

NEW INSIGHTS FROM SKYSCAPE ARCHAEOLOGY ON THE MEGALITHIC SITES AROUND HARTASHEN, SHIRAK PROVINCE, ARMENIA

Marc Frincu and Maitane Urrutia-Aparicio

Faculty of Computer Science, West University of Timisoara, Bld. Vasile

Parvan No. 4, Timisoara, 300223, Romania.

E-mails: marc.frincu@e-uvr.ro; maitane.urrutia@e-uvr.ro

and

Levon Aghikyan

Institute of Archaeology and Ethnography, National Academy of Sciences

Republic of Armenia, Charents Str. 15, Yerevan, 0025, Armenia.

E-mail: levonaghikyan@gmail.com

Abstract: Armenia is home to several megalithic sites yet to be thoroughly researched. The area near the villages of Hartashen and Ashotsk in the Northern Shirak region is home to three such sites. While some investigations have been performed, they failed to provide an interpretation of the purpose of the megaliths. Although the sites have not yet undergone formal dating, the material remains and contextual evidence points to a plausible period that we adopt provisionally; within this framework, we seek to explore the possible meaning of their configuration. In this study we perform a skyscape analysis of the orientation and illumination effects of two megalithic sites consisting of several three-row linear avenues. The analysis consists of *in situ* measurements of their azimuths and horizon profiles to determine the celestial declination. In addition, 3D models of the terrain and megaliths are used to analyze the illumination effects throughout the year. An interesting discovery is represented by a megalith in Ashotsk 2 resembling Mt. Aragats visible to the East. Statistical analysis shows a high similarity between the two. Furthermore, results show that the orientation and position of the megaliths can be linked to the solstices and lunastices as well as with the circumpolar region of the sky. This behavior is similar to those of cultures in the region (e.g., Hittite Kingdom, Egyptian Kingdom, Mesopotamia) especially in relation to funerary practices. The statistical analysis indicates a low probability that these alignments are accidental.

Keywords: Armenia; megaliths; archaeoastronomy; skyscape, prehistory.

1 INTRODUCTION

The Shirak region in the far North of Armenia is home to several prehistoric stone structures that have not been thoroughly investigated.

There are three megalithic sites located near the villages of Hartashen and Ashotsk (see [Figures 1–3](#)). The sites contain three-row stone avenues ([Figures 4 and 5](#)). The height of each stone ranges from 0.6 to 1.5 m ([Spatzier and Bertemes, 2011](#)). In Hartashen, we also find several tumuli or *kurgans* (i.e. burial mounds, although there are now no longer burials there). Even though ditches are incorporated within the stone avenues (e.g. as at Ashotsk), no clear relationship between them can be derived, other than that they may have been constructed later to reinforce the stone rows damaged previously ([Spatzier and Bertemes, 2011](#)).

Parts of the Hartashen site have been investigated archaeologically and geomagnetically by [Schunke et al. \(2011\)](#) and [Spatzier and Bertemes \(2011\)](#). In discussions with locals it has been suggested that in ancient times the site could have been (1) part of a defensive structure or a military training site, or (2) used as a sort of calendar linked to the stars. Local legends also mention the tomb of a queen, but the

only sign of a burial complex—with the exception of two *kurgans*—was located inside a region defined by two three-row stone avenues and a small river (see [Figure 2](#)). In this context, perhaps the stone avenues could have been used to define sacred ground.

On the other hand, a defensive role for the stone rows structures is unclear. They would have been ineffective against infantry, and while better suited to stopping animal carts, this would date them before the first half of the twentieth century ([Schunke et al., 2011](#)). However, there are no known settlements in this area that date back to Medieval times, and the site is surrounded by the Bazum and Javakhk ranges to the East, Northeast and North, while to the South is the deepest part of Akhuryan River gorge. Therefore, an artificial defensive structure was unnecessary.

Moreover, similar megalithic avenues exist elsewhere in Eurasia, e.g., at Dartmoor in the UK, ([Worth, 1893](#)), indicating an independent interest in building such structures by past cultures. Most similar to those around Hartashen is the three-row 40-m avenue at Challacombe in the UK, which contains 103 stones ([Ormerod, 1875; Worth, 1892; 1894](#)).



Figure 1: A map of Armenia showing the locations of the Ashotsk 1, Ashotsk 2, Hartashen and Zorats Karer megalith sites (Google Earth; map modifications: authors and Wayne Orchiston; scale: 200 km).

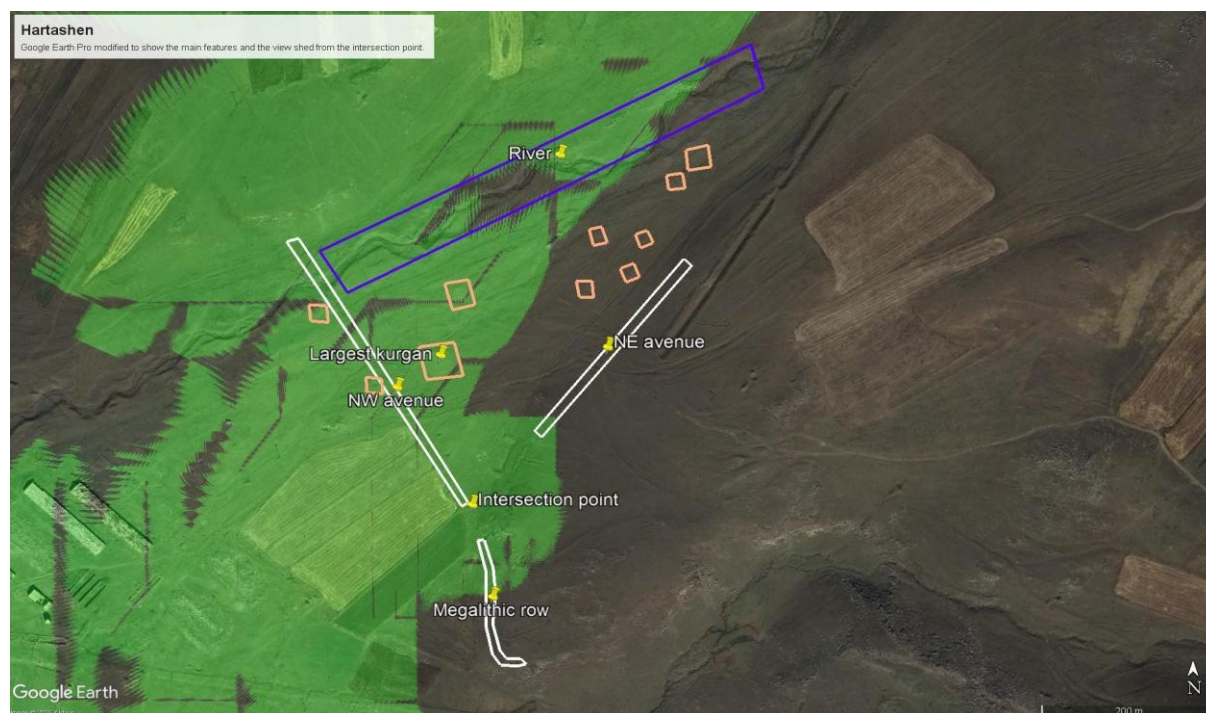


Figure 2: Satellite map of Hartashen NW and NE stone avenues and the Ashotsk 2 site ('Megalithic row') with key features marked. Google Earth Pro. modified showing main features. North is up, and the scale is shown in the lower right corner. For views of the Hartashen and Ashotsk 2 sites see Figures 4 and 5).



