivalves (Fig. 6 and supplementary text), while the opposite one is flat (Fig. 6). The other disk, Gradina 2, has been identified in the Bronze Age cemetery next to the upper rampart (Figs. 1.B and 7), composed of a few cist tombs within platforms divided by low walls. Despite its slightly smaller size, with a diameter of about 44cm and without wedge holes, it closely resembles the Rupinpiccolo disk 2. Its frontal surface, partially damaged on one side, is very flat and without any chisel marks. It was obtained by selecting a stone slab with a regular bedding plane and through a careful retouching of the disk edges by using a hammer precursor.

Chronology of disks from Gradina on Veliki Brijun

Disk 2 is very important to date the north-eastern Adriatic disks, since it is the only one belonging to a secure Bronze Age context. The disk comes from the small cemetery next to the upper rampart (Fig. 1.B), composed of three burials within platforms divided by low walls. The infant burial and burial 1 of Figure 1B are characterized by a stone cist, not present in burial 2. Significant Bronze Age pottery was found in tombs 1 and 2. Both a hemispherical bowl characterized by a straight rim with an inwardly slanted edge (burial 2; *Vitasović 2002.Pl. 3.3*) and a cup with a raised triangular handle with a rounded end plate (burial 1; *Vitasović 2002.Pl. 5.1*) point to a MBA I-II chronology according to the Italian relative chronological system (*Cardarelli 2009; 1983.91, Pl. 17, type 15; 93, Pl. 18, type 65*) cor-

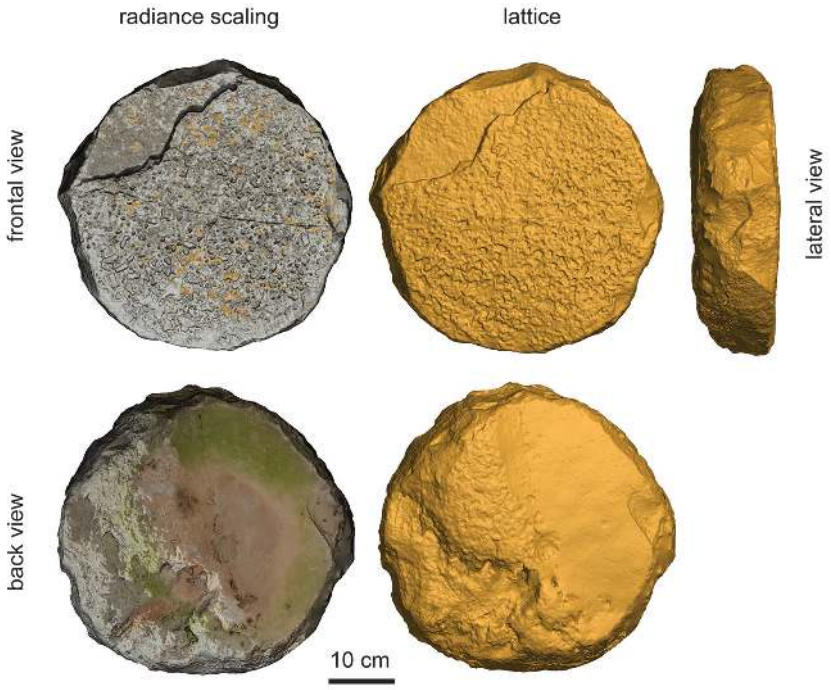

Fig. 7. Gradina disk 2 from the Bronze Age cemetery next to the upper rampart of Gradina on Veliki Brijun island (Croatia).

responding to the Bz III phase of the Istrian chronology (*Hänsel* et al. *2015*). They can be compared to similar artefacts from the recent phase of Monkodonja (roughly 1600–1450 BC; *Hellmuth Kramberger 2017.139, Fig. 110; 144, Fig. 115, variant a1; 324, Fig. 255 for the bowl; 84, Fig. 57; 89, 323, Fig. 254*).

Considering the stratigraphic relations, the platform of burial 2 was the first one to be built. The disk was found on the top of the low wall of the platform of burial 2, likely being visible when the burial was in use. The cemetery was uncovered by excavations which brought to light only Bronze Age materials.

