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ORIGINAL ARTICLE

Possible stellar asterisms carved on a protohistoric stone

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Abstract

Chisel marks on a stone uncovered in Rupinpiccolo protohistoric hill fort from north-eastern Italy were suggested to be a representation of the night sky (Bernardini et al. 2022 *Documenta Praehistorica XLIX*). The patterns of the 29 marks are analyzed here to establish if they reproduce popular stellar asterisms. Nine marks are found to match the Tail of Scorpius and five the Orion's Belt, together with Rigel and Betelgeuse. Nine marks are found in the approximate position of the Pleiades showing some match with the cluster members. On the back side, 5 marks possibly reproduce Cassiopeia. One mark slightly North of Orion cannot be identified. The 28 marks show a Pearson correlation coefficient $r(28)$ with stellar positions higher than 0.99 with a probability p of a wrong correlation lower than 0.001. Departures are about one degree, or about 7 mm, as the mean diameter of the marks, which suggests a manufacturing limitation in the charting. The fort dates ≈1800–400 BCE when Scorpius and Orion showed about the same orientation at the heliacal rising. The unidentified mark challenges the whole picture. We suggest it could have been the progenitor of a failed supernova, thus offering also the possibility of a verification.

KEYWORDS

bronze age, precession, star maps, stellar asterisms, stone disks

1 | INTRODUCTION

Two pairs of stone disks found at the entrances or graveyards of two Protohistoric hill forts from north-eastern Adriatic area have been recently interpreted as ritual artifacts, possibly a representation of the Sun and of the Night Sky (Bernardini et al. 2022). These protohistoric settlements were generally protected by massive stone walls and are known today as *castellieri*. They were settled for a very long time spanning from the late Early Bronze Age, approximately between 1800 and 1650 BCE, to the late Iron Age (Mihovilić 2013). The disks are from Gradina on the Brijun/Brioni Maggiore Island facing the southern coast of Istria, Croatia, and from Rupinpiccolo/Repnič, located in the Trieste Karst, Italy. The stone from Gradina suggested to represent the Night Sky that does not show any real representation of the sky and is clearly symbolic. The face is covered with shallow hemispherical depressions produced by marine bivalves pre-existing the manufacturing of the disk. Instead, in the stone disk from Rupinpiccolo representing the night sky the chisel marks are produced by human hand and do not look randomly distributed (see Figure 1).

We thus explore here the possibility that the patterns of the chisel marks may represent some popular asterisms. Several human cultures around the world seem to have recognized the same asterisms. For instance, Orion, the Big Dipper, the Pleiades, and the Southern Cross

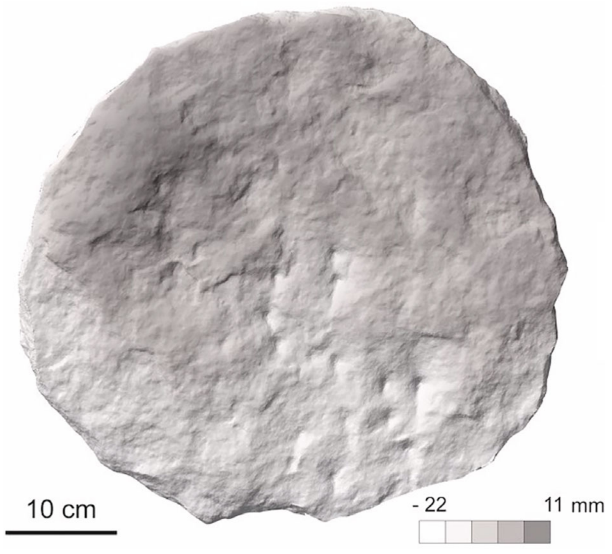

FIGURE 1 Digital elevation model of the frontal face of Rupinpiccolo stone disk from an adaptation of fig. 1 of Bernardini et al. (2022). The orientation is arbitrary.

are widely recognized across different cultures following a universal perceptual principle rather than a cultural one (Bucur 2022; Kemp et al. 2022). Observations of the rising and setting of striking stellar asterisms were one of the earliest means of regulating the season variations in ancient societies (Murray 2015), and iconographic elements referring to the cyclic movements of celestial objects are known at least since the late 3rd millennium BCE (Delano Smith 1987).

2 | THE STONE DISK OF THE CASTELLIERE OF RUPINPICCOLO

The *castelliere* of Rupinpiccolo is located on the southern side of the central Karst ridge, which presently marks the border between Italy and Slovenia. The ruins of its massive defensive structures were noticed at the beginning of the last century (Burton 1877; Marchesetti 1903) and later were subject of intensive archaeological investigations (Cannarella 1970; Maselli Scotti 1988). The *castelliere* of Rupinpiccolo was built along the slope of a low hill. It was defended by massive ramparts, up to 7 m wide, 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 entrance located on the hill top is approximately 2 m wide, while the width of the southern one is about 3.2 m, externally delimited by a corridor-like structure. The stones used for the fortification include massive blocks up to about 3 m in width taken from the local limestone outcrop. The use of such huge blocks is not reported in other sites and therefore Rupinpiccolo is a unique site. Archaeological survey has revealed that it is part of a small-scale cluster of four hill forts (Bernardini 2012). The hill fort was in use from about 1800/1650 to 400 BCE with no traces of a later Roman occupation of the site (Bernardini et al. 2022; Cannarella 1975). However, after the work of Bernardini et al. (2022), round stone artefacts of similar shape and dimensions were identified in the collection of the Museo Archeologico Nazionale di Aquileia. Probably they are roughed-out blocks for lids for circular tombstones. Since the exact archaeological context of the stones from Rupinpiccolo cannot be determined with precision, the possibility of Roman origin cannot be ruled out.

Two stone disks have been found close to each other next to the south-eastern entrance of the *castelliere* of Rupinpiccolo (Bernardini et al. 2022). They are made by the same material and were carved from the local limestone with roundish shape (Jurkovšek et al. 2016). Their diameter is of about 50 cm and the thickness is of 30 cm. The former stone shows a flat frontal surface without any chisel marks and it was suggested to represent the Sun (Bernardini et al. 2022). To produce it, a rock with a very regular bedding plane was selected, extracted, and carefully retouched by using a hammer to obtain a round shape and a flat frontal surface. The stone still shows the remains of two different half-wedge holes that allowed extracting the block and shaping the artifact. The presence of such wedge holes connects the disks with the quarrying sites likely used to build the rampart. The latter stone, which was suggested to represent the Night Sky, shows numerous chisel marks arranged in patterns onto a relatively flat upper face. There are 24 chisel marks on the disk surface shown in Figure 2. On the back surface are present 5 additional chisel marks, cf. fig. 2c of Bernardini et al. (2022). The relatively flat morphology of the frontal surface was not natural, but the chisel marks do not seem correlated with flattening operations. In fact, no traces of fine hammering or polishing are present on the surface of the disk.