Figure 3: Satellite map of the Ashotsk 2 site with key features marked. Google Earth Pro. modified showing main features. North is up, and the scale is shown in the lower right corner. For the location of this site relative to the Hartashen sites see Figure 2 and for a view of this site see Figure 5).



Figure 4: Views of the NE (left) and NW (right) three-row megalithic avenues at the Hartashen site. For the relative locations of these two stone avenues see Figure 2 (photographs: the authors).

Pottery from the Kura Araxes Culture (first half of the third millennium BCE) and from later periods (end of the second or beginning of the first millennium BCE) was found in Hartashen (Schunke et al., 2011). This corroborates our opinion (although no excavations of the burial mounds have taken place yet) that the *kurgans* most likely date from the Middle Bronze Age. The large *kurgan* (marked 01 in Figure 15 in Schunke et al. (2011)) contains a processional road heading northeast. Similar roads have been found at *kurgans* in Southern Georgia,

north of Hartashen which have also been dated to the Middle Bronze Age (Narimanishvili et al., 2019: 82–84; Narimanishvili, 2024). Colluvium samples obtained in 2011 provided dates of between the fifth millennium BCE and the Iron Age (Iskra and Zakyan, pers. comm., 2019; Schunke, pers. comm., 2025).

Another partially damaged stone avenue was found near the village of Azatan, south of Gyumri. This megalithic complex was close to a large Late Bronze Age site and two Middle Bronze Age *kurgans* (Aghikyan, 2022).



Figure 5: View of the Ashotsk 2 three row avenues from the end of the Hartashen SW avenue (the arc where the SE avenue starts is clearly visible).

Ashotsk 1 contains a series of three-row avenues and intercalating ditches (with megaliths found collapsed in them). It is non-linear, and seems to follow the terrain elevation line. It is not discussed here.

Similar megalithic structures to those at Ashotsk and Hartashen are found to the south in the Syunik region at Zorats Karer (Figure 1). There, a large burial mound is located in the middle of the North–South avenue (see Figure 6). The site has been built in several phases, ranging from the Middle Bronze Age to the Iron Age (Piliposyan et al., 2019).

Plans for Hartashen and Zorats Karer are available from Schunke et al. (2011) and Piliposyan et al. (2019) respectively, whereas for Ashotsk only satellite imagery is available as the site has yet to be investigated archaeologically.

Zorats Karer is the only site that has been thoroughly investigated (Piliposyan, 2016) by taking both archaeological and interdisciplinary approaches. Several hypotheses have proposed that the complex functioned as a prehistoric

observatory, an idea that gained considerable public attention. However, these ideas have been criticized by archaeologists and cultural astronomers alike for methodological weaknesses (González-García, 2015). Key critique concerns the interpretation of the drilled holes in the megaliths. Although these holes have often been cited as evidence for intentional astronomical sighting devices, their dimensions, orientations, and in some cases their partially buried positions make such a function difficult to sustain. Further, similar holes found elsewhere (e.g., on tomb stones around various Armenian churches) suggest that they were probably used for moving or handling the stones. Although these issues highlight the need for more contextually grounded methodologies, the debate surrounding the site demonstrates the value of these interdisciplinary perspectives.

In recent years, skyscape archaeology (Henty, 2016) has demonstrated strong new methodological approaches (Higginbottom and Clay, 2016) that have led to a better understanding of the possible purpose of ancient structures considering the relationship between

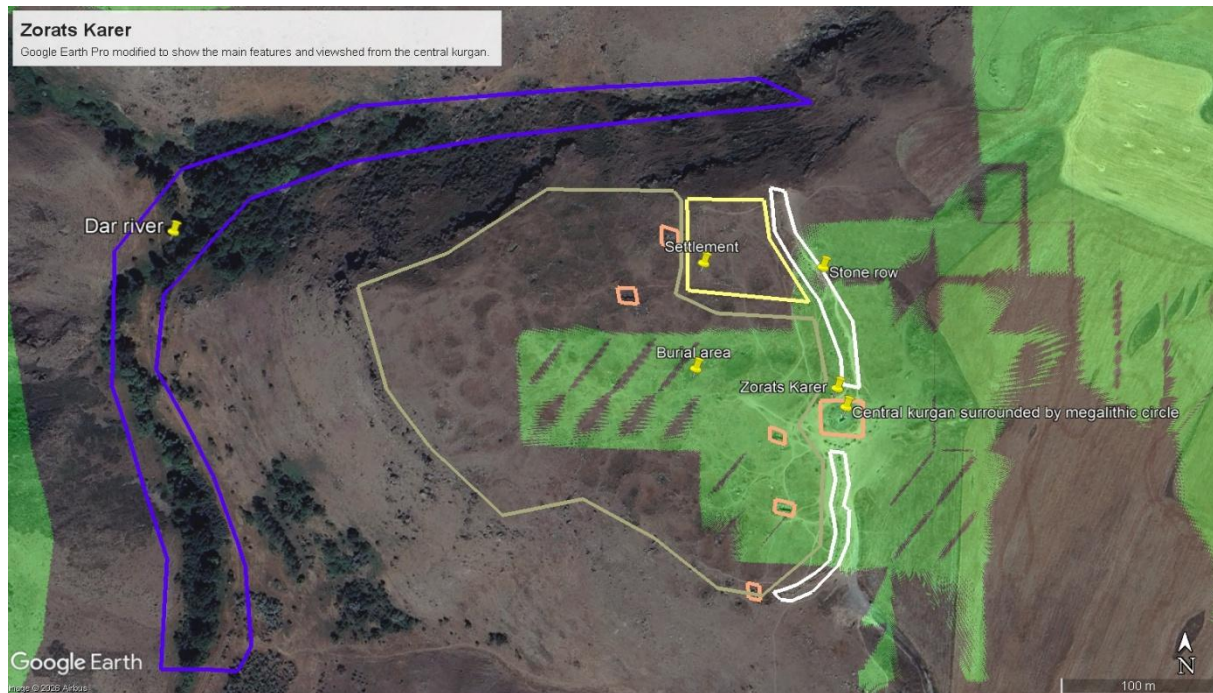


Figure 6: Satellite map of the Zorats Karer site viewed from the central *kurgan*. Google Earth Pro. modified showing main features. North is up, and the scale (100 m) is shown in the lower right corner.

the sky and human culture. It does this by focusing on the role of the sky in the shaping of archaeological sites and landscapes by bridging archaeology and archaeoastronomy (Magli, 2020), i.e., the study of how people in the past understood and utilized the sky, and how the sky influenced their cultures by focusing on material remains, e.g., temples, megaliths. Furthermore, the importance of the skyscape within a broader cultural context is recognized by the International Astronomical Union (IAU) through its Commission C5 on Cultural Astronomy.