Disk 1 can be generally attributed to protohistory and probably to the Bronze Age on the basis of comparisons with Gradina disk 2.

Discussion and conclusions

Structure from motion photogrammetry has been proved to be a low-cost, effective and accurate method to document and represent in 3D the stone disks and related quarrying areas presented in this paper.

Gradina disk 2 can be safely dated to the Bronze Age and likely to the MBA on the basis of pottery findings; Rupinpiccolo disks could be related to an early building phase of the settlement that was established during the late EBA/MBA, while no precise contextual chronological data are available for Gradina disk 1, and a general protohistoric attribution can be proposed. However, considering their typological homogeneity and similar finding contexts – *i.e.* entrances or cemeteries – all probably belong to a similar chronological horizon (*i.e.*, an early phase of *castellieri* culture).

The disks show flat and plain surfaces or are covered with sub-circular depressions and without any macroscopic use-wear traces. Gradina disk 1 shows two larger cup-marks at the centre of both faces.

It is worth mentioning that simple slabs and blocks with cup-marks are reported from IA cremation cemeteries of Istria (*i.e.*, Nezakcij/Nesazio, Kaštel/Castelvenere and Limska gradina/Gradina di Leme), but at least some of them could originally belong to Bronze Age tombs (*Mladin 1964; Mihovilić 1996; 2014*). Cup-marks are, indeed, reported from a block belonging to tomb 2 of the Bronze Age cemetery of Gradina on Veliki Brijun itself (*Vitasović 200.14*), where the Gradina disk 2 has been identified.

We propose to interpret the stone disks as ritual artefacts and/or possible cult representations