The distribution of the marks is not uniform. Sometimes they are very close to each other with distances of less than 2 cm, which suggests they were created intentionally. The diameter of the chisel marks is rather constant, and ranges from about 5 to 10 mm with most of them being about 7 mm. The diameters and depths of all chisel marks are given in Table 1 and few examples are shown in Figure 3. The position coordinates X,Y of the marks are also provided with reference to the system of coordinates shown in Figure 2. The depth of the marks ranges considerably from about 1 to 22 mm with the shallower ones severely worn by atmospheric agents. To note that the shallower marks are also those which show the smaller

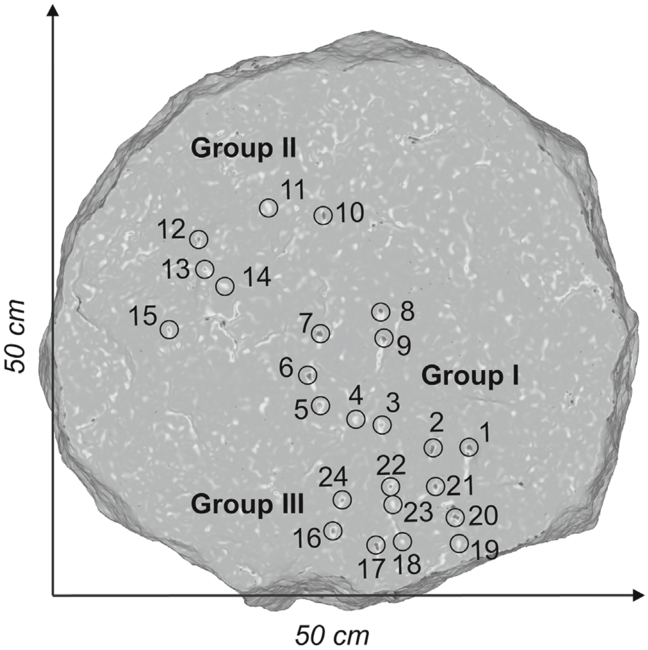

FIGURE 2 Front face of the stone disk from an adaptation of fig. 1 of Bernardini et al. (2022). Curvature map of the disk with the position of the chisel marks indicated by black circles and numbered.

diameters. Note also that the chisel marks show tails that are iso-oriented and were created by a person holding an oblique bronze chisel with one hand and a hammer with the other. A procedure which allows the production of narrow marks with a rudimentary tool. The use of an oblique chisel on the same spot from different directions would have produced much larger cup marks, limiting the minimum distance among them. The constancy in size of the marks implies that the stone was carved by using a metal point chisel with a point about 6–7 mm wide. A bronze chisel of 15 cm in size but with a flat tip few millimeters thick, shown in Figure 6,[1] was found in the *castelliere* of Elleri which is located at a distance of few km away from the one of Rupinpiccolo. A similar chisel used from the side can leave marks of a few millimeters such as those observed in our stone. Note that the orientation of the tails of the engraved marks provides a natural orientation for the stone depending on whether the maker was left-handed or right-handed.

3 | STATISTICAL ANALYSIS

There is a total of 24 chisel marks on the front face of the stone disk and 5 on the back. The chisel marks are not randomly distributed. In particular, in the central part of the stone, 9 marks show a hook-like pattern which is shown in Figure 2, which for practical reasons we call Group I. At first glance these marks resemble the brightest stars of the Tail of Scorpius. To verify this impression with an objective analysis in Figure 4 we have superimposed the 9 chisel marks with the sky map of the Scorpius constellation by using Stellarium[2] The arrangement of the orientation and of the scale was arbitrarily made by eye to get the best agreement with the pattern in the stone. The superposition shows a good match and there is a satisfactory reproduction of the sequence of stars of the Scorpius's tail from α Sco, Antares to the sting, λ Sco, Shaula. The deepest mark with depth of 22 mm corresponds to Antares, the brightest star of the Scorpius constellation. For the last chisel mark there is ambiguity concerning the star it should be linked to. The closest is G Sco, or HR 6630, but we prefer to connect it to the bright κ Sco which could hardly have been omitted in a representation of the Tail asterism. Note that another star close to κ Sco is ι1 Sco, but it is only 1.4° away and it could not be resolved in the engraving with the adopted scale.

To assess quantitatively and objectively the likelihood of this preliminary identification we studied the correlation of the distances of the chisel marks and real stars from a reference point. The position coordinates X,Y of the marks on the front face are also provided with reference to the system of coordinates shown in Figure 2. These will allow independent statistical analysis. The sky coordinates of the marks are obtained by overlaying the stone positions as shown in Figures 4–9 onto the Digitized Sky Survey available online (https://archive.eso.org/dss/dss). This is a manual procedure but it should be accurate enough for the purpose. The positions of chisel marks and stars are given in arc minutes in Table 2 both for Right ascension (RA) and for Declination (DEC). The angular distances of the 9 chisel marks from the sky position of the associated stars of the tail of Scorpius are reported in the last column of Table 2. The mean value is $1.23° \pm 0.75$. The angular distances with respect to a reference point are also shown in Figure 5. We choose to keep the distances separated for declination and right ascension since the human eye has different abilities to evaluate equatorial and azimuthal distances. A distribution of the distances along a line at 45 degrees in the plot is evidence of a perfect correlation. For the nine chisel marks identified with the asterism of the Tail of Scorpius, the Pearson correlation coefficient $r(9)$ is 0.988 and 0.995 in DEC and RA, respectively. The Pearson correlation coefficient is a measure of correlation based on observed data and does not take into account the uncertainty of the data. Errors in

[1]The chisel is on display in the Archaeological Museum of Muggia (Trieste) https://muggiacultura.eu/cultura/luoghi/civico-museo-archeologico/.

[2]https://zenodo.org/records/8378342.

TABLE 1 Diameter and depth of the chisel marks on the stone following the numeration shown in Figure 2. The position coordinates X,Y of the marks are also provided with reference to the system of coordinates shown in Figure 2.

