Global Sharing of Information about Prehistoric Rock Art

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Abstract: The paper brings together the findings of two separate projects:

The first one is hosted by the Mikkeli University of Applied Sciences, Finland. The purpose of this project is to develop methods for using high level ontologies such as the CIDOC CRM to describe and merge information from official museum institutions as well as private collections about the prehistoric Astuvansalmi site in the Lake Saimaa area in Finland. The Astuvansalmi rock includes 15 documented image groups that contain over 65–80 figures painted with red ochre. The metadata developed for the project will be compatible with the LIDO format as well as the formats required by the Europeana portal.

The second project is directed towards developing IT-related resources within the framework of the CIDOC Co-reference Working Group. A specific aim is to create an open, accessible infrastructure for unique, shared and persistent identifiers for prehistoric rock art. This infrastructure enables the merging of information e.g. from national institutions with information produced in research projects of universities and other research institutions, networks and projects.

One aim of the paper is to invite CIDOC-related and other institutions and groups to participate in a global network related to prehistoric rock art.

A specific backdrop for the paper is the process started in Helsinki in January 2010 to develop a shared high level ontology for libraries, archives and museums. This process is pertinent for the paper due to the fact that information about prehistoric rock art is stored in publications, archival and electronic library resources as well as in it's original natural context.

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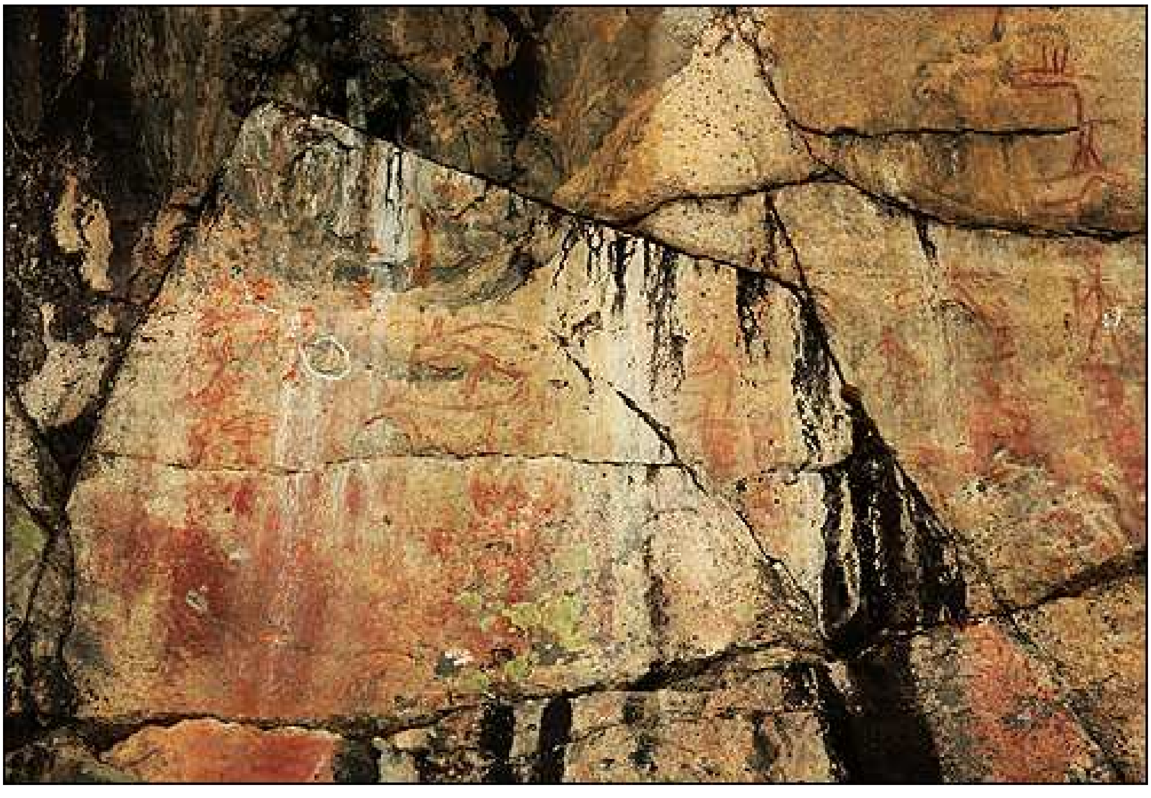
The Astuvansalmi rock art site