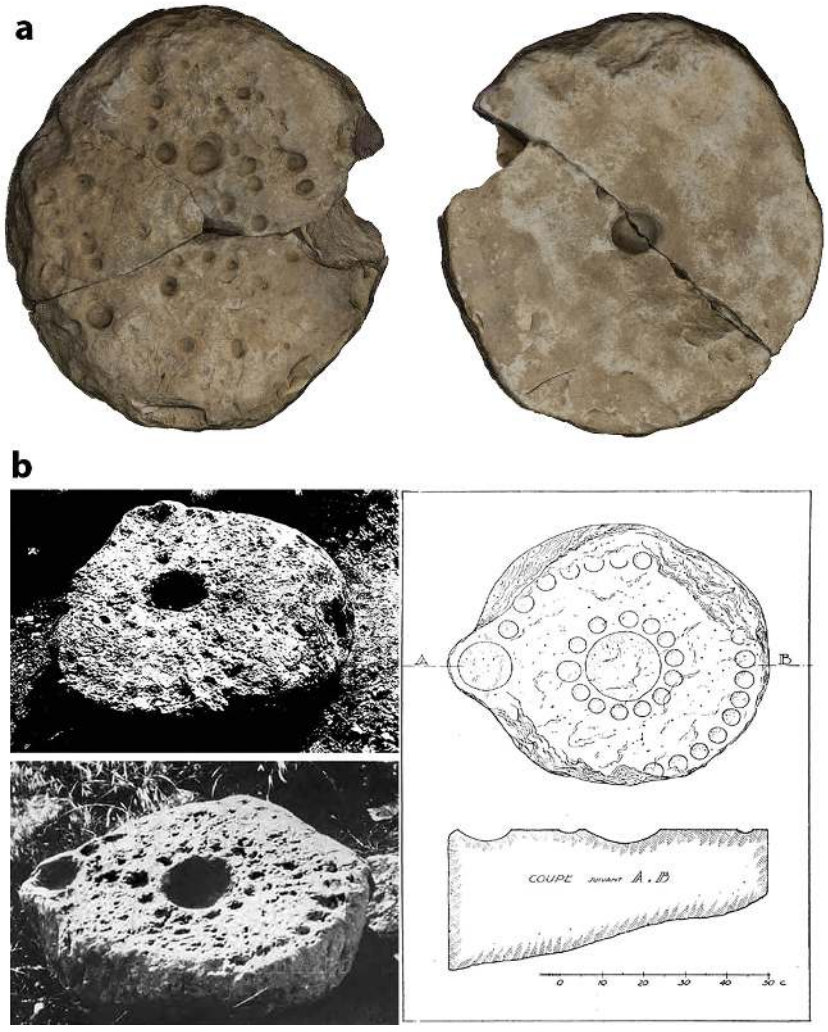

Fig. 8. Gradina disk 1 compared to the Bronze Age offering table from Chrysolakkos (Crete). Photo top left from de* Pierpont 1987*, the other photo and the drawing from* Demargne 1932 *(image modified from* Arcà 2015*).

based on the association of all disks with significant and sacred settlement locations (they could be related to some type of cult designated to protect the hill forts and/or connected to the dead and the afterlife), the absence of functional traces and comparisons with cup-marks from Istrian protohistoric cemeteries (see above), and similar Bronze Age stones covered with circular depressions found mainly close to citadel entrances in Anatolia and burial sites, entrances and thresholds in the Aegean area.

In Anatolia blocks with cup-marks have been found in front of the gates of Troy, probably reflecting Anatolian religious elements before the end of the 2nd millennium BC (*Korfmann 1998*), in the city gates or funeral contexts of Boğazköy-Ḫattuša (*Neve 1977/78*), close to the north-west gate of Kuşaklı-Sarissa (*Mielke 2018.Fig. 6.6*) and in some 2nd-millennium BC citadels in the Marmara Lake basin of the Gediz Valley (*Luke, Roosevelt 2017*). They are generally interpreted as evidence of libation rituals (*Neve 1977/78; Luke, Roosevelt 2017*).

Other significant comparisons are cylindrical stones of similar size with a central large cup-mark but surrounded by circularly arranged circular depressions, defined as offering tables, known from protopalatial Crete, more precisely from the New Palace of Mallia (roughly 1700–1500 BC; *Chapouthier 1928; Cucuzza 2010.Fig. 1; Arcà 2015*) and Chrysolakkos (*Demargne 1932; de Pierpont 1987; Arcà 2015*). Similar circularly arranged cup-marks, mainly carved into steps and pavements and belonging to the same chronological horizon, are common in Phaistos and in other sites in Crete, where they have been variously interpreted as evidence of rituals or games, or both at the same time. Among other identifications, they are variably defined as stone kernoi, Minoan cup-holes, and stone slabs with depressions (*Whittaker 2002; Cucuzza, Ferrari 2004; Hillbom 2005; Cucuzza 2010; Arcà 2015*).

Gradina disk 1 is quite similar to the Crete offering tables from Mallia and Chrysolakkos due to the size, shape and presence of the central, quite large cup-marks (Fig. 8), but it differs because the smaller circular depressions around the central cup-marks are irregularly arranged and probably the result of marine bio-erosion.

Some chisel marks of Rupinpiccolo disk 1 show a sub-circular distribution which is, anyway, more irregular than in the *kernoi* from the Aegean area. Moreover, their dimeter is relatively small (5–10mm) compared to that of most *kernoi* (*Cucuzza, Ferrari 2004*). This leaves open the question as to whether the chisel marks of Rupinpiccolo disk 1 could have a different meaning and function.

Interestingly enough, disks with a plain face and no cup-marks similar to Gradina 2 and Rupinpiccolo 2 are so far unknown in the eastern Mediterranean. Considering their possible ritual meaning, stone disks with a plain face could perhaps be interpreted as a representation of the Sun. Solar motifs are in fact known from EBA/MBA pottery from the north-eastern Adriatic (*Hänsel* et al. *2015*), including Rupinpiccolo itself. Iconographic elements referring to the Sun and its cyclic movements spread out in Europe at least from the late Copper Age, probably in connection with the large-scale migrations from the Pontic steppe region to western Europe during the 3rd millennium BC (*Kaul 1998; West 2007; Kristiansen 2010; 2012; Allentoft* et al. *2015; Haak* et al. *2015; Kristiansen* et al. *2017*). The bronze and gold chariot from

