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The Bedolina Map – an Exploratory Network Analysis

Abstract: This paper applies the techniques of network analysis to an example of Iron Age mappiform rock-art in Valcamonica, Italy, (known as the Bedolina map) in order to better understand the nature and creation of the representation. Measures such as vertex degree, closeness centrality and density support the conclusions that the image forms a coherent whole, that there may well be a preferred compositional primitive consisting of a particular combination of element types and that different image elements differ in the way that they relate to the mappiform as a whole.

Introduction

Valcamonica in Lombardy, northern Italy is justly famed as one of the world's great rock-art sites and has been recognised by UNESCO as an important component of the world's cultural heritage. Within the valley there are hundreds of thousands of petroglyphs (see Anati 1975) carved into glacially smoothed and polished sandstone and schist and a much smaller number of surviving pictographs (Fossati 1993).

The petroglyphs fall into a variety of categories – warriors, horsemen, animals, geometric figures, scenes of ploughing, buildings and so forth – and date from the Epipalaeolithic / Mesolithic through to medieval Christian times with the bulk being attributed to the Iron Age, meaning the first millennium BCE in the local cultural sequence. One particular class of images that have aroused much interest is the so-called mappiforms. The simpler, smaller and more numerous of these are argued to be Neolithic / Chalcolithic while the larger and more complex – my focus here – are widely agreed to be of Iron Age origin.

The mappiform at Bedolina *(see Fig. 1)* is situated in a commanding position on the western slope above the valley floor just outside Capo di Ponte in the mid-section of Valcamonica. It is probably the most complex example known in the valley. The rock itself measures about 9 x 4.3 m while the engraved area measures about 4.3 x 2.4 m. There are 6 readily identifiable buildings and around 30 fields – that is, geometric forms typically identified as fields.

To me, one of the most fascinating things about

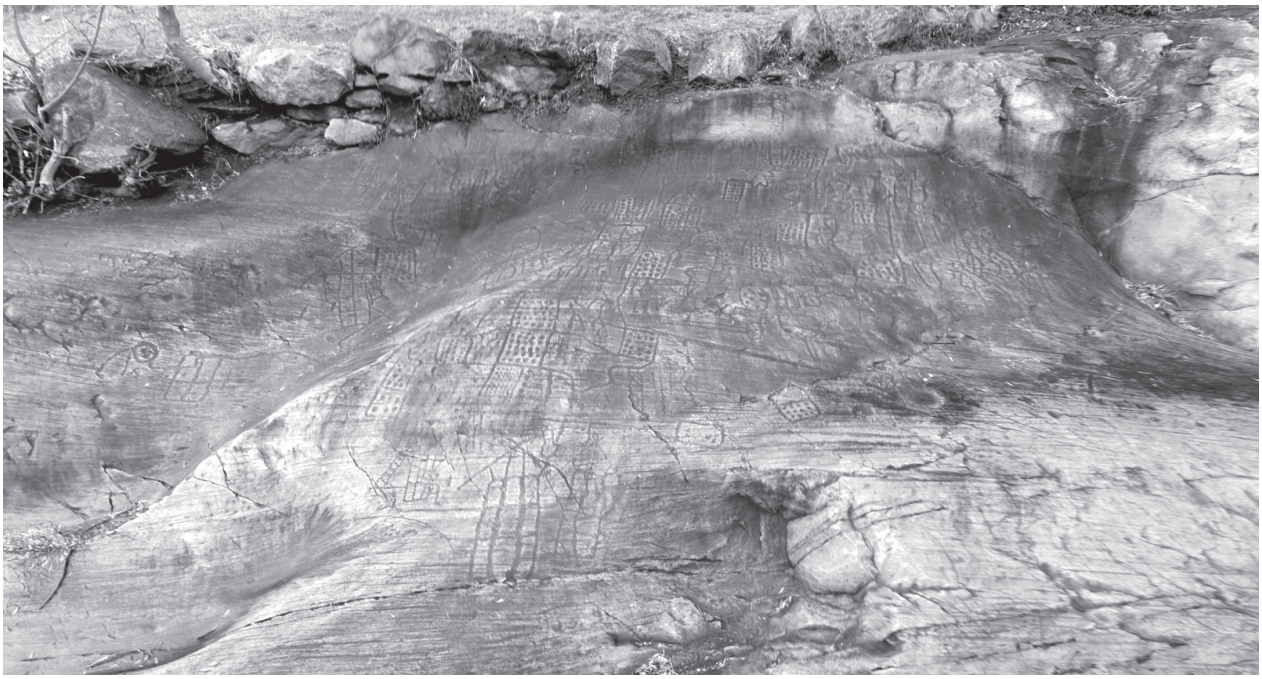

Fig. 1. The Bedolina Map.