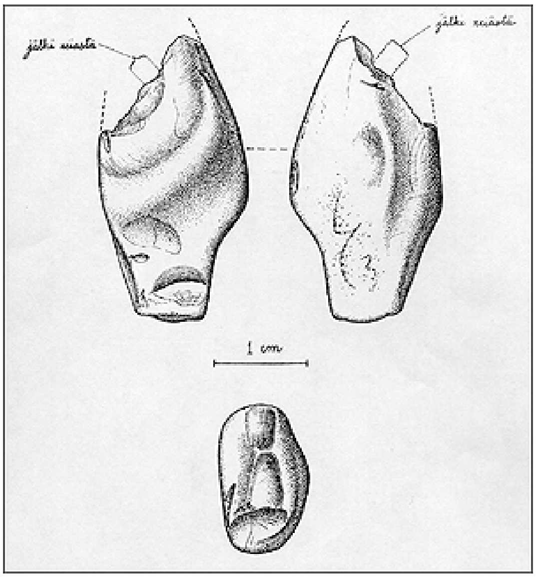
Among Finland´s over 100 prehistoric rock-painting sites and 750 images, Astuvansalmi in Ristiina, Southern Savo, in the Lake Saimaa region, has proven to be one of the most interesting. 3800 before Common Era water level dropped 10 metres lower. As a consequence, the paintings are located 6,8–11,8 metres above present water level. The earliest rock paintings might be dated before 3800, but most paintings are done later, after the formation of the River Vuoksi.

The rock has a face-shaped form and is oriented southwest towards sunlight. The face is reflected from the water. The colors of the paintings look different depending on the season, the time of day or night as well as weather conditions. The paintings were done from canoes. The color used was red ochre. Lake iron ore used in red ochre was available locally.

Finnish rock paintings include representations of anthropomorphic figures, elks, and boats, as well as hand and paw prints etc. The paintings represent features of Nordic animism such as shamanism. Anthropomorphic figures are the most common element in rock paintings. They are usually shown in frontal view, and some of them represent shamans or spirit beings. Elks are also very common. Some of the elks have a heart spot. Images of fish, birds, snakes and elk might represent the zoomorphic spirit helpers of the shaman. The boats are more difficult to interpret. Sometimes they are interpreted as antlers. There are also some unexplained geometric motifs.



PICTURE 1: Sections D, E and partial F from Astuvansalmi representing varied paintings, for example horned-anthropomorph, elks with heart spots and woman with a bow.

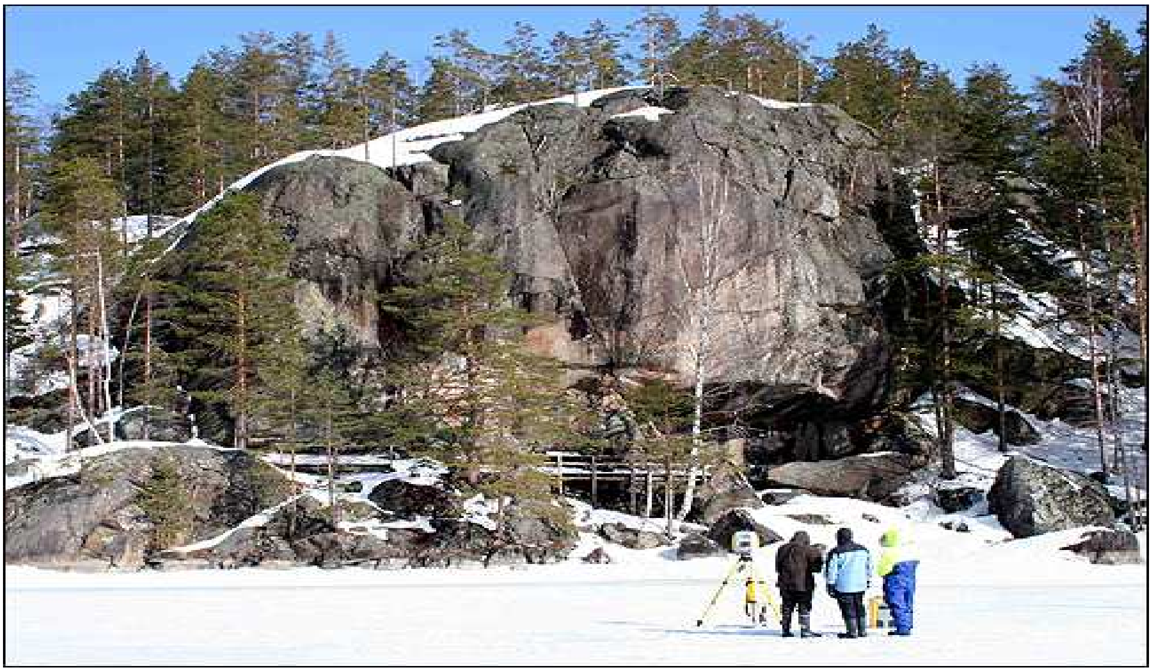


DRAWING 1. Pendant resembling the head of a bear.