In this study, we perform a skyscape analysis by combining on-site measurements and observations, statistical and astronomical analysis, 3D modeling, and comparative analysis to interpret the megalithic avenues at Hartashen and Ashotsk 2. Our intention is not to date the sites, but rather to explore the possibility that the orientation could hold contextual or symbolic significance within a cultural setting and that its occurrence as a purely random orientation may therefore be less likely.

2 MATERIALS AND METHODS

2.1 Data Gathering and Preparation

We used a Suunto compass and clinometer with a theoretical precision (0.33° respectively 0.25°), within the accepted values for prehistoric structures of $\pm 1^\circ$ for single measurements and $\pm 30'$ (Polcaro and Polcaro, 2009) for multiple measurements. These values reflect the

degree of precision realistically attainable on structures whose architectural edges are often irregular, eroded, or otherwise difficult to define with sub-degree accuracy. They also correspond to the level of precision that can reasonably be expected of prehistoric builders if intentional orientation was part of their original design. In addition, we measured the orientations using Google Earth Pro. 5 for azimuths and <https://www.heywhatsthat.com> for the elevation profile based on 30 m resolution SRTM data. The online tools provided measurements within an error of 1.35° for azimuths and of 1° for the horizon altitude (Rodríguez-Antón et al., 2018).

Hartashen and Ashotsk 2 are the only sites where the megalithic avenues are linear. For these we measured the azimuth of each megalithic avenue several times in both directions, took the average value and computed the quadratic error, $\sigma_A = \sqrt{\sigma^2 + \varepsilon^2}$, where σ is the standard error of the azimuth measurements and $\varepsilon = 0.5^\circ$ is 5 times the average error of the measurement. In the case of Hartashen, measurements included several taken during a previous campaign, in 2019. The errors (c.f. Table 1) are higher for Hartashen since the megalithic avenues follow uneven terrain.

The azimuths measured with the compass were adjusted for the magnetic declination for the date of measurement with values from <https://>

Table 1: Compass average azimuths, altitudes, and measurement errors for the megalithic lines. The altitude error was considered as 0.25° . Azimuth and altitude values are averages and are provided in both directions of each avenue.

Parameter	Hartashen NW	Hartashen NE	Ashotsk 2 SW	Ashotsk 2 SE
Azimuth	147.9°/328.9°	38.8°/221.7°	64.6°/245.4°	130.6°/312.3°
Azimuth error	1.3°	0.8°	0.6°	0.7°
Altitude	3°/2.8°	7.5°/−0.75°	4.8°/7°	1.5°/10°

Table 2: Weighted declination with declination error for each megalithic avenue.

Hartashen NW	Hartashen NE	Ashotsk 2 SW	Ashotsk 2 SE
$42.6 \pm 0.9^\circ$ facing NW from the intersection point, and $-37.0 \pm 0.9^\circ$ in the opposite direction	$41.9 \pm 0.7^\circ$ facing NE from the intersection point, and $34.87 \pm 0.7^\circ$ in the opposite direction	$-13.4 \pm 0.6^\circ$ facing SW from the intersection point, and $+22.2 \pm 0.6^\circ$ in the opposite direction	$-28.2 \pm 0.6^\circ$ facing SE from the intersection point, and $+37.8 \pm 0.7^\circ$ in the opposite direction

www.ngdc.noaa.gov/geomag/calculators/magcalc.shtml computed with the WMM model for 2025 and the EMM model for 2019.

Since the path of celestial bodies in the night sky depends on the latitude of the site, we used the celestial declination δ instead of azimuths: $\sin(\delta) = \sin(\varphi) \cdot \sin(h) + \cos(\varphi) \cdot \cos(h) \cdot \cos(A)$, where δ is the declination, φ is the latitude, A is the azimuth and h is the horizon altitude. We computed the declination by considering the declination error which includes the azimuth and altitude errors. We used the Astrocult library (Urrutia-Aparicio and Frincu, 2026) which is based on previous archaeoastronomical research (i.e. Belmonte et al., 2024).

In addition to data measurements, we also took 3D scans using the Polycam App for Android (Polycam, 2025) for six megaliths in Hartashen and one in Ashotsk 2. The models were incorporated into the generated 3D terrains to create a realistic depiction of the megalithic avenues in order to assess the possible illumination effects.

The date of each site was set, as an approximation, for 1500 BCE and an average value of $\delta_{\text{solstice}} = \pm 23.9^\circ$ and $\delta_{\text{southern major lunastice}} = \pm 28.72^\circ$ for the lunisolar extremes from Stellarium using the DE431 algorithm.

2.2 Software Processing

Three-hundred and sixty degree panoramas from the intersection points of the avenues at Hartashen and Ashotsk 2 were created using Hugin (d'Angelo et al., 2025). Additional panoramas for Hartashen were created using Peakfinder (Soldati, 2025) based on SRTM data: one from the mid-point of each avenue. All panoramas were imported into Stellarium (Zotti et al., 2025), an accurate sky simulator, set for the year 1200 BCE based on available dating information. They were used to evaluate sunrise/set and moonrise/set points from various positions.

3D digital terrains.*obj* files were generated

with 30m SRTM data in *geotiff* format from <https://opentopography.org/> using L3DT Standard edition (Bundysoft, 2025).

Unity 2022.3 was used to import the 3D models for the terrain and megalithic structures. The sky inside Stellarium was rendered in the Miller cylindrical projection and projected inside Unity as a skybox texture using the KlakSpout plugin (Takahashi et al., 2025) for a realistic representation of the sky in the past in 1500 BCE. This allowed for a detailed analysis of the illumination/shadow effects of the megaliths themselves.

To analyze horizon features with various stone structures, we binarized the captured images using adaptive thresholding from Python's CV2 library. The parameters were set to `adaptiveMethod=ADAPTIVE_THRESH_MEAN_C`, `blockSize = 11` and `C = 2`, where `blockSize` represents the size of the neighborhood used for computing the mean values from which `C` is subtracted). After that the contours were extracted using canny edge detection and the result was filtered for noise. Finally, the contours were extracted as a time series (where the X-axis represents the width of the image and the vertical Y-axis the location of the contour pixels on the vertical). Dynamic Time Warping (DTW) (Müller, 2007) was used to assess the similarity of various contours as discussed in Sections 3 and 4. A value close to 0 indicates identical time series.

