Proceedings of the 38th Annual Conference on Computer Applications and Quantitative Methods in Archaeology, CAA2010
F. Contreras, M. Farjas and F.J. Melero (eds.)

GIS Use in Open-Air Rock Art Conservation: the Case of the Côa Valley, Portugal

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The use of GIS space analysis tools will be examined in reference to the conservation of the Côa Valley rock art. It is proposed that, conservation wise, each outcrop containing rock art is differently affected by slope, aspect and solar radiation. Therefore, the accurate determination of the precise situation of each outcrop regarding the above-mentioned spatial distribution variables will be a valuable aid in the full characterization and assessment of the condition of outcrops with rock art.

Keywords: Open-air rock art conservation, spatial distribution of rock art, Côa Valley, Portugal

1. Introduction

The Côa Valley Archaeological Park (PAVC, www.arte-coa.pt), located in Northern Portugal, possesses an extraordinary collection of ancient open-air rock art motifs. Prehistoric imagery ranges from the Upper Paleolithic (Figure 1) to the Iron Age, and is located on the banks of the Côa and Douro Rivers and their tributaries (BAPTISTA, 1999). So far, around 40 different rock art sites possessing around 1000 engraved and painted outcrops comprising a total of more than 5000 individual motifs were identified (Figure 2). Due to its significance, the Côa Valley rock art has been inscribed in the World Heritage List (UNESCO, 1999).

Since 2000, the author has been developing a Conservation Program for the rock art at Côa Valley (FERNANDES, 2007). The first stages of research attempted to holistically understand and characterize the origin and activity of the interconnected weathering dynamics that act upon the rock art outcrops (FERNANDES, 2006). Currently, undergoing research implies the creation of a method to systematically evaluate the condition of the engraved outcrops, thus prioritizing future conservation work by establishing an urgency intervention scale (FERNANDES, 2009).

Within a total of 1000 rock art outcrops, it is essential to determine which ones are in more urgent need of intervention. Therefore, the urgency scale is a vital tool to-

Figure 1: *Upper Paleolithic representation featuring a two-headed goat in Quinta da Barca rock 1. (Photo: BAPTISTA 1999).*

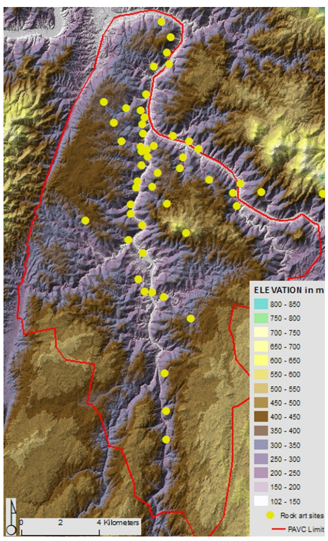

Figure 2: *Location of the Côa Valley rock art sites.*

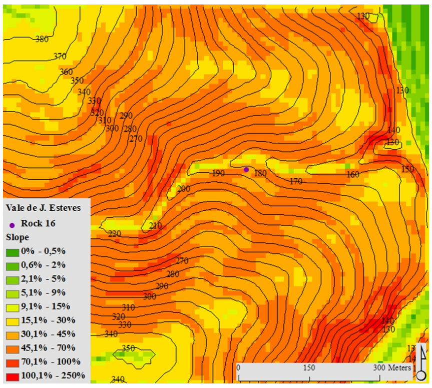

Figure 4: *Location of Rock 16 from the Vale de José Esteves (16VJE) site.*

wards informed conservation, and thus, in extending the 'life expectancy' of the rock art outcrops.

In order to establish which outcrops are in worse condition it was indispensable to identify evaluation parameters. Some have to do with geology (rock characteristics namely petrology, porosity, rock strength and so on) others with biology (such as lichen colonization). Once all active parameters were identified it is possible to compare the overall condition and situation of each outcrop, thus ranking them regarding the urgency of performing conservation work. Since there are almost 1000 outcrops that possess rock art motifs, a sample of 40 was chosen. These 40 outcrops will have their condition thoroughly characterized by examining each of the identified parameters.

2. Open-air rock art conservation oriented GIS spatial analysis

Some of the identified parameters have to do with Geomorphology issues. Since the GIS ArcView 9.2 software suite offers a powerful spatial analysis tool, it was decided to be used to determine aspect, slope, contour and solar radiation. The work base was a 10m resolution DEM of the area of the PAVC, supplied by Instituto Geográfico Português (www.igeo.pt) of which a TIN elevation model can be seen in Figure 2.