this piece of rock-art is that so many of the elements are explicitly linked by lines that, in the eyes of many viewers, suggest pathways. The extent of these linkages suggested to me that investigation using the tools of network analysis (de Nooy 2005; Scott 2000) – itself an application of graph theory – might yield insight into the relative importance of different landscape/takscape (Ingold 2000) elements in the minds of the image's creator(s). For example, are certain types of field more closely linked to other map elements? Do certain map elements "control" flows through the network of trackways? Are there identifiable nucleations of elements within the maps – sub-maps, if you will? Such information can give us insights into the mental geography – the world-view – of the map's creator(s).

Prior Work

A petroglyph "map" at Bedolina was first noted in print by Battaglia (1934) who, Fossati (2002) notes, had also referred to the petroglyphs at the first International Congress of Prehistoric and Protohistoric Sciences in London in 1932.

The first "scientific" work on the Bedolina map dates from as recently as 1969 (Beltran Lloris 1972) and the most recent published work specifically on Bedolina is that of Brunod, Ramorino and Gaspani (2004). Perhaps the most exhaustive recent treatment of Bedolina is Turconi (1997) – work that developed from her thesis research at Milan.

Beltran Lloris (1972) and Turconi (1997) both focused on the chronology of the images. The former dated the mappiform to the Bronze Age, around 1400–1500 BCE while Turconi's reanalysis shifted the date forwards about 700 years to the 8th century BCE, placing it firmly in the Iron Age.

In terms of interpretation, recent authors disagree to a considerable extent. Brunod, Ramorino and Gaspani (2004) and Priuli (2006) see the Bedolina map as a literal map of the valley, going so far as to identify particular geographical features. Turconi, on the other hand, sees the map as symbolic, perhaps related to increasing private claims on landholdings.

Analytical Strategy

Before all else, one must settle on a definitive representation of the Bedolina map. The original tracing was carried out in 1969 and published by Beltran Lloris (1972). Turconi subsequently retraced the images in the 1990s. Comparing both representations against the actual rock surface during March 2007 I decided that Turconi's image is the more accurate.

How, then, to analyse the Bedolina map in terms of a network? One must make decisions about the elements of the mappiform: which to include and how to treat linkages amongst elements?

The Bedolina map contains the following elements:

- Huts/houses
- Rectilinear "fields", usually linked to other objects and containing dots but not exclusively so
- Single sub-circular "field"
- Tracks/paths
- Circular elements, usually within "fields" but not exclusively so
- Warrior figures
- Animals
- Dots without enclosing boundaries
- A single Camunian Rose
- A single ladder form

I excluded all warriors and animals, the unenclosed dots and two of the three unique elements, the sub-circular "field" being retained because it appears to be linked into the network of pathways. This decision requires some justification as Turconi (1997) notes that the mappiform is superimposed on these figures and, indeed, cuts through at least two warriors. Might the mappiform not be seen as linking these elements together in some way? Leaving aside the notorious difficulty of judging superimposition (Chippindale 1989), I argue for ignoring these earlier (if so they be) figures on the grounds that they do not seem to be well-integrated into the overall image. Is it, perhaps, more likely that the rock was re-used because of either its existing importance or its commanding position in the valley? The six hut/house images will also be excluded from the analyses as they are intrusive and not typically linked by pathways to other mappiform elements. One might, however, also argue that the placement of the huts could be meaningful with respect to the other mappiform elements. Further work may incorporate these additional images.

That leaves us with four elements constituting the Bedolina map:

- Rectilinear "fields", usually containing dots and linked to other objects but not exclusively so
- Single sub-circular "field"
- Tracks/paths
- Circular elements, usually within "fields" but not exclusively so

There are some 33 rectilinear fields – my count differs slightly from earlier researchers as I consider sets of 2 or 3 fields that are directly contiguous to be single units. Five of the fields are not connected to the network and occur mainly at the far left and bottom right of the mappiform.