	GI								GII						GIII								
Mark n.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
X (mm)	352	321	278	259	227	218	227	276	279	229	181	125	130	147	102	240	276	298	343	342	326	289	291	247
Y (mm)	124	125	145	147	160	183	220	292	215	318	324	297	271	258	220	55	41	45	45	67	93	93	76	80
Diam. (mm)	10	7	7	7	7	8	9	7	7	6	7	7	6	7?	7	7	7	5	6	7	7	7	5	7
Depth (mm)	22	10	4	2	5	6	5	4	6	4	2	3	3	1	3	5	5	1	3	5	4	5	1	3

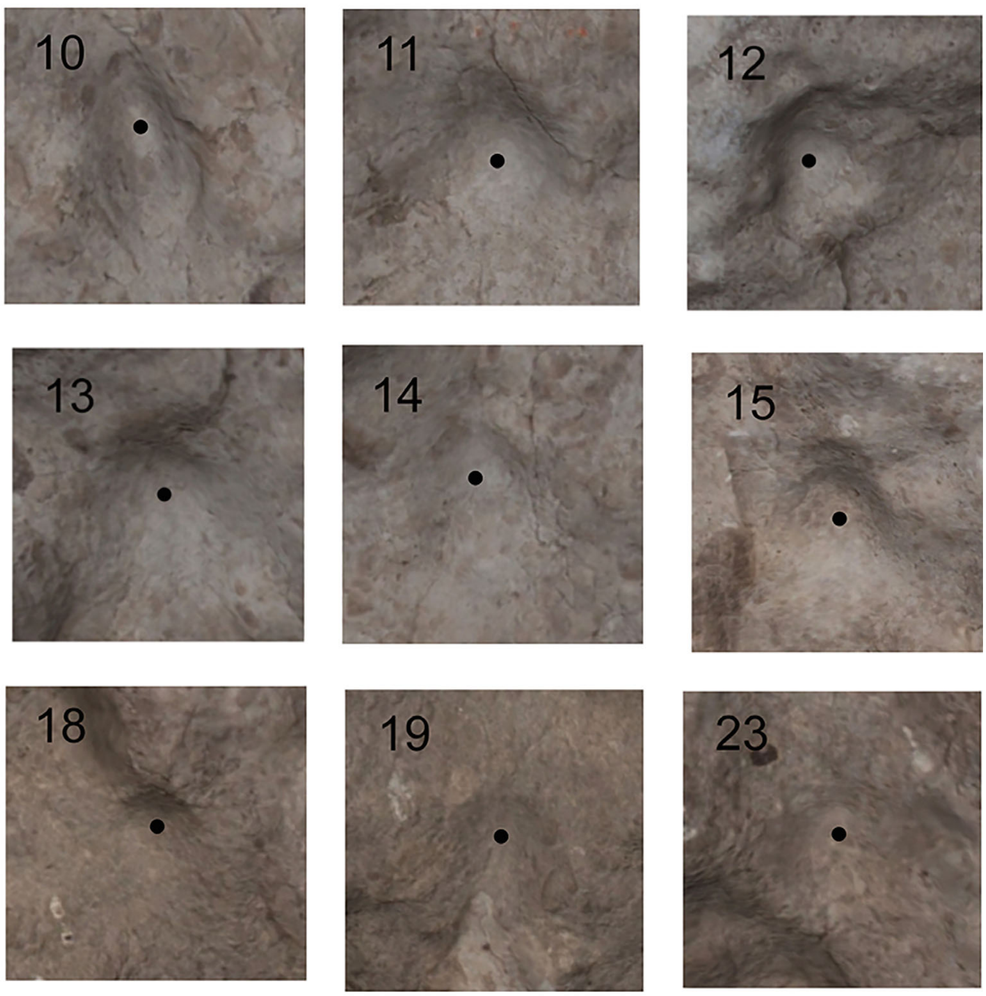

FIGURE 3 Same examples of chisel marks. The numbers of the chisel marks refer to those of Figure 2. N. 10 is the most controversial chisel mark since it is the only one that remains without a plausible identification. N 11 to N15 are the marks corresponding to 5 stars in Orion, and N18 to N23 are three members of the Pleiades. All chisel marks are also shown in fig. 7 of Bernardini et al. (2022).

determining the centre of the chisel marks, which have a mean size of ≈7 mm in the stone, or ≈1 degree on sky, have not been considered and should result into an attenuation of the correlation coefficient (Saccenti et al. 2020). However, the probability *p*-values are much lower than 0.001. Thus, the statistical analysis shows high correlation and the probability that the chisel marks randomly reproduce the asterisms by coincidence is low despite the limited number of data points. We consider now the rest of the chisel marks on the stone.

Another group of 9 chisel marks, from N 16 to N. 24, is located East of Scorpius tail and filling the area up to the edge of the stone disk. This group cannot be identified with either the head of the Scorpius constellation or with any other asterism close to Scorpius. Clearly a failure of identification is a killing problem also for the likelihood of the previous interpretation. It is very unlikely that some chisel marks could reproduce precisely an asterism and another close group of 9 chisel marks remain without any clear association. We call these chisel marks group III and

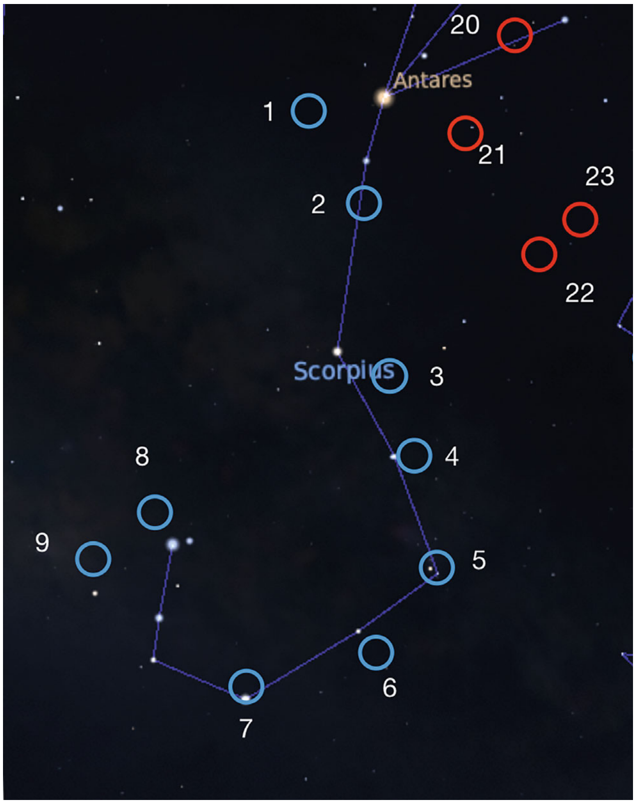

FIGURE 4 Chisel marks from N.1 and N.9 of Figure 2, Group I, are sketched with light blue circles and are superimposed onto the sky map of the Scorpius constellation produced with Stellarium. Scale and orientation are adjusted by hand to get the best agreement between the pattern in the stone and the Scorpius constellation. The marks have a diameter of about one degree corresponding to about 7 mm in the stone. Chisel marks 21, 22 and 23 on the top right of the figure are marked with red circles and cannot be identified with any star close to Scorpius, see text for a possible explanation.

we will return on it shortly after the analysis of a second cluster of marks.