3 RESULTS

The celestial declinations were computed in both directions of the avenues. Table 2 shows the values for the direction defined by the intersection points of Hartashen NW with Hartashen NE (Figure 2) and Ashotsk 2 SW with Ashotsk 2 SE (c.f. Figure 3). The intersection point was selected as it represents a suitable position for observing along both avenues. The reported values are for on-site measurements. Google Earth Pro. measurements were used for cross-

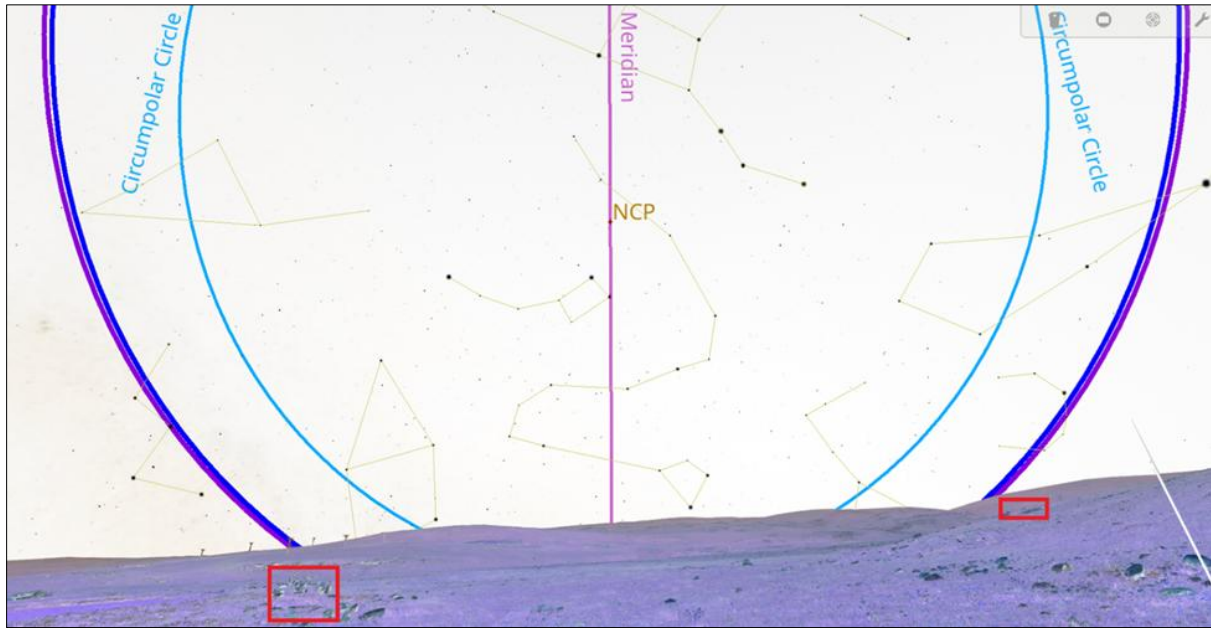


Figure 7: Simulation of the circumpolar night sky (inverted colors) in 1500 BCE on summer solstice at 12:00:00 created using Stellarium 24.3: circumpolar circle (light blue) and the 2 declination lines (magenta and navy blue) corresponding to the avenues. The North Celestial Pole is marked (NCP). The two avenues are marked in red boxes.

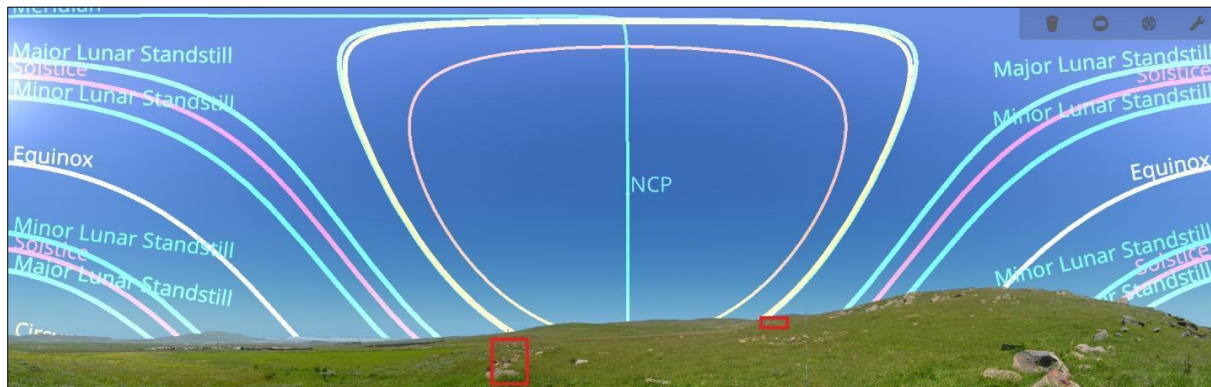


Figure 8: Panoramic view showing the solstitial, equinoctial, circumpolar and lunar extremes declination lines together with the two avenues' declination lines in 1500 BCE on summer solstice at 12:00:00 created using Stellarium 24.3. Red boxes mark the stone rows. The thick overlapping yellow and green lines mark the location of the declination lines corresponding to the two rows. North is marked by the meridian line.

checking, and no significant differences were observed.

By analyzing the declination values, we observe that the Hartashen avenues are almost symmetrically placed around the North Pole axis. Circumpolar stars (i.e., stars that never set) for the latitude of Hartashen reside inside a circle with radius equal to a declination of ca. 49° for a flat horizon, and ca. 55° for an altitude of 6° , an average Northern horizon profile in this site (c.f. Figure 7). The declinations of the NW and NE avenues in Hartashen differ by 1° and are between 7° and 13° away from the circumpolar declination circle (c.f. Figure 7). Figure 8 shows the panoramic view from the intersection point with the main lines. The NW avenue is oriented right of the NW marker in the direction

of the double line while the NE avenue starts on the rim of the foreground hill left to the NE marker in the direction of the same double line. This near perfect framing of the circumpolar area provides an impressive view of the night sky as it rotates around the North Pole located in the center. Figure 9 shows a timelapse taken on site from the intersection point.

Analyzing the declinations in Table 2 we notice that Ashotsk 2 SE points in the direction of the Southern major lunastice, while Ashotsk 2 SW points roughly towards of the Summer Solstice sunrise, when viewed along the edge from the end of the avenue (where a rock resembling Mt. Aragats¹ is found) towards the intersection point (declination of $+22.2^\circ \pm 0.6^\circ$). The other declinations, irrespective of how the