The single sub-circular field occurs on the middle right and contains 7 dots of the type usually found in rectilinear fields.

Tracks/paths have various shapes and lengths, some suggesting a series of hill-climbing switchbacks. For the purposes of this analysis path length and shape will be ignored. Similarly, a pair of paths connecting two vertices will be regarded as a single linkage.

There are 16 circular elements, all but 3 of them within fields.

Analysis thus proceeds with four classes of elements represented by network vertices – the pathways are represented by edges, being undirected *(see Fig. 2)*:

- Fields with circular elements (coded as E): 13
- Fields without circular elements (coded as F): 15
- Unenclosed circular elements (coded as G): 3
- Sub-circular fields (coded as C): 1

Results

Fig. 3 represents the end-point of a series of visual representations which have been omitted here for reasons of space but are available from the author. The overall patterning is always similar. We see that three "fields without circular elements" – labelled F1, F2 and F15 – are quite isolated while the remainder are quite tightly integrated. Similarly, of the 13 "fields with circular elements", one – E10 – is isolated. All the "non-field" elements are isolated. There appears to be quite a tight grouping of four elements visible in the upper left – elements E4, E7, F7 and F11. These four elements are more closely integrated with each other than with the remainder of the map. This is not immediately obvious from the petroglyphs themselves.

There is also some patterning evident in the intermediate representations that has been smoothed away in *Fig. 3*. In particular, the following groupings of fields with (E) and without (F) circular elements appear to be stable across the range of factors employed:

- E5, E8, F8
- E9, F10
- E11, F12
- E13, F13, F14

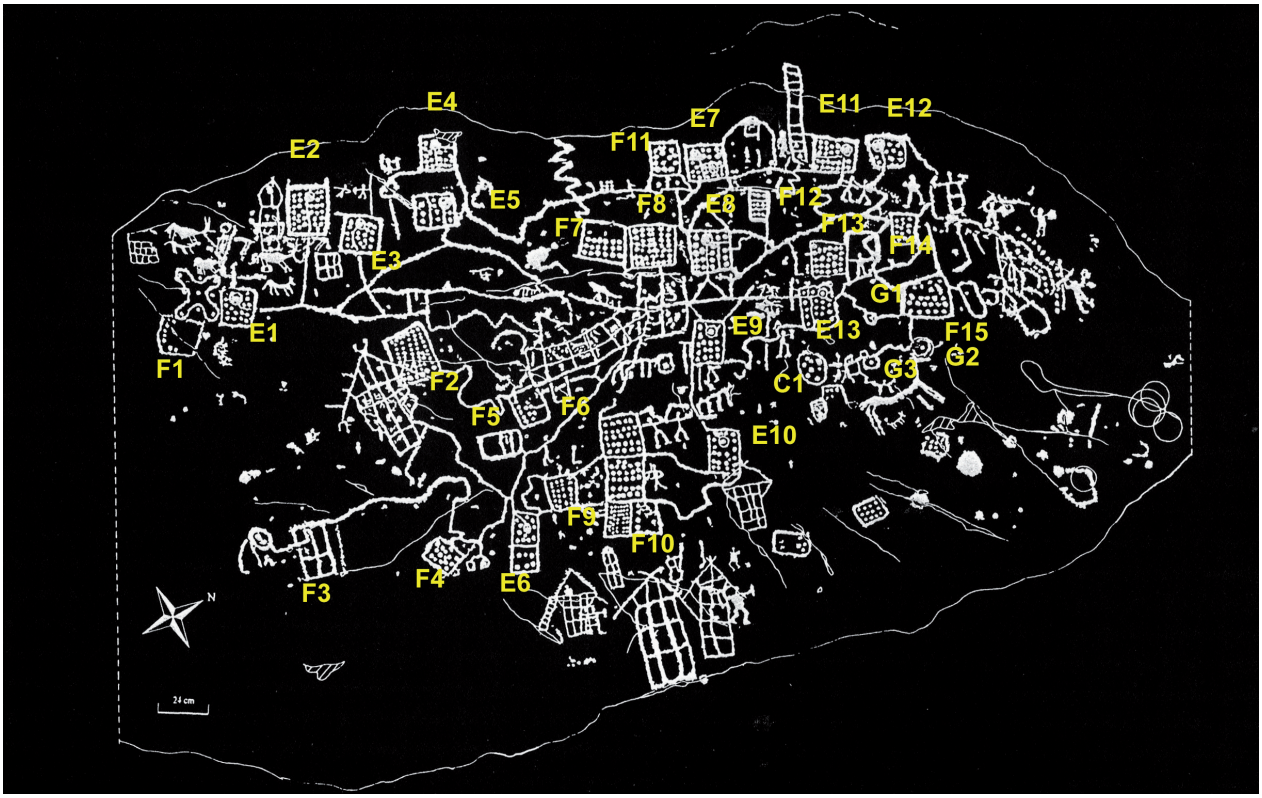

Fig. 2. Turconi's tracing of the Bedolina map.

While one would certainly not call it a mathematically strong conclusion, 3 of the 4 groupings involve only one field with a circular element. In all but the first case the elements are relatively close to one another in the original rock-art. Perhaps, then, these are related "fields" – maybe, one might conjecture, representing an ideal combination of field types and also a compositional primitive?

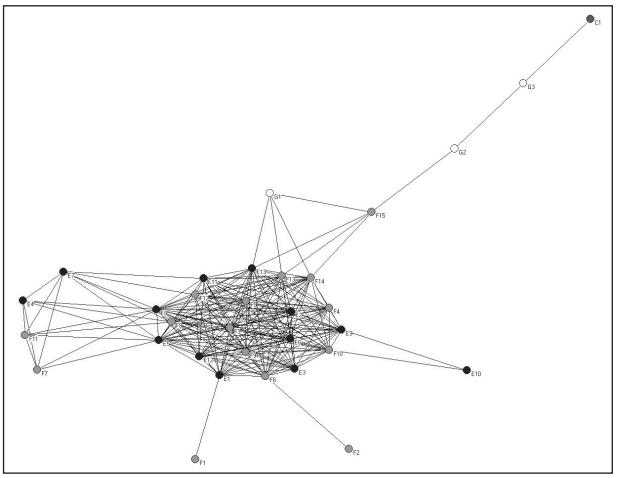

Fig. 3. Network representation of the Bedolina map.

In addition to the graphical representation, Network Analysis provides a variety of numerical measures. The density of this network is, for example, 0.447: so 44.7% of all possible linkages exist, making this quite a strongly connected system. Turning now to the extent of linkage of individual elements we can first assess degree – simply the number of direct connections that each element has with others. *Fig. 4* summarises this information.

So, three elements are linked to only one other whilst two elements are linked to 23 others. These latter two are E5 and E8, two of the fields with circular elements. The apparent centrality of E5 would not be immediately visible from the original petroglyph. The shape of the graph suggests that there are distinct groups of more (to the right) and less (to the left) connected vertices. Are there, indeed, systematic differences amongst the types of element? (In this and all subsequent analyses I will treat the sub-circular field along with the unenclosed circular elements.) *Fig. 5* presents the box-and-whisker plots (Tukey 1977).

We immediately see that, while the median values and range for the fields with and without circular elements are very similar there is, apparently, a much smaller interquartile range for the fields with circular elements – their connectivity values are much more tightly clustered. (Mean values are similar.) The non-field elements are – as is quite apparent from the mappiform itself – much less tightly connected into the network.

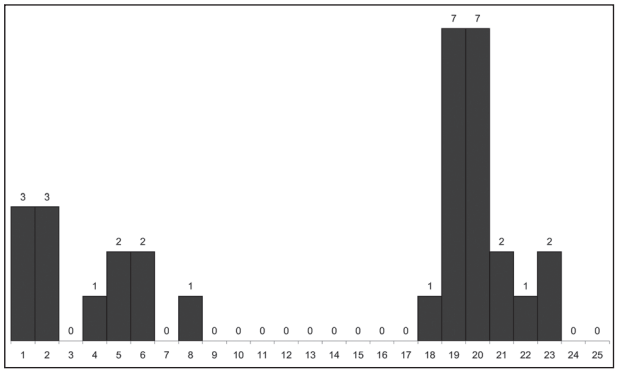

Fig. 4. Histogram of vertex degree.