2.1. Location of the rock art outcrops

Since the precise location of each rock art outcrop in the valley is known, it is possible to determine topographical situation, namely rise. Using ArcMap statistics tool, it is possible to conclude that more than half are situated in altitudes between 110 and 218 meters, that is, at the foot of sharply inclined hills (see next subsection.). It is also possible to determine average (212 m) and median altitudes (190 m) of the Côa Valley rock art outcrops.

2.2. Slope

It has been demonstrated that when slope angle increases, the susceptibility for landslides or rock slope failure also increases (YALCIN *et al.*, 2007; SUMMERFIELD, 1991). Slope dynamics play an important part in outcrop instability. Gravity itself will force different sized elements (from small soil particles to heavier loose rock blocks) to roll downhill which may result to serious damage to the outcrops located below. Furthermore, the hill itself applies great pressure to the outcrops located at its base. The hillsides are in a continuous process of trying to reach a more stable profile (in fact, to have less pronounced slopes). Therefore, the progressive dismantlement of the outcrops located at its base is a part of that process (Figure 3).

After calculating the slope for the entire area of study, and for the sites included in the sample (Figure 4), it is possible to accurately ascertain the slope of the hillsides where each engraved outcrop is situated (Figure 5).

2.3. Aspect

YALCIN *et al.* (2007) review the ways in which aspect can contribute to mass wasting events, all connected with meteorological phenomena: exposition to rainfall, wind and solar radiation. On the other hand, EGLI *et al.* (2006) have investigated the role of aspect in rock weathering, arriving to the conclusion that there is a marked difference in weathering between south and north facing rock surfaces (greater in north facing surfaces).

Again using the DEM it was possible to determine aspect in the area of study. Following YALCIN *et al.* (2007), aspect was divided in 5 categories: Flat (-1º/0º), North (315º/45º), East (45º/135º), South (135º/225º) and West (225º/315º) (Figure 6). Specific aspect cartography of the rock art sites and outcrops in the sample was also produced in a similar fashion, as the maps shown in Figures 4 and 5.

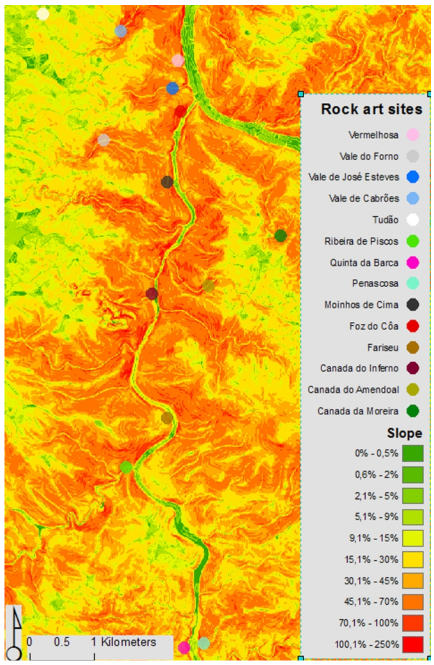

Figure 5: *Location (regarding slope) of the rock art sites that have engraved outcrops included in the sample.*

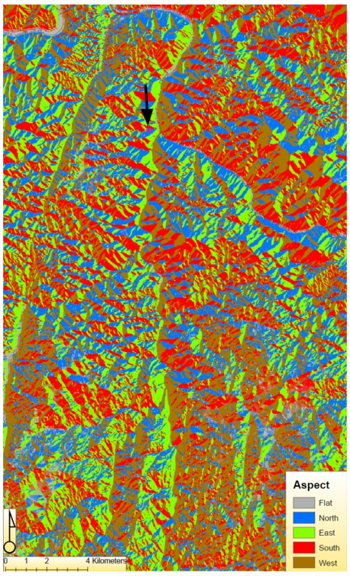

Figure 6: *Aspect in the study area with indication of 16VJE, located at the foot of a North facing slope.*

2.4. Solar radiation

It is known that rocks undergo expansion and retraction cycles. This behavior can be induced by solar radiation which determines temperature and moisture of any given rock surface (BENNIE *et al.*, 2008).

Solar radiation was calculated in the area of study with the help of the previously mentioned DEM. It is possible, resorting to the raster calculator, to determine the amount of radiation each individual engraved outcrop endures (Figure 7).