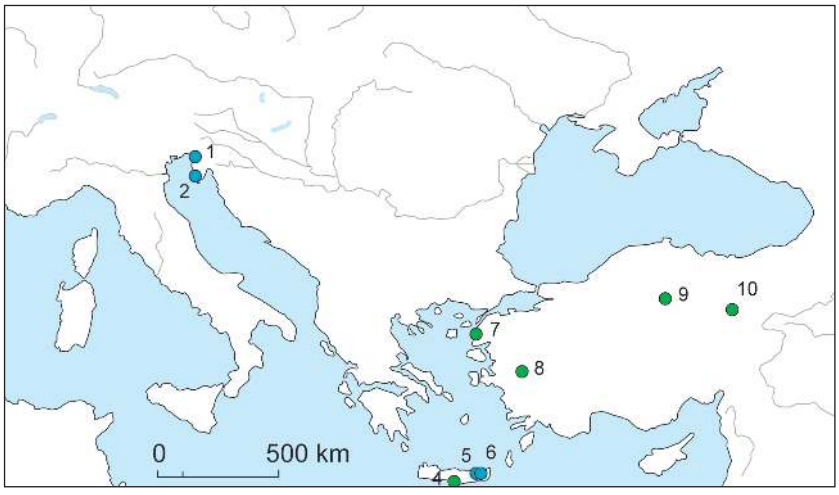

Fig. 9. Location of Rupinpiccolo and Gradina on Veliki Brijun hill forts (1 and 2 respectively) and other main sites where cylindrical offering tables (5–6) or blocks with cup-marks have been found close to citadel entrances, burial sites and thresholds both in the Aegean area (4) and Anatolia (7–10). 4 Phaistos; 5 Mallia; 6 Chrysolakkos; 7 Troy; 8 Marmara Lake basin; 9 Boğazköy-Ḫattuša; 10 Kuşaklı-Sarissa.

Trundholm, Denmark, carries an elaborate image of the Sun of the 14th century BC (*Kaul 1998; West 2007*). Similar ornate gold disks have come to light in various parts of Europe and probably are deity representations. They were produced over a long time, between the late Copper Age and late Bronze Age (*Cahill 2015*).

The occurrence of two circular faces on the same artefact, such as at Veliki Brijun, or on two associated but separate objects, such as at Rupinpiccolo, is reminiscent of solar symbolic imagery of the European Bronze Age related to the representation of the Sun's daily journey from day to night (*Kaul 1998; West 2007; Pásztor, Roslund 2007; Kristiansen 2010; 2012*). If this interpretation is correct, the plain faces could be a representation of the Sun, while those covered with chisel marks of the night sky. Bronze Age representations of the night sky in the European Bronze Age are rare, and the Nebra disk from Germany is the most famous example (about 1600 BC; *Meller 2002; Schlosser 2002; Pásztor, Roslund 2007; Kristiansen 2010; Pásztor 2015; Pernicka* et al. *2020*).

In conclusion, we propose interpreting the disks from north-eastern Adriatic hill forts as Bronze Age ritual artefacts reflecting the position of north-eastern Adriatic regions between the Mediterranean and central Europe. They seem to be related to the solar symbolic imagery of European Bronze Age, but at the same time show strong connections with the eastern Mediterranean during an early phase of the *castellieri* Culture (Fig. 9). This is in line with the hypothesis – mainly based on specific types of pottery, metal artefacts and architectural models – that the first Istrian settlements had direct contacts precisely with this area (*Hänsel* et al. *2015; Hellmuth Kramberger 2017*). The stone disks would show that the inhabitants of north-eastern Adriatic regions not only shared some aspects of the material culture, but also common religious habits.