A group of 6 chisel marks, from N.10 to N. 15, are located off-centre on the other half of the stone. We call these six marks group II. We found that five of them match well the Orion asterism. In particular, the three stars of the Belt and the two brightest stars of the constellation, Betelgeuse and Rigel, are well reproduced as it is possible to see by their overlay with a sky map provided in Figure 7. γ and K Ori are not reproduced in the stone and it is not clear if this is deliberate or if they have been possibly cancelled by erosion since they would have been be located in most degraded portions of the stone. However, one isolated mark, N. 10, cannot be associated with any star close to the Orion asterism. This crucial mark will be discussed in detail in the discussion section. We applied the same statistical analysis applied for the Scorpius asterism also for the Orion asterism. The distances from the marks and the stars are given in Table 2 and shown in Figure 5. The analysis returns a Pearson correlation coefficient $r(5)$, greater than 0.99 and 0.95 in DEC and RA, respectively, and the p-values always lower than 0.001.

The average value of the residuals of the difference from the true positions is of about one degree and it should be compared with the mean size of the chisel marks. The scale can be derived from the distance of any pair of stars. For instance by taking the distance between α Sco, Antares and θ Sco, Sargas, the scale of the Scorpius asterism is found of 1.5 degrees for 1 cm. In Orion by using the distance between α Ori, Betelgeuse, and β Ori, Rigel, the scale is about 1.4 degrees for 1 cm, which is very similar to that of Scorpius. A similar scale in two asterisms is worth noting since the Pearson correlation coefficient is invariant under scale transformation. Thus, the mean value of the diameters of the chisel marks is of about 7 mm which corresponds to about 1 degree in the sky. To note that the scale in the Belt is slightly larger but this could be due by the need to keep the marks of the three stars of the Belt separate since their separation in the sky is of about one degree. Thus, the precision in the reproduction of the asterism onto the stone is seemingly limited mostly by the employed carving technique. This would indicate the intention to faithfully reproduce the positions of the stars rather than a mere symbolic representation of the asterism.

We discuss now the 9 chisel marks close to the Scorpius tail. They cannot be associated to Scorpius but we noted that they lie on the prolongation of the Orion Belt for about 5 times the Belt's size. This is the well known way used by sky watchers to find the Pleiades in the sky. The proximity of this group to the real Pleiades location in the sky is between two to ten degrees. The chisel marks are rather spread since the Pleiades are a very compact cluster. A representation of the Pleiades is shown in the overlay in Figure 8 with a tentative link between the chisel marks and its members. The bright Alcyone has been taken as initial reference, adjusting orientation and scale to obtain the best match with the other members of the Pleiades. A relatively good match could be found for 6 members of the cluster and slightly worse for Pleione, Maia, and Asterope. Not surprisingly, the statistical analysis returns lower values for the correlation coefficient with $r(9) = 0.87$and a p value of $p = 0.0023$. Pleiades are a very compact cluster about 0.5×1 degrees, and therefore here the scale is much larger. With the previous scales the whole Pleiades group would be in a single chisel mark. Pleiades are one of the most represented asterisms in ancient times, but isolating the members is very challenging since they are very close to one another. Generally, six or seven members are reported and often with a mere symbolic representation (Rappenglück 2015). Nine members is quite exceptional but it is actually possible to see up to 14 of the stars with the naked eye in areas

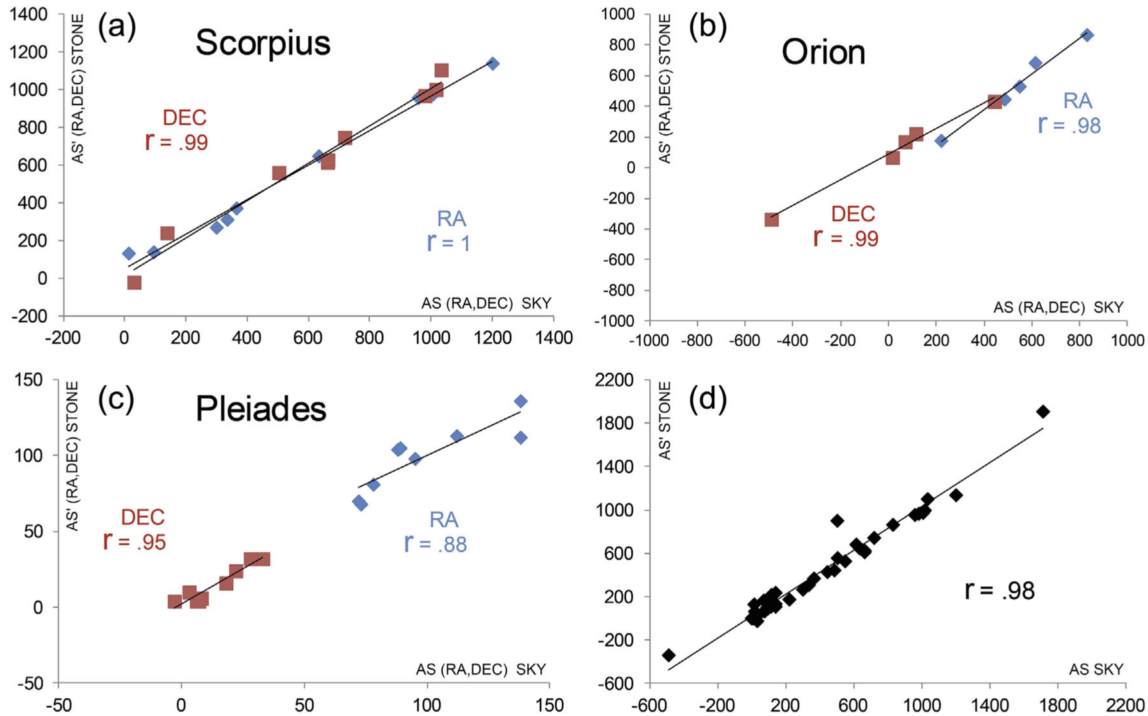

FIGURE 5 The angular separation AS', in RA (blue rhombuses), and in DEC (red squares) from the position of 23 chisel marks with the reference point reported in Table 2 are on the Y axis. In the X axis is the angular separation AS from the associated stars with the same reference point. Note that the units are in arcminutes both for RA and DEC. (a) AS and AS' for the 9 data point of the Tail of Scorpius, (b) AS and AS' for the 5 data points of Orion, (c) AS and AS' for the 9 data points of the Pleiades. The panel (d) shows the AS' and AS obtained by combining the RA and DEC distances, for all the 23 data points in the front face of the stone. The Pearson correlation coefficients *r* between AS and AS' are also reported on the figures.

without light pollution. Michael Maestlin, the mentor of Johannes Kepler, mapped out 11 Pleiades stars before the invention of the telescope. According to what Kepler wrote in his *Dissertatio cum Nuncio Sidereo* it is even possible that Maestlin had seen as many as 14 stars in the Pleiades (Winnecke 1878).