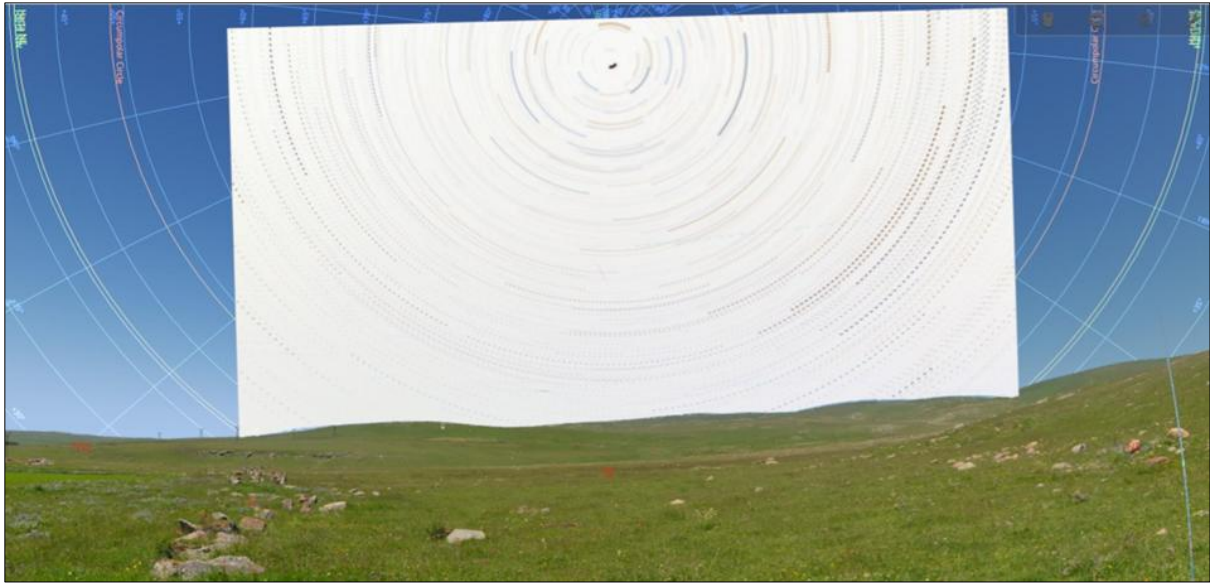


Figure 9: Example of circumpolar stars (real inverted colors image overlapped over panorama) taken during the 2025 summer solstice to simulate how the stars rotate around the NCP.

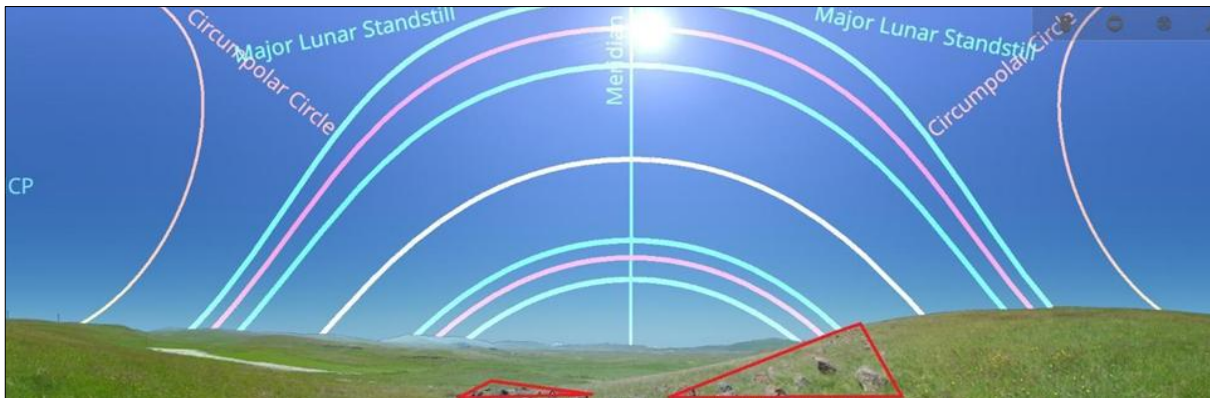


Figure 10: Panoramic view for 1500 BCE on summer solstice at 12:00:00 created using Stellarium 24.3. showing the solstitial, equinoctial, circumpolar and lunar extremes declination lines together with the two avenues' declination lines (colors are the same as in Figure 8). Red boxes mark the stone rows. South is marked by the meridian line.

direction in which they are computed towards or away from the intersection points, do not point to significant lunar or solar extremes. Figure 10 shows a panorama with the main declination lines from the intersection point. The two avenues are visible towards SE and SW. To assess whether these apparent orientations could arise by chance, we next evaluate the statistical significance of each alignment. Statistically, and following the works of Heggie (1981) and Ruggles (1999), the probability that a randomly oriented structure falls within a given declination interval depends on latitude, the target declination, the declination uncertainty and the local horizon profile. In our case, this probability is obtained from the derivative of the visible azimuthal range with respect to declination, computed for the horizon at each site. For completeness, we note that alternative probabilistic approaches for point-pattern matching have

been proposed (e.g., Vecchiato, Bernardi and Cora 2025), although their method is not directly applicable to this analysis. As a complement, we also use the Z-score as a measure of how many standard deviations an observed declination differs from the expected value, allowing us to assess whether two orientations are statistically distinguishable. For Hartashen, a Z-score of 0.61σ indicates that statistically, the two avenues are pointing in the same direction, being indistinguishable. To compute the conditional probability that both avenues point to it we calculated the combined declination and uncertainty (from Table 2). The probability of such an alignment arising by chance is 0.0057%. At Ashotsk 2, the two Southern orientations (measured from the avenues' intersection points) show low chance probabilities (0.48% and 0.51%). However, the SW (declination of -13.4°) alignment lies 17.5σ from the

Table 3: Orientation analysis of the megalithic avenues' perpendiculars in Hartashen.

Avenues and Perpendiculars	Hartashen NW		Hartashen NE	
	$\perp$ NE	$\perp$ SW	$\perp$ NW	$\perp$ SE
Avg. A	58.9°	238.3°	310.3°	130.3°
Avg horizon altitude	8°	2°	5°	2°
Avg. δ	28.7°	-22.3°	32.3°	-27.7°
Avg. δ difference from solstice	5.0°	-1.6°	9.0°	3.8°
Avg. δ difference from major lunastice	0.2°	-6.4°	4.2°	-1.0°
Avg. A difference from solstice	9.0°	1.3°	13.3°	5.3°
Avg. A difference from major lunastice	1.72°	6.28°	7.3°	1.7°

solstitial declination and also seems incompatible with either major or minor lunar standstills. In contrast, the SE (declination of -28.2°) alignment lies 0.87σ from the Southern major lunastice. Together, the Ashotsk 2 orientations produce a combined random probability of 0.0025%, which indicates that these orientations are unlikely to be random. Nevertheless, as these results come from only two sites, and although the observations are certainly suggestive, additional evidence is needed.

During the 2025 Summer solstice visit in Hartashen, we noticed a particular illumination at sunrise with shadows cast by the megaliths being almost perpendicular to the NW avenue. The average perpendicular azimuths for the NW avenue are 58.3° respectively 238.3° , while for the NE avenue are 130.3° respectively 310.3° . Table 3 shows the declinations and differences from the solar and lunar extremes (in terms of δ and A in the direction of the rise/set on the horizon, given an average altitude of the horizon calculated from the mid-point of each avenue). The best values are provided by the NW $\perp$ SW corresponding to the Winter Solstice sunset (at an angle only 1.3° away from a perfect perpendicular shadow).

It is interest that the perpendiculars closely match the shadow of the Moon at its rise during the Northern and Southern major lunastice (respectively 1.7° away).