ACKNOWLEDGEMENTS

The project was supported by the Monton MMS company in the framework of the ICTP project "Interdisciplinary study of the ancient landscape of north-eastern Adriatic regions".
Author contributions: F. B. identified the Rupinpiccolo stone disks and related quarrying traces, designed, initiated and led the study; F. B, G. V., V. M. produced photogrammetric data; G. V. produced plans of investigated sites; F. B., G. V. performed archaeological research; F. B., G. V., A. D. M., S. F. performed geomorphologic research; A. B. performed ichnological research; F. B. wrote the manuscript with significant input from G. V., A. B. and with contributions from all authors; all authors contributed to final interpretation of data.

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Appendix

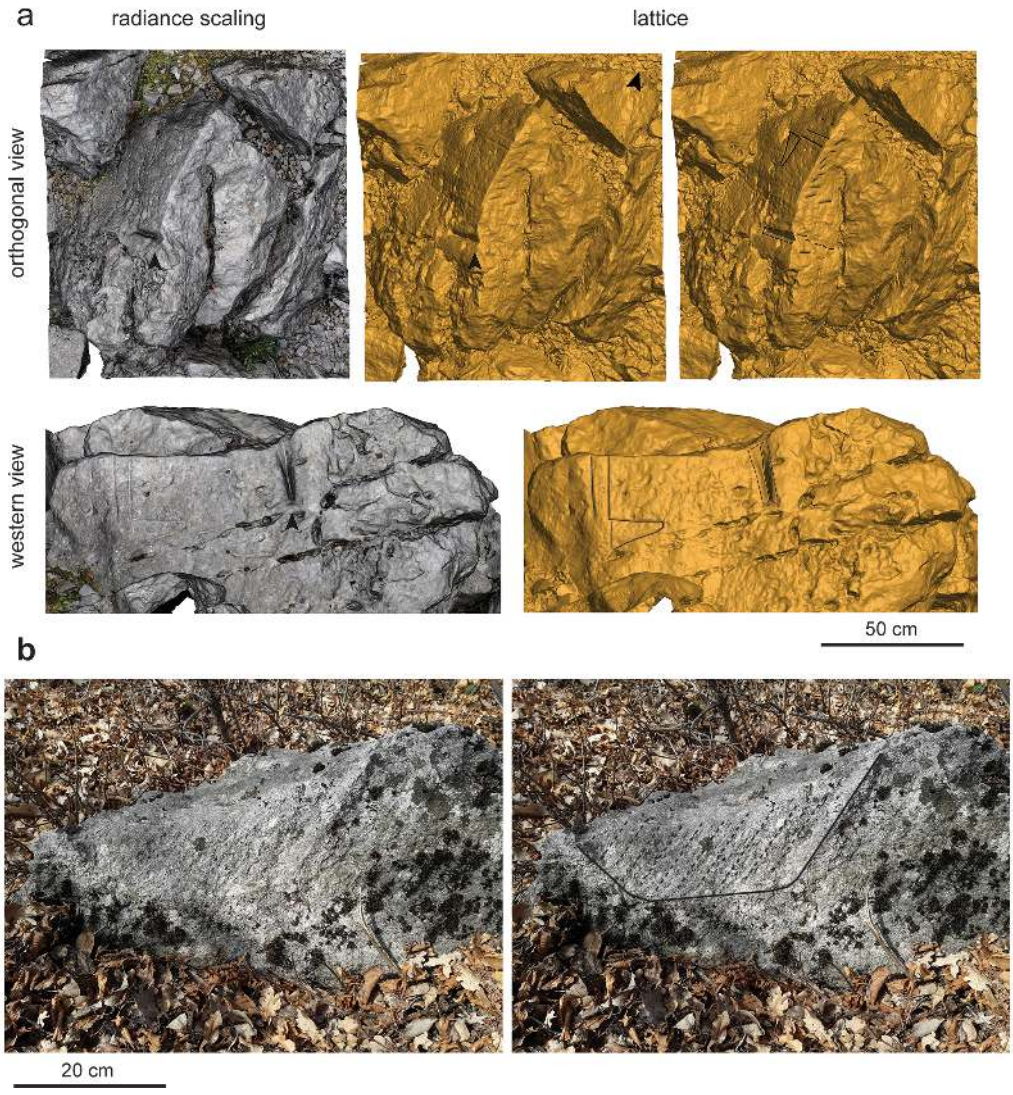
Supporting information: Gradina stone disk 1