In panel d of Figure 5 the angular distances for all the 3 asterisms are considered. All together they return a high value for the correlation coefficient of $r(23) = 0.98$ and a p value lower than 0.001. Thus, although with a configuration where there is an interplay of the maps of two different portion of the sky, which is quite unique, the identification is supported by a correlation statistical analysis and has the advantage to provide an explanation for all, but one, of the chisel marks of the stone.

On the back of the disk stone there are 5 additional chisel marks located in a rather central position; see the back view of the stone in fig. 2 of Bernardini et al. (2022). The stone surface on this side is less flat and it could be that marks were created by the flattening process. However, we note here that the pattern is reminiscent of the W typical of the Cassiopeia asterism. A possible match is shown on Figure 9. The Pearson correlation coefficient is $r(5) = 0.98$ in RA and 0.92 in DEC with a p value of 0.003 and 0.026, respectively. Statistically it is relatively easy to reproduce a W shape with 5 points, but the possible identification of Cassiopeia acquires significance in the context of all chisel marks having a meaningful astronomical association. Traditionally, a sample size of at least 30 data points is considered the minimum requirement for a correlation analysis. This is based on the central limit theorem which suggests that the sampling distribution of the Pearson correlation coefficient becomes approximately normal with larger sample sizes. However, smaller sample sizes may be sufficient to rule out the probability of making a Type I error, that is, a wrong correlation, when set as the significance level $p < 0.05$. In our analysis we satisfy both criteria of an adequate sample of 28 chisel marks and a low probability $p < 0.001$ of casual correlation. Note also that the scale used in this asterism computed using the separation from ϵ and β Cas is of 1.3 degrees for 1 cm which is similar to Scorpius and Orion asterisms. In summary, all the 29 chisel marks but one present on the stone disk show a statistically significant association with 4 of the most popular asterisms used by ancient population. This avoids the risk of a cherry picking practice of taking only some and the most beneficial marks to support the working hypothesis.

FIGURE 6 Bronze Chisel of ≈15 cm from the *castelliere* of Elleri. not far from that of Rupinpiccolo, on display at the Archaeological Museum of Muggia (Ts). A similar tool could have been used to produce marks on the stone with a diameter of ≈7 mm. Courtesy of Soprintendenza ABAP FVG – MiC. Reproductions forbidden, art. 108, co. 3 del D. Lgs 42/2004 s.m.i.-DM 161/23.

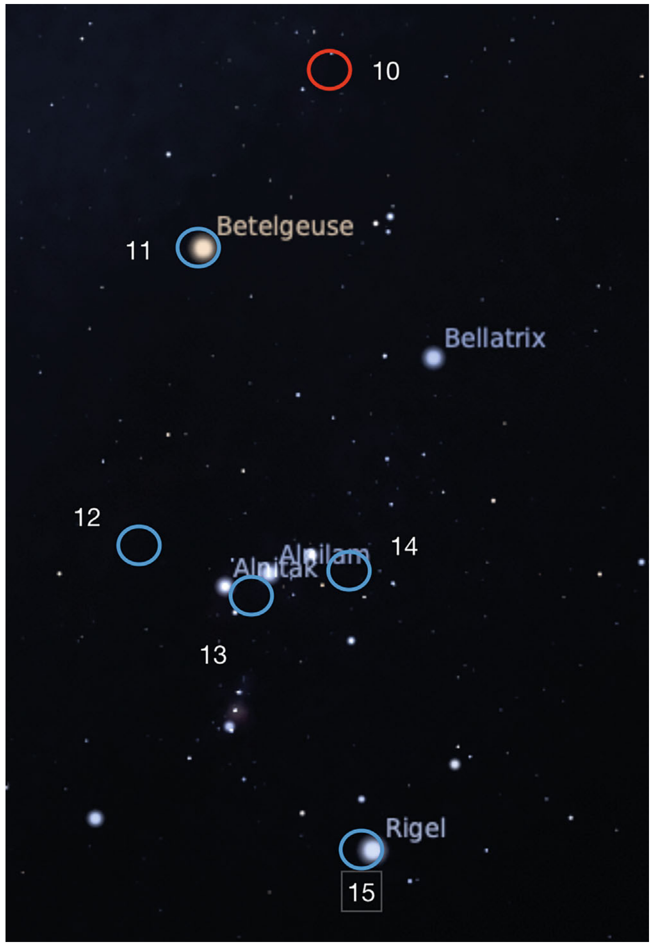

FIGURE 7 Chisel marks sketched with light blue circles of diameter of about one degree, or 7 mm as on the stone, are superimposed onto the sky map of the Orion constellation produced with Stellarium. Scale and orientation are adjusted by hand to get the best agreement between the pattern in the stone and the constellation. Note the absence of Bellatrix and Saiph due to possible erosion and the presence of a mark, with a red circle, with no correspondence in the sky. κ Ori on the bottom left is very close to the border of the stone.

4 | DISCUSSION

4.1 | The non-identified chisel mark

As we have seen there is only one isolated mark, N. 10, which we fail to associate with any star close to the Orion or other asterisms identified in the stone. This is clearly a crucial point and we discuss here below several possibilities. One possibility is μ Ori, a star of V magnitude 4.12 in proximity of that chisel mark. However, it would be strange that λ Ori which is slightly brighter is not reproduced as well. λ Ori as Bellatrix are located in a particularly eroded area of the stone and this could explain why it is that they are missing. Alternatively, this mark could be associated with the Group I of the Scorpius asterism and could correspond to the V≈1.8 mag star of Epsilon Sagittarii very close in RA though slightly displaced by about 6.5° in declination. We also recall that geometrical patterns on the sky are by no means universal, and in most cultures the Orion asterism is composed only by the Belt (Kemp et al. 2022).

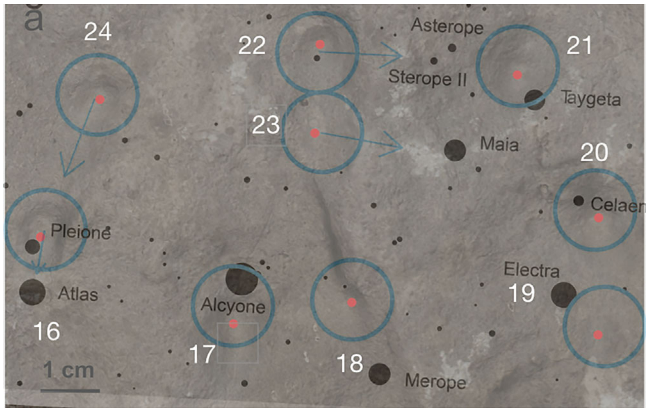

FIGURE 8 Portion of the stone superimposed onto the sky map of the Pleiades. The chisel marks on the stone are sketched with light blue circles of about twice the size of the real marks, that is, with a diameter of about 8 arcminutes, with the center of the marks highlighted with red dots to allow their visibility. Alcyone has been taken as initial reference, adjusting orientation and scale to obtain the best match with the other members of the Pleiades. The arrows show tentative associations of the chisel marks with the nine brightest stars of the Pleiades. The seven sisters are Alcyone with the chisel mark N. 17, Merope with N. 18, Electra with N. 19, Celaeno with N. 20, Taygeta with N. 21, Sterope with N. 22 and Maia with N. 23, along with their parents Atlas and Pleione with the chisel mark N16 and N. 24, respectively.