These calculated values provide similar illumination effects with shadows almost perpendicular to both avenues (c.f. Figures 11 and 12): at Winter Solstice sunrise (NE) and sunset (NW) with the shadows towards the *kurgans*; and at Summer Solstice sunrise (NW) and sunset (NE) with the shadows in both cases pointing away from the *kurgans*.

Finally, at the Southern end of the SW avenue in Ashotsk 2, a foreground rock resembling Mt. Aragats caught our attention (Figure 13). As the only snow-covered peak on the horizon, this feature stands out in the landscape. A 3D scan of the rock allowed us to perform a profile similarity analysis. Figure 14 shows the profiles before and after applying DTW. The resulting values (DTW = 0.006 for Aragats vs. the larger

stone, and DTW = 0.010 for the hills in front of Aragats vs. the smaller foreground stone) indicate a strong similarity between the stones and the corresponding horizon shapes (i.e., a value of 0 represents identical profiles).

4 DISCUSSION

Circumpolar stars played an important role in past cultures, including those that had economic relations to the Southern Caucasus area dating back to at least the Bronze Age. These included Egyptians, Babylonians, and Hittites, for whom circumpolar stars symbolized eternity/stability being outside of the temporal structure of the calendar: the stars of Enlil in Babylonian astronomy (Rogers, 1998); "... those who do not know the setting ... the immortals ..." in ancient Egypt (Belmonte and Lull, 2023: 238); or the deities led by the supreme god Teshub for the Hittites (Zangger et al., 2021). They can symbolize the place where people, especially rulers, would go after death, as is the case of ancient Egypt, where we find pyramids aligned with the North (Belmonte, 2001), have entrances facing North (Belmonte and Lull, 2023: 400) and shafts pointing to circumpolar stars (Magli and Belmonte, 2009).

For ancient Egypt there is evidence in some Pyramid texts (second half of the third millennium BCE) that the circumpolar area comprised not only the circumpolar stars but those above the ecliptic (i.e., the Sun's apparent path during the year) since a star's heliacal rising in that region precedes its heliacal setting effectively making the star visible throughout the year (Belmonte and Lull, 2023: 239).

For Babylonians, the *Three Stars Each* system from the late second millennium BCE (Steele, 2016) includes stars corresponding to the three regions of the sky (above ecliptic, on the ecliptic, and below ecliptic) while MUL.APIN (first millennium BCE) contains 33 stars of Enlil (Rogers, 1998) some circumpolar. Enlil's great temple of Ekur in Nippur was also known as the "... mooring rope of heaven and earth ..." connecting the divine with the earthly world (Black and Green, 1992: 62). Emerging evidence from the region also supports the role of

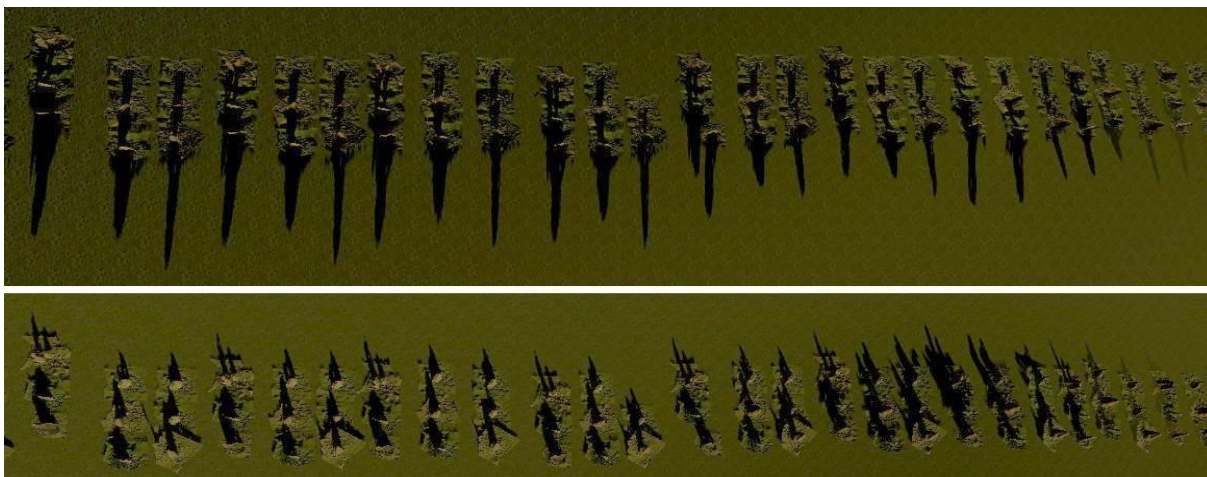


Figure 11: Simulated illumination effect of megaliths at Hartashen. The Winter solstice sunrise (top) and summer solstice sunset (bottom) for the NE avenue.

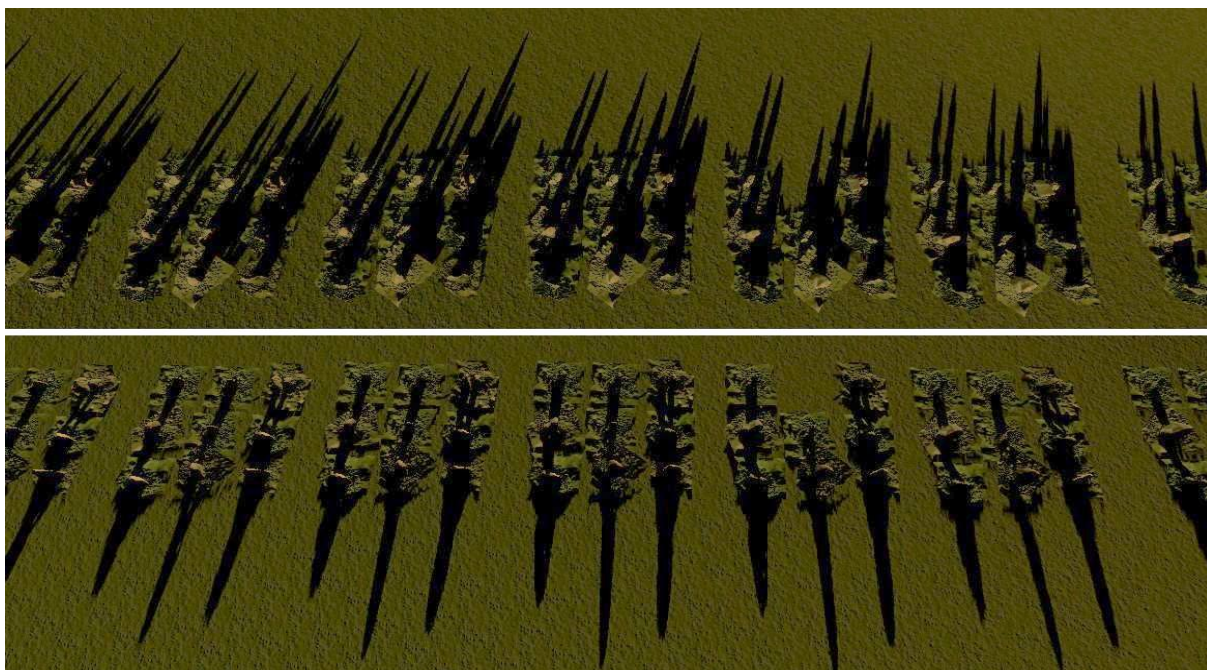


Figure 12: Simulated illumination effect of megaliths at Hartashen. The Winter solstice sunrise (top) and summer solstice sunset (bottom) for the NW avenue.

circumpolar stars in the design of the rock sanctuary of Yazılıkaya ([Zangger et al., 2021](#)) and the Northern orientation of the Yerikapı (i.e., gate in the ground, or tunnel) at Hattuša, the Hittite capital.