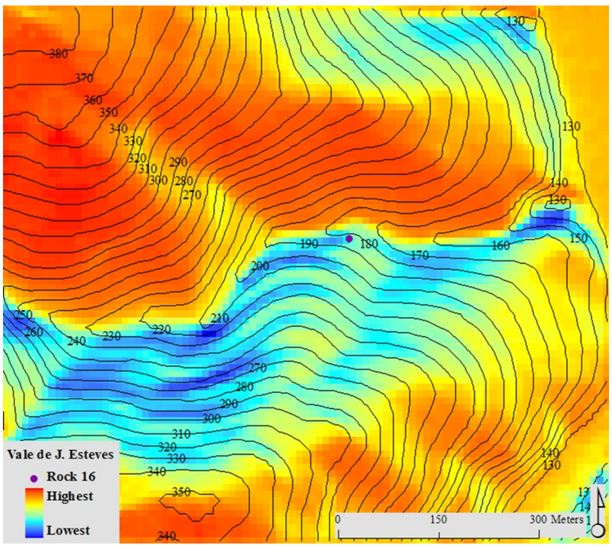

Figure 7: *Average solar radiation affecting 16VJE in 2009.*

3. Discussion

Beyond the primary goal of identifying parameters to distinguish the condition of different outcrops, GIS spatial analysis has made possible to reach some interesting conclusions regarding the spatial positioning of rock art sites in the Côa Valley. For instance, after calculating the percentage of each aspect class within a rectangular river corridor where the huge majority of rock art sites are located, an even distribution of each class was apparent with the exception of flat terrain that accounted for only 2.75% (N equaled 24.36%, E 23.33%, S 24.66% and W 24.86%).

Previous estimation established that the great majority of all Côa rock art sites have an Eastern aspect (46,8%, against 29,8 for S, 14,9% for W and a mere 8,5% for N). Considering these discrepancies, one main explanation arises. Differential conservation issues may have determined that less rock art outcrops situated in North facing slopes (thus exposed to harsher conditions) have survived until today but research is still ongoing regarding this matter

Conclusion

GIS use in research and management of archaeological remains in general, or rock art sites in particular, is common. However, to the best of the author's knowledge, this is the first time GIS methodologies are being specifically used in open-air rock art *conservation*. GIS spatial analysis within ArcView 9 is a powerful tool to obtain important statistical data, or to create suitable maps and models for illustration purposes (for instance, Figure 8). However, in Archaeology, statistical data and cartography are nothing if not used as an aid to interpret the past, or in facilitating the conservation and preservation of significant cultural heritage.

The spatial analysis possibilities presented by GIS were essentially used towards the goal of devising methods to identify the conservation state of rock art outcrops. Rise, aspect, slope and solar radiation were the factors considered in present research. Preliminary consideration of the first results suggests that there is a clear pattern in the spatial distribution of (surviving) rock art outcrops in the valley. However this pattern might be explained, the acquired data shows that only when GIS use goes beyond plain, 'push-button' solutions, spatial analysis

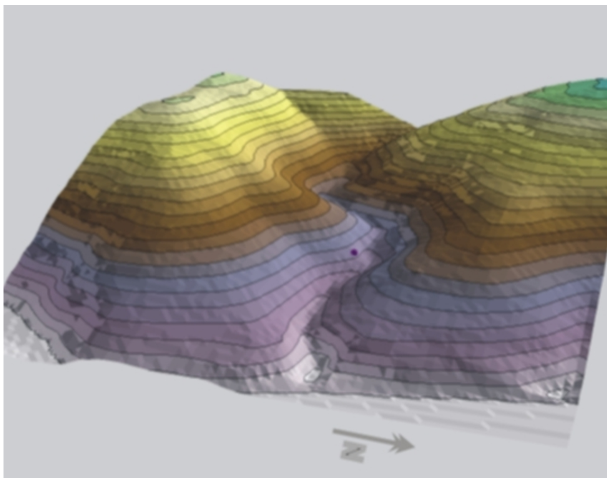

Figure 8: *Location of VJE16 pictured in a 3D elevation model produced with ArcScene.*

does become a key element in, for instance, the creation of innovative archaeological data interpretation models, deriving pertinent background data useful in understanding rock art weathering dynamics, or in planning, devising and implementing heritage conservation actions.

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