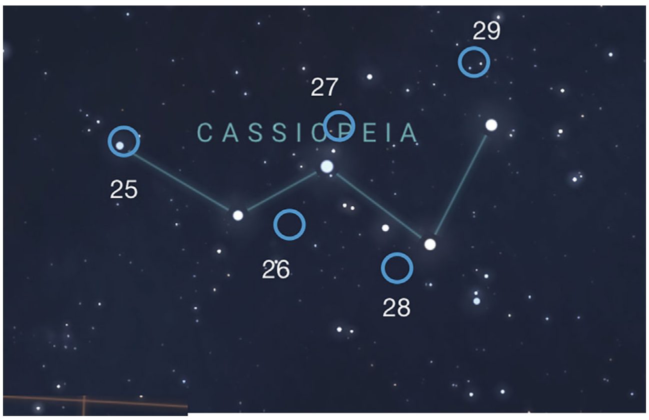

FIGURE 9 Position of the five chisel marks on the back of the disk stone sketched with blue circle of about one degree superimposed to the Cassiopeia map. Scale and orientation are adjusted by hand.

One more intriguing possibility suggested by the astronomer Alessandro Bressan is that this chisel mark could indicate a star in the Orion cluster that was present at the time the stone was carved but that later exploded as a Supernova. The remnant could be a neutron star or a black hole which is not visible today but that may be detected by means of modern astronomical observations. In particular, a black hole is expected in the case of a *failed* supernova (Adams et al. 2017; Tsuna 2021). We recall that there have been seven supernovae that exploded in the Milky Way recorded by humankind in 185, 393, 1006, 1054, 1181, 1572, and 1604 AD. Betelgeuse, α Ori, belonging to the Orion asterism is expected to be the next Galactic Supernova. The area where to search for the possible supernova remnant is about 6 degrees North of Betelgeuse and about the same RA, that is, about 5h40m and +13° degrees. In the supernova remnant catalogue of Green the closest one is at RA = 6 h and DEC = +18°, with a 70×60 arcminutes size, that is, displaced to the North by about 5 degrees which is a bit off candidate considering that typical errors are of the order of one degree. However, a failed supernova would have been undetected (Adams et al. 2017; Tsuna 2021). The case of a failed SN is really intriguing as one of the techniques to search for them is precisely to look for missing stars in the current sky, by using images taken at previous times. This possibility offer a way to verify the proposed interpretation.

4.2 | Dating and visibility from the site

Very little is known of the population that had been living for thousands years in the hill forts and we do not have a precise date for the manufacturing of the stone disk from Rupinpiccolo. The pottery assemblage from this *castelliere* shows that the hill fort was in use from about 1800/1650 to 400 BCE and the stone disks can be safely referred only to this long time-span. However, Bernardini et al. (2022) link them to the earlier building phase of the hill fort. The wedge-holes and chisel marks on the stone disks suggest they are coeval with the construction of the rampart. An early dating is also supported by the dating of the stone from the cemetery of Gradina on the Veliki Brijuni Island, which is dated to the Middle Bronze Age by close archaeological context (Bernardini et al. 2022).

Scorpius is a constellation of the southern hemisphere and the precession of equinoxes plays an important role in its visibility from the *castelliere*'s site. Sargas, the southernmost star, has a declination of DEC = −43.0° and nowadays is almost not visible from Rupinpiccolo, which is located at a latitude of 45.72°7. From the top of the nearby mount Lanaro (544 m above sea level) the horizon towards South-East is defined by the Julian Alps with mountains of about 1000–1300 m at a distance of about 20 km. The mountain range rises the horizon by about 2 degrees towards South-East, but even more from the Rupinpiccolo hill fort which is located lower at about 300 m above sea level. Therefore, while nowadays θ Sco is not visible from the Rupinpiccolo site it was visible in 1800 BCE due to precession of the equinoxes. Almost 4 thousand years ago the star was at DEC = −30.5°, that is,

TABLE 2 Distances in arc minutes of the chisel marks and of the stars from a reference point indicated on the first row. The chisel marks are numbered according to Figure 2 and their positions are the center of the circles shown in Figures 4,7 and 8 after projection onto the Digitized Sky Survey. The last column reports the angular separation AS* between the chisel marks and the stars in degrees, or in arcminutes for the Pleiades.

		V mag	RA AS_{Sky}	RA AS'_{Stone}	DEC AS_{Sky}	DEC AS'_{Stone}	AS* Degrees
	Scorpius	**AS, AS' from**	**16^h**	**30^m**	**-26°**	**00′**	
1	α Sco Antares	0.92	12	133	30	-21	2.19°
2	τ Sco Paikauhale	2.82	94	140	138	240	1.86°
3	ϵ Sco	2.29	299	270	503	560	1.07°
4	μ Sco Pipirina	3.04	334	312	718	746	0.59°
5	ζ^2 Sco	3.62	364	372	980	968	0.24°
6	η Sco	3.32	633	649	1033	1104	1.21°
7	θ Sco Sargas	1.86	1006	977	1016	1000	0.55°
8	λ Sco Shaula	1.62	958	958	662	614	0.80°
9	kappa Sco	2.41	73	77	772	626	2.57°
	r			0.99		0.98	
	p			<0.00001		<0.00001	
10	ϵ Sgr,μ Ori, SNR ?						
	Orion	**AS, AS' from**	**5^h**	**00^m**	**-10°**	**00′**	
11	α Ori Betelgeuse	0.50	826	840	1052	1052	0.22°
12	ζ Ori Alnitak	1.26	617	750	482	543	2.44°
13	ϵ Ori Alnilam	1.69	545	560	532	482	0.88°
14	δ Ori Mintaka	2.23	480	405	586	551	1.45°
15	β Ori Rigel	0.13	225	247	113	110	0.38°
	r			0.95		0.99	
	p			0.0117		0.00086	
	Pleiades	**AS, AS' from**	**3^h**	**40^m**	**24°**	**00'**	
16	Atlas	3.62	138	136	3	10	7.3'
17	Alcione	2.86	112	113	6	4	2.2'
18	Merope	4.17	95	96	−3	4	7.1'
19	Electra	3.70	73	68	7	4	5.8'
20	Celaeno	5.44	72	70	18	16	2.8'
21	Taygeta	4.29	78	81	28	32	5.8'
22	Asterope	5.64	89	105	33	32	16.0'
23	Maia	3.86	88	104	22	24	16.0'
24	Pleione	5.09	138	112	8	6	26.0'
	r			0.88		0.95	
	p			0.00195		0.000122	
	Cassiopeia	**AS, AS' from**	**0^h**	**00^m**	**56°**	**00'**	
	ϵ Cas	3.3	1710	1695	461	468	0.34°
	δ Cas	2.7	1290	1125	256	194	1.70°
	γ Cas	2.5	855	750	284	341	1.24°
	α Cas	2.2	615	750	34	35	1.30°
	β Cas	2.3	135	45	191	322	2.30°
	r			0.98		0.92	
	p			0.0034		0.026	
	Tot 28, *r*			0.99		0.99	
	Tot 28, *p*			<0.00001		<0.00001	

about 13° higher allowing a full and easy view of the whole asterism over the horizon from the site. Note that going back in time due to the precession of the equinoxes the rise of the Scorpius asterism moves towards South-East by about 10°, while that of Orion moves towards South-West by about the same quantity.