In Hartashen, we could have a representation of a similar belief, where the necropolis is delimited by avenues marking equal areas around the North and framing the circumpolar stars. The region was close to the Hittite area and Mesopotamia, with further evidence of Egyptian inspired seals and scarabs (including one mentioning Thutmose III) found in present day Armenia and dating from the mid-second millennium BCE. The artefacts can be seen in the History Museum of Armenia in Yerevan

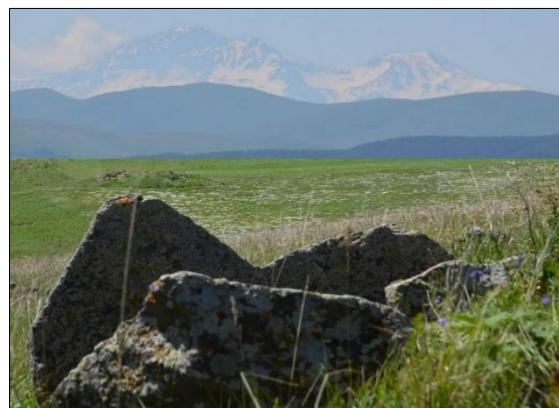


Figure 13: The rock (in the foreground) at Ashotsk 2 that resembles the profile of Mt. Aragats (in the background).

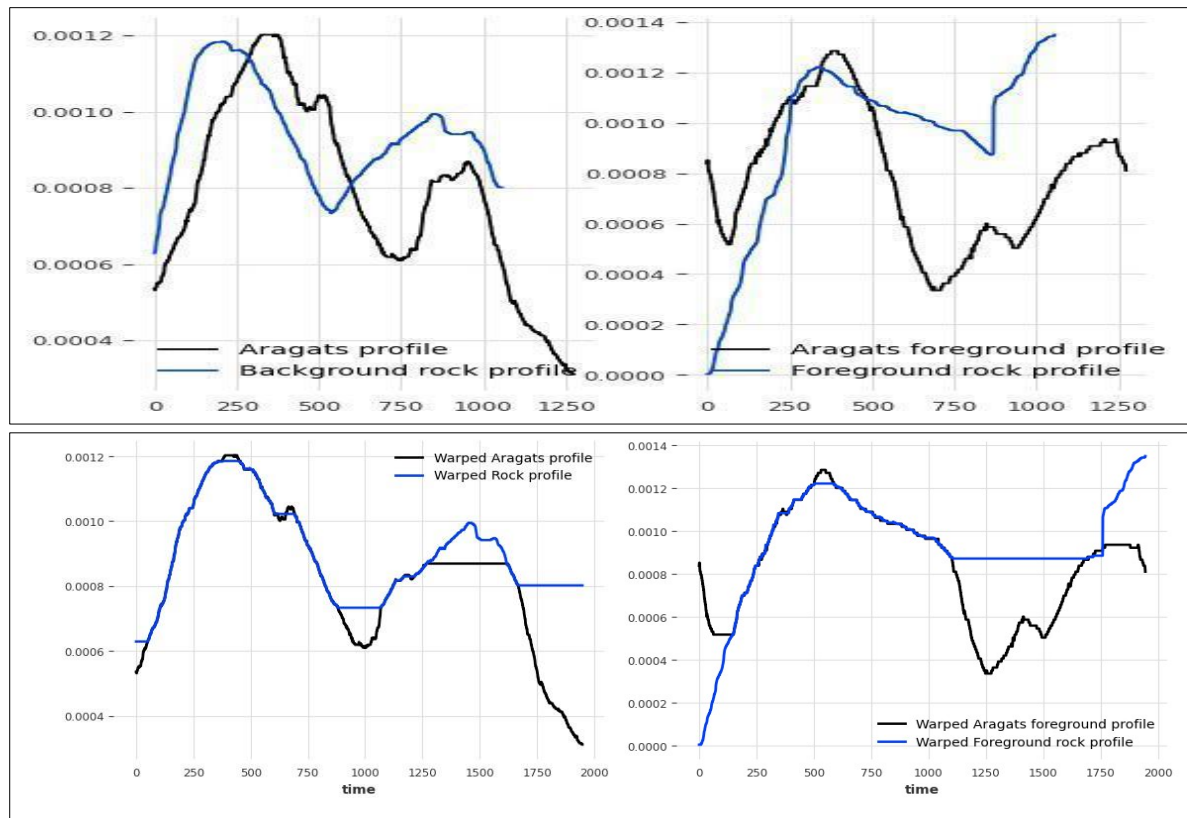


Figure 14: Profiles of Mt. Aragats on the horizon as seen from Ashotsk 2 and the rock at the end of the SW avenue that resembles it, created by extracting the shape contours from Figure 13 and processing them as described in Section 2.2. At the top are the raw profiles, while below them the profile alignment using DTW shows the high similarity between their perceived shapes.

and the Archeological Museum in Metsamor.

Hartashen (Figure 2) consists of a necropolis of 31 *kurgans* inside a triangle defined by two stone avenues intersecting in the South and a small river to the North. For a detailed map see Schunke et al. (2011). A similar delimitation exists in Zorats Karer (Figure 6) where a necropolis is found occupying a large portion (except for the settlement in the North-east) of the triangular site delimited by the Dar River and a megalithic wall to the East with a North–South orientation (Piliposyan et al., 2019). A comparative analysis between the sites suggests a delimitation of the necropolis in both cases by combining anthropic and natural boundaries. In the case of Hartashen, the circumpolar area fits inside the area delimited by the two three-row avenues, suggesting a possible ritualistic symbolism and hinting, as seen in other cultures mentioned earlier, at the immortality of the people inside—perhaps separating them from the mortal realm. In addition, the positions of the Sun at sunrise and sunset at Winter Solstice created almost perpendicular shadows facing towards the necropolis, which could also have played a symbolic role in delimitating the space of the dead from that of the living. The Winter Solstice

was seen as a turning point in the year, marking the longest nights, after which the days grew longer, hence signifying rebirth. Megalithic monuments elsewhere (e.g., Newgrange, see Hensey (2021)) were connected with it.