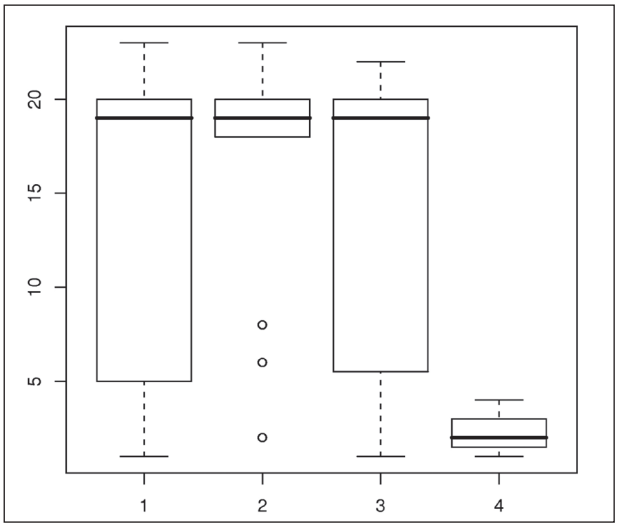

Fig. 5. Box-and-whisker plots for degree (left-to-right: all, fields with circular elements, fields without circular elements, other).

The network representation of the Bedolina map contains no strong components – essentially, isolated sub-maps. Given the high degree of connectivity shown this is unsurprising.

Other metrics investigated include closeness centrality and "betweenness" (see de Nooy 2005). Closeness centrality results match those for vertex degree while "betweenness" results suggest that no particular element of the map "controls" movement between elements – there is no element that one must typically pass through to reach other points. Details are not presented here for reasons of space but are available from the author upon request.

Given the high degree of network connectivity there are, unsurprisingly, no cut-vertices – vertices whose deletion would break the network up into components.

Conclusions and Suggestions for Future Work

When I began this analysis I had hoped to find major differences in connectivity between the fields with and without circular elements – perhaps that fields without circular elements tended to be grouped around fields with such elements, indicating, one might argue, cohesive landholding units. What, then, have I found? Has the application of network analysis yielded insight beyond what would be gained from inspection of the rock-art itself?

One must answer "yes" – in particular, it is interesting that the degree of dispersion of connectedness measures (degree and closeness centrality) – shows evidence of much greater skewing amongst the fields with circular elements. The highly connected/central nature of field E5 would also not be obvious from simple observation. Further, the identification of groupings of elements, often of different types – both within the central core and the distinct sub-group comprised of E4, E7, F7 and F11 – would be difficult in the absence of the analysis.

What, then, can be concluded about the world view of the Iron Age creator(s) of the Bedolina map? Bearing in mind the exploratory nature of this analysis, I think that we can quite strongly suggest that fields with circular elements occupy a privileged place in that they are more strongly linked to other elements. Might they perhaps be fields with habitations (field-houses or similar)?

Further, there is some evidence for an "ideal" grouping of mappiform elements: while numbers are too small for statistical significance it remains suggestive that of the four groupings of elements that remain stable across three or more scale factors, three contain a single field with a circular element and one or more other fields.

Finally, the Bedolina map appears to be a unified composition in that we cannot identify any sub-maps: that is, there is some evidence that it represents a single idea or concept in the minds of its creators.

Where can one go from here? One obvious extension is to try to incorporate the later Iron Age hut/granary images into the analysis. The main issue here is that they are not all connected to the earlier map by pathways. Do the huts change our representation of the mappiform – do they, for example, dominate certain groups of fields?

There are also other mappiforms in Valcamonica – most obviously the newly discovered example at Bedolina (Marretta 2006) but also, for example, at Pià d'Ort (Sansoni / Gavaldo 1995) – that might profitably be analysed in this way.

Additionally, one might also try to incorporate distance metrics, perhaps beginning with "short" and "long" direct paths to see whether this changes the results.

In conclusion, it would appear that network analysis offers us some interesting new ways of perceiving the subspecies of rock-art known as mappiforms.

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Illustration Credits

I am grateful to dott.ssa Cristina Turconi and the Cooperativa Archeologica "Le Orme dell'Uomo" for permission to use tracings of the Bedolina map. All other images were created by the author.

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