The two asterisms of Orion and Scorpius are not contemporarily visible in the sky on the same night, and therefore they need to be drawn at a time distance of at least six months from one another. Despite this, they show a similar orientation in the sky, that is, by positioning the stone in a position with one asterism with the North on top and the East to the left, then also the other asterism has the North on the top and the East on the left. This is unlikely fortuitous. The precession of the equinoxes changes the declination in opposite directions. Rigel today is at DEC = −8.20° but it was at DEC = −20.0° in 1800 BCE, and the whole asterism was about 12° lower while Scorpius was about 13 degrees higher. Thus, going back in time the precession of the equinoxes brings the two asterisms closer in declination. Thus, if observed at approximately the same hour they hold a similar orientation in the sky. One special moment is when they become visible at dawn, namely their heliacal rise. In Figure 10 the two asterisms are shown at heliacal rise for the representative year of 1000 BCE. Scorpius was observable from Rupinpiccolo in the heliacal rising around the 10th of December while Orion around the 17th of July. To note that precession is not relevant for the relative position of stars which depends on the proper motions and do not change significantly even in the course of several thousand years. The proper motions are in the range of 1–30 mas/yr, that is, of the order of few arcminutes over a period of 4000 yrs. In the Pleiades they are of about 50 ars/yr but moving in the same

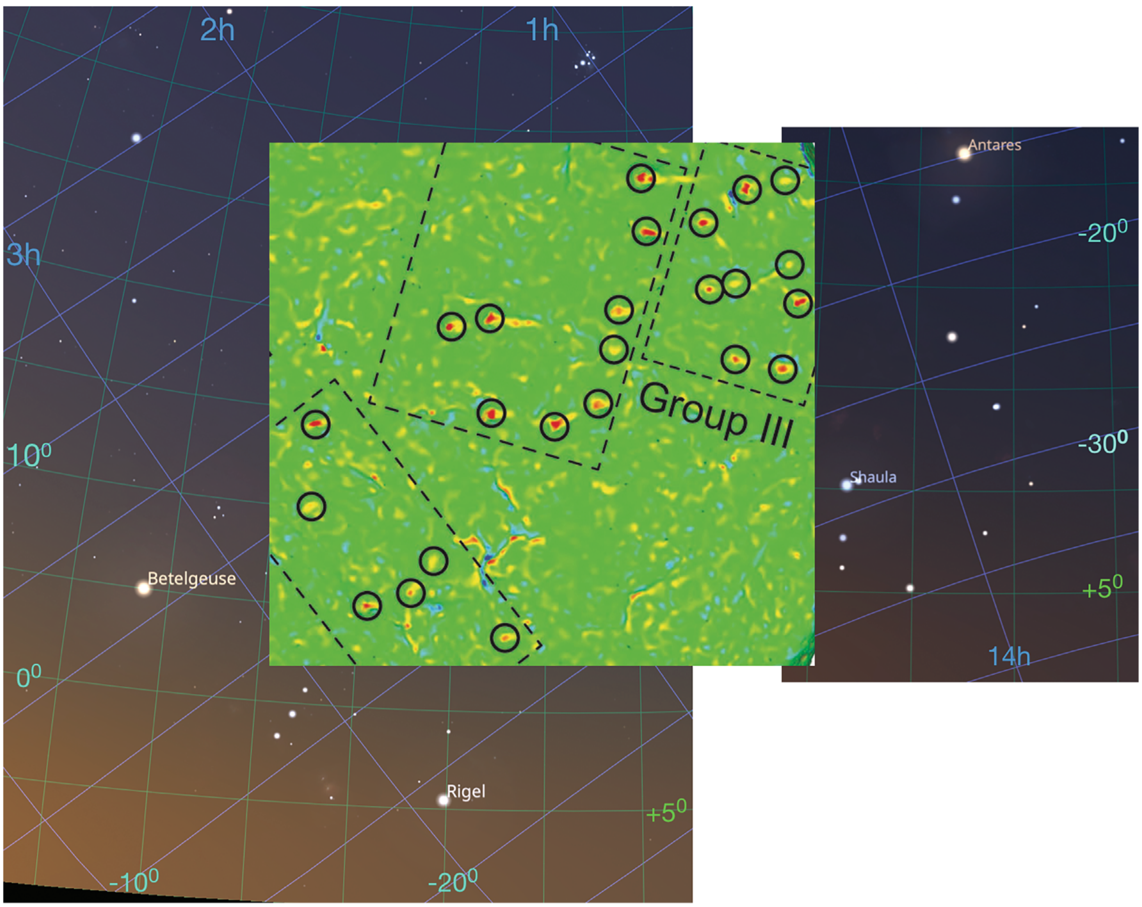

FIGURE 10 The two asterisms as seen from Rupinpiccolo at 1000 BCE close to their heliacal rise by means of Stellarium. The Left panel shows the Orion and Pleiades asterisms on 17 July at 3h 38m UTC (+55m for the Local Mean Sidereal Time, LMST). The right panel shows the Tail of Scorpius on 10 December at 6h 43 m UTC (+55m LMST). The time is set when the most southerly stars of the two asterisms were at 5 degrees over the horizon. However, the heliacal rise could differ by few days, depending on the twilight brightness and the adopted visibility threshold. In the middle there is a curvature map from Figure 2. The colors show curvatures in the stone. Yellow and red show increasing curvature and highlights the tails and the chisel marks. Note that the tails of the chisel marks of Orion and Scorpius asterisms are iso-oriented and provide the orientation of the stone going from West to East. Pleiades are different, but they have been probably drawn in the best sky conditions when they were very high in the sky.

direction in such a way that the relative positions remain unchanged. Interestingly, the highest proper motion is that of ϵ Sco with 665.82 mas/yr which translates into about 44 arcmin in 4000 yrs. The direction is with direction 247.4 deg thus bringing the star closer to the chisel mark N.3 in Figure 4.