Complementing the illumination effects at Winter Solstice, the Summer Solstice sunrise and sunset created almost perpendicular shadows at the opposite rows, pointing away from the necropolis (Figure 12). The incorporation of shadow and light effects is not singular and has been observed in the design of other megalithic structures. For instance, Pritchard (2017) analyzed the shadow effects at solstices on stone pairs in Southwest Wales, while Meaden (2017) focused on Avebury and Stonehenge, UK. Shadow effects were not used exclusively in monoliths, as shown by González-García et al. (2019) who focused on the light and shadow effects at the winter solstice inside the Dom-bate dolmen in Galicia, Spain, and how it might have decided the location of the decorative art.

Another interesting architectural feature of Hartashen is the lack of physical intersection between its two megalithic avenues (Figure 2). Despite this gap, an observer standing in the theoretical intersection point, retains an unob-

structed view along the entire NW avenue and the beginning of the NE avenue. The lack of stones at the end of the NE avenue that would connect it with the NW avenue suggests that the monument's layout might have been shaped by visual alignment rather than physical connectivity.

While Hartashen is focused on the North, the nearby V-shaped megalithic structure at Ashotsk 2 is opening toward the South (cf. Figure 3) and possibly to the movement of the Moon and Sun. A similar design could have been used at Zorats Karer where from the *kurgan* in the center an observer sees the Eastern and Western horizons, but some details such as the settlement and parts of the necropolis are hidden (Figure 6).

In addition, the strong resemblance between the rocks in Figure 13 and the profile of Mt. Aragats in Ashotsk 2 (Figure 14) is noteworthy, since Aragats is one of the most prominent landmarks in the region with snowy peaks throughout the year, and carries long-standing cultural and mythological significance. In Armenian tradition, the mountain is associated with the legendary King Ara, and its surroundings host numerous Bronze Age sites and Dragon Stones (Gurzadyan and Bobokhyan, 2025). The mountains of Armenia seem to play an important role in connection with the sky. For instance, in Metsamor, the temple is facing South towards Mt. Ararat while the so-called observatory has its three platforms also facing South (Parsamian, 1985). Furthermore, in Sevsar, the isolated petroglyph high up in the mountain and containing solar symbols has Mt. Sev in the South and possibly was once used as a gnomon (Frincu et al., 2021).

5 CONCLUDING REMARKS

In this study, a different view on the megalithic sites in the Hartashen area in Armenia has been provided. A site in Hartashen and one in nearby Ashotsk have been analyzed by considering the skyscape. Measurements of the sites complemented by statistical analysis indicate that astronomy might have been used in relation to the funerary practices around Hartashen, with the two megalithic avenues forming a V-shaped structure delimitating the funerary area and marking symmetrically the circum-polar areas around the North Pole. A similar

separation of the funerary areas can be seen at Zorats Karer. Furthermore, 3D analysis of the landscape and illumination effects showed that the shadows at Winter Solstice sunrise and sunset were almost perpendicular to the avenues pointing inside the funerary area. In Ashotsk 2, the megalithic avenues also form a V-shaped structure but facing South, with one avenue pointing close to the major Southern lunastice moonrise.

A curious rock found at the end of the SW avenue at Ashotsk 2 resembles Mt. Aragats, a fact reinforced by statistical analysis. This may also hint at the role played by the landscape horizon in shaping the megaliths.

This study offers a basis for gaining further insight into the purpose of the structures, and archaeoastronomy and statistics can be used to indicate intentionality in placing a structure at a certain location and in a certain way. Although the analysis suggests a meaningful pattern, fully understanding the significance of such orientations ultimately depends on situating them within the correct cultural and chronological context. Therefore, until the site is dated, the conclusions presented here should be viewed as informed but provisional. However, such practices of orientating structures and considering illumination effects were enacted elsewhere around the world, as we have discussed earlier and indicate that the structures in the Hartashen area might have played a symbolic role in funerary practices and other rites related to the skyscape.

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7 NOTES

1. Mt Aragats is an isolate 4-peaked volcano and at 4090 m, is the highest mountain in Armenia. It is located in northern half of Armenia and in Figure 1 is represented by the white (snow-capped) mountains about half-way between the city of Gyumri and the 'A' of 'Armenia'. Most Armenians regard Mt. Aragats as sacred.

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Professor Marc Frincu was born in Timisoara (Romania) in 1983 and has a PhD degree in Computer Science from West University of Timisoara Romania (2011). He is currently employed by the same University as a full Professor. He also serves as Secretary for the European Society for Astronomy in Culture (SEAC) and the Romanian Society for Cultural Astronomy. He is an IEEE Senior Member.



He has been supervising PhD students since 2017. In the past he was employed as a Postdoc at University of Strasbourg France (2011–2012) and University of Southern California, USA (2012–2015). Between 2020–2023 he was a Senior Lecturer in Computer Science at Nottingham Trent University (UK).

He has published 4 books on cultural astronomy, 3 in Romanian (*Cerul de Piatră / The Sky of Stone* - 2018, *Timpul și Calendarele / The Time and the Calendars* - 2019, *Astronomia Străbunilor / Astronomy of the Ancients* - 2019) and 1 in English (*Ancient Skies of Banat* - 2023). He has also edited the 2022 SEAC Proceedings, which he organized in Timisoara Romania.

His current interests include Big Data analysis and archaeoastronomy, being involved in research in Romania, Armenia and Serbia.

Dr. Maitane Urrutia-Aparicio was born in Mungia (Spain), she holds a PhD in Astrophysics from the Instituto de Astrofísica de Canarias and the University of La Laguna (Tenerife). She is currently an Assistant Professor at the Universidad Europea de Canarias (Spain) and a researcher at the West University of Timișoara (Romania).



Her academic and research work has focused on the Middle Ages, a period she explored in depth during her doctoral thesis on the archaeoastronomical study of Romanesque churches along the Camino de Santiago, later expanding her analyses to other examples of Medieval architecture.

She is currently engaged in several cultural astronomy projects in diverse regions: from prehistoric funerary tumuli in the Western Sahara to historical sites in Romania and Armenia, the latter forming the basis of the present study.

Levon Aghikyan received his Master's degree in archaeology from Yerevan State University, Armenia, in 2013. Since 2013 he has been a researcher in the Early Archaeology Department at the Institute of

Archaeology and Ethnography of the Academy of Sciences of the Republic of Armenia. Since 2022, he also has been a Research Fellow at the Shirak Regional Museum.



Over the past ten years, Aghikyan's research has focused on the Kura-Araxes Culture, in particular on the burial customs of the Early Bronze Age in the South Caucasus. Since 2008 he has participated in approximately 30 expeditions of the Institute of Archaeology and Ethnography and the Shirak Regional Museum, including excavations in Aknashen (2011–2019), Gegharot (2014–2018), Karnut (2016–2022), and Voskeblur (2020–now). Since 2018 he has also co-directed the Armenian-French “Tavush Archaeological Project”, and from 2022 the Armenian–German Azatan expedition and the Armenian–French Beniamin expedition (also since 2022).

Levon has many publications about Armenian archaeology, and also on the genetic evidence linking Caucasus Cultures and those of Europe and the Middle East.