Both frontal and opposite faces show at their centre an artificial cup mark about 6cm wide but only the frontal one is covered with a network of slender pits (width: about 1–3mm) arranged in sub-linear sets (length: about 1–3cm; Fig. 6). This morphology is characteristic of the sponge boring *Entobia cateniformis*, consisting of cylindrical chambers arranged in coalescing sub-linear chains (*Farber* et al. *2016*). Clionid sponges produce incipient *Entobia* in the Adriatic Sea (*Bromley, D'Alessandro 1989*). *Entobia* is a proxy for marine rocky substrates.

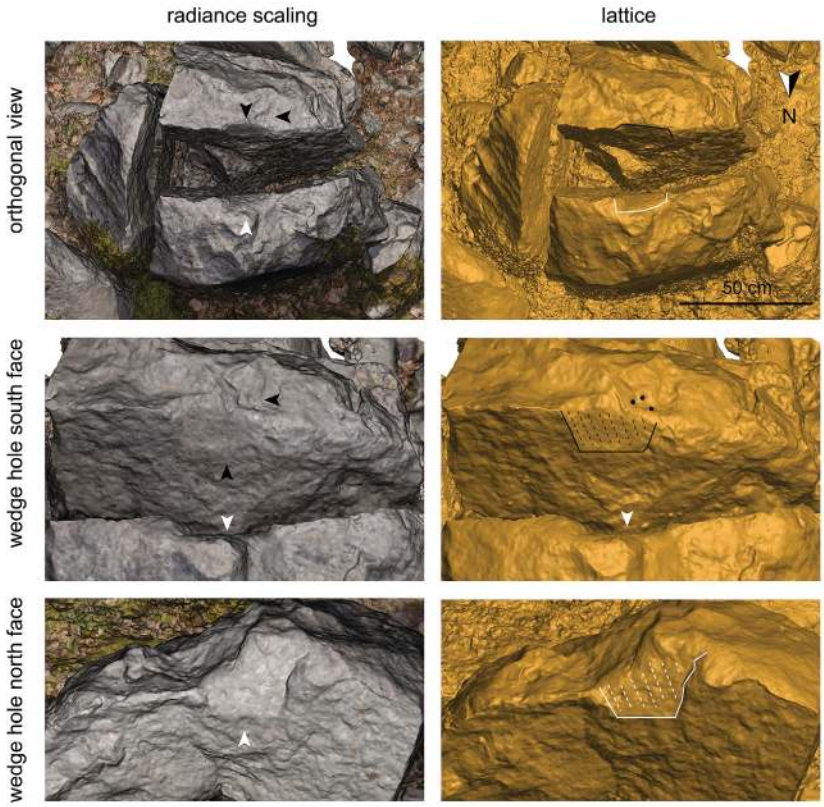
On Gradina stone disk 1, *Entobia* crosscuts larger, shallow hemispherical depressions (diameter: about 0.5–3cm). Vitasović (*2005*) considered these hemispherical depressions as artificial cup marks, but some of them are cut by the central cup mark or interrupted at the edge of the stone, implying they were already present when the disk was shaped. In addition, the observed cross-cutting relationships suggest that they were produced in marine environments as well as *Entobia*. This hypothesis is supported by the morphological cor-

respondence with the boring *Gastrochaenolites*, which is produced by marine bivalves (*Donovan, Hensley 2006*). In fact, *Gastrochaenolites* is a clavate boring that is preserved as a hemispherical depression when truncated by physical and/or biological erosion (*Domènech* et al. *2001*). In the Mediterranean Sea, the bivalve *Rocellaria* (=*Gastrochaena*) *dubia* produces incipient *Gastrochaenolites*, whereas the date mussel *Lithophaga lithophaga* is another important bivalve bioeroder (*Casolia* et al. *2016*).