These arguments suggest that the stone could show the two asterisms that mark two turning points of the year. They could have been used to determine the time for agriculture tasks upon which the survival of an agricultural population as the one of the *castellieri* depended. In fact, Orion, the Pleiades and Scorpius are among the most common sky asterisms in agriculture civilizations (Litchfield West 1976; Pásztor 2015; Pásztor & Roslund 2007; Schaefer 2005; Sun 2015). Hesiod in the VIII century BCE described the timing of the agricultural year with the heliacal rising of few main asterisms which include Orion and the Pleiades and α Scorpii (Litchfield West 1976).

The earliest possible dating of the disk corresponds to about 1800 BCE, but even considering the latest possible protohistoric date of 400 BCE, the representation of the sky on the stone remains significantly very old if compared to other similar finds. The oldest depiction of the sky is probably the Nebra disk from Germany dating around 1600 BCE (Meller 2002; Pásztor 2015; Pásztor & Roslund 2007; Schlosser 2002). The Nebra disk is a round bronze plate decorated with gold figures that represent the Moon, the Sun and the Pleiades. However, the disk is more a representation of folk world view rather than an astronomical map (Pásztor 2015; Pásztor & Roslund 2007).

The Dalby and Venslev stones in Denmark which belong to the late Neolithic and present several cup marks have been suggested to represent some celestial entities (Schutte 1920). Schutte (1920) claimed to have recognized Ursa Major, Cancer, Little Dog, Bull, Pegasus, Capricorn and the Milky Way. However, he also admit that the relationship between the groups of constellations is not as correct as it should be and the suggestion remains controversial (Delano Smith 1987). Actual sky maps came much later. The first illustrative star charts date back to the 1st century BCE. The earliest are the Kitora tumulus star map located at Nara in Japan, the Ship She Xingjing and the Korean stone star map entitled Cheon-sang Yeolcha Bunyajido which have been dated at 81 (±42 BCE, 54 ±12BCE, and 66±13 BCE, respectively (Nakamura 2021). The Dendera Zodiac showing the Mesopotamian zodiac surrounded by the Egyptian constellations is of the mid-1st century AD (Aubourg 1995). The Farnese Atlas is a 2nd century AD Roman copy of a Hellenistic statue carrying a celestial globe with figures of constellations (Duke 2006; Rogers 1998; Schaefer 2005). These constellations are probably drawn from the lost star catalogue of Hipparchus.

The Hipparchus catalogue that was made around 135 BCE is probably also the source for the Almagest by Ptolemy and, therefore, the first and by far the most complete and accurate (Nakamura 2021). Accepting a protohistoric dating, the relatively precise charting of few stellar asterisms on the Rupinpiccolo stone is of at least few centuries earlier and would show evidence of unexpected astronomical curiosity in protohistoric Europe.

5 | CONCLUSIONS

Two couples of stone disks found at the entrances and cemeteries of Protohistoric hill forts in the north-eastern Adriatic area were suggested to have a symbolic meaning representing the Sun and the Night Sky (Bernardini et al. 2022). In one pair the night sky is symbolically represented by a number of natural holes made by marine bivalves but in the other stone studied here the marks are made by a human hand and show a pattern. We performed a statistical comparison of the chisel marks with the most common asterisms to try to establish if they were randomly made or they had some intentionality. We have found that:

- The whole pattern is composed by 29 chisel marks, 24 in the front face of the stone and 5 on the back. 28 chisel marks are consistent with the asterisms of Scorpius, Orion, Pleiades and, perhaps, of Cassiopeia on the back side of the stone. The correlation between the chisel marks and the stellar position is very high with $r(28) = 0.994$. The p-value is formally $\ll 0.001$ and provides a very low probability that the chisel marks were produced accidentally.
- One chisel mark remains without an obvious identification. This is the most problematic chisel mark to explain.The mark is close to the stellar system of μ Ori, formed by two physical binary systems with an integrated magnitude of V = 4.1. Alternatively, if it belongs to the portion of sky of Scorpius it could be associated to ϵ Sgr. However, all these identifications are quite unsatisfactory. One intriguing possibility is that a bright star was present in that position that produced a supernova or more likely a failed supernova leaving a black hole as a remnant. Interestingly, this prediction could be tested through detailed observations and, therefore, specific studies are solicited.
- The asterisms are quite complete showing all the bright stars. Notable missing are γ and κ Ori. However, the location is in the most exposed part of the stone and the mark could have been possibly deleted by stone erosion.
- The deviations from real positions are of about one degree which are comparable with the size of the marks

in the stone. For comparison, in the catalogue of Ptolemaios the error distributions is of 27 and 23 arcmin in longitude and latitude respectively, which is only about a factor 2–3 better than those on the stone (Verbunt & van Gent 2012). This requires a careful preparation and patient persistence in the execution. As such, the reproduction is not symbolic but faithful, showing an effort in providing the true stellar positions in the sky.

- The hill fort of Rupinpiccolo was in use from about 1800/1650 to 400 BCE. Several data suggest to link the stones to the early building phase of the hill fort during the Bronze Age (Bernardini et al., 2022), even if we cannot completely rule out a Roman origin based on the similarity of the disks with roughed-out blocks of tomb stones. Even for the latest protohistoric chronology (400 BCE), the disk stone would represent one of the oldest cartography of the sky. It should be noted that the population of the castellieri did not know writing and therefore it is difficult to assess the degree of evolution they had reached. However, to reproduce a group of stars does not require specific astronomical knowledge. A unit of measurement of angular distances such as the width of a hand finger or a simple ruler are sufficient, together with a very basic ability of elementary counting.
- Today the tail of the Scorpius constellation is barely visible from the site. However, the precession of equinoxes at about 1800 BCE places Scorpius 13 degrees higher and Orion 12 degrees lower than today. This would have allowed the Scorpius tail to be fully visible from the Rupinpiccolo site. Moreover, the two asterisms were at much closer declination which could explain why they show a similar orientation in the stone though carved 6 months apart without invoking any intentionality in the making. The appearance of the asterisms in the helical rise could have been a sort of tool marking two different periods of the year. This was a normal practice in agricultural societies. We also note that while the Pleiades and Orion are the top-ranked asterisms in all culture. Scorpius is a less common than the Big Dipper or Corona Borealis and it is ranked only 14 in the study of Kemp et al. (2022). This implies that its choice could have had a specific meaning in the sky chart reproduced in the stone.

In summary, the comparison of the chisel marks with the real sky analysis suggests that they might be a real rendering of the most common asterisms. There are still remaining problems as the missing of Bellatrix and Saiph, the charting of two separate portions of the sky overlayed on the same stone and overall the presence of a single chisel mark without obvious identification. We regard this interpretation as a suggestion and we urge additional studies and searches of other astronomical evidence in the civilization of the *castellieri* to avoid fanciful interpretations. The discovery of the remnant of a failed supernova in the position of the unidentified mark to the North of Betelgeuse would prove our reading.

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