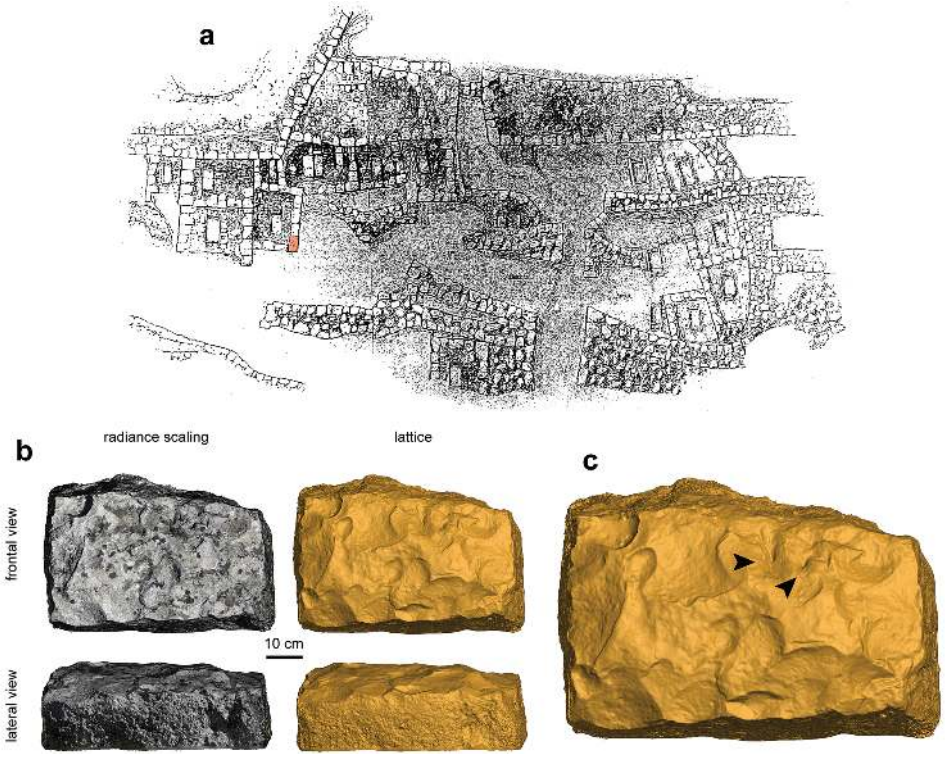
The association between *Gastrochaenolites* and *Entobi* typically arises from long-term bioerosion, such as occurs on sediment-free submarine cliffs (*Entobia* ichnofacies *sensu Bromley and Asgaard 1993*). The Gradina borings are unfilled and therefore might have been produced few decades before being collected by humans. This hypothesis is supported by the relatively fast bioerosion rates observed in the Mediterranean Sea, *i.e. Entobia cateniformis* can be produced in two years whereas *Gastrochaenolites* requires longer (*Domènech* et al. *2001; Farber* et al. *2016*). The depth of penetration (tiering) of *Entobia cateniformis* is usually restricted to the first centimetre within the substrate (*Farber* et al. *2016*). Therefore, the *Entobia* from Gradina could have been produced a short time after *Gastrochaenolites*. A similar explanation is provided by Domènech *et al.* (*2001*) for *Entobia-Gastrochaenolites* assemblages of Spain.



Supporting Fig. 1. Quarrying sites next to the Rupinpiccolo rampart. **a** ***Quarrying site east of the north-eastern gate of the rampart with short and linear chisel marks (black lines) and a wedge hole (dotted black lines).*** **b** ***Quarrying site next to the corridor-like structure in front of the south-eastern entrance.***



Supporting Fig. 2. Rupinpiccolo rampart block with two symmetrical half-wedge holes and a few chisel marks. The southern half-wedge hole and close chisel marks are shown by black arrows and lines; the northern half-wedge hole is shown by white arrows and lines.



Supporting Fig. 3. Block belonging to one of the platforms of the Bronze Age Vrčin cemetery in Istria with clear chisel marks. a Position of the block (in light red) in the cemetery; plan taken from Battaglia (1958). b Radiance scaling and lattice visualizations of the block. c Lattice visualization of the block with chisel marks indicated by black arrows.