The Astuvansalmi rock area has been a sanctum. Two prehistoric arrow points have been found in front of the cliff, and four rare amber pendants in underwater excavations in the immediate vicinity of the painted rock face. Three human-faced miniature sculptures found at the site bear a clear resemblance to each other. Although they are of different shapes and sizes, they appear to depict the same model. All have similar profiles, eye-pits, and cheeks. The brows and noses are in the same arc and the withdrawn chins depict a similar primitive expression. The fourth pendant appears to depict the head of a bear.

3D digitizing of the Astuvansalmi site

There are several reasons to turn Astuvansalmi rock art site into digital 3D form, though it is quite well documented and studied already. A textured digital 3D surface makes possible to investigate and measure the paintings without a difficult setting of ladders or scaffolds on site, which happens to be a lake cliff. It makes more precise measurements possible, as also the depth dimension can be taken into account, and projection errors can be eliminated from taken images. Also, the rock itself is a complex three-dimensional object, and in certain angles of view it has the appearance of a sleeping human face. Furthermore, the resulting model can be used for other purposes such as media productions, or as a starting point for more detailed modelling in future projects. In addition, it simply is interesting explore how paintings are located on the surface of the rock.



PICTURE 2: Astuvansalmi rock art site and laser scanning team.

Even more value can be added, if the digitizing is done georeferenced, i.e. measuring and modelling is done in a known real world coordinate system, including height. This makes later additions of new measurements, data, etc. easier, as well as it gives the possibility to deliver and join data to other coordinate aware solutions e.g. Google Earth or others. 3D georeferencing also gives an opportunity to use the coordinate values as a part of a unique identifier.

Technical details of the 3D scanning

The 3D digitizing process involved four groups of tasks: (1) making an overall 3D environs of the site, (2) digitizing field work, i.e. 3D scanning and photography, (3) making a precise 3D surface of the rock and texturing it, and (4) modification and preparation of the results for different uses.

The environs of the rock art site were 3D modelled by using commonly available nationwide data sets from the Finnish national mapping authority, the National Land Survey of Finland (NLS). Resources used were the digital elevation model in 10 m grid and the topographic map database. In order to maintain real world coordinates, modelling was made by using 3D capable geographic information system (GIS) Esri ArcGIS 3D Analyst. The Modelled area covers 120 km2, and its visual level of detail (LOD) can be compared with LOD0 of CityGML standard of Open Geospatial Consortium, Inc (OGC). This kind of 3D model can also be used to examine and to analyze the environs at prehistoric time when the water-level of the front lake was substantially higher.

The rock was 3D digitized using a terrestrial laser scanner. The scanning was made by setting the scanner on the iced front lake. Three different scanner stations were used to get round the obstacles, and station coordinates were measured by professional GPS equipment. The scanning process also provided images by the scanner’s built-in digital camera. As a result, nearly 2 million coordinated 3D points with colour and laser pulse strength information, and 104 digital images with the known position, were captured. Point spacing inside the 3D point cloud was approx. 2 cm on the rock surface. In addition 36 photographs were taken with a normal DSLR camera using high dynamic range imaging (HDRI) technique. Used 3D scanner was Trimble GX, and DSLR camera Canon EOS 5D. Also total station like scanner Trimble VX Spatial Station was tested.

The laser captured data was processed with the point cloud capable modelling software into 3D mesh surface. Obstacles, like trees etc., and other irrelevant features were extracted from the data. The final resulting 3D mesh was made in 10 cm point density, and it includes about 900 000 points, 80 000 vertices and 153 000 triangles. To start with, the 3D mesh was fully textured with 3D scanner’s coordinated images, and then improved with 3rd party professional documentary images and other taken images by projecting them on the 3D mesh surface. Level of detail (LOD) can be compared with LOD4 of CityGML standard. Used point cloud and modelling software was Trimble RealWorks Survey Advanced Modeler.

Scanning and related software were delivered by the very kind help of Mr. Kari Immonen and Geotrim Ltd. Professional documentary photographs were taken and very kindly delivered by Mr. Ismo Luukkonen.

PICTURE 3: Textured 3D surface. Projected hi-res photographs at the lower left area, other textures from 3D scanner.

Ceating unique identifiers for rock art

In order to share information about prehistoric rock art in global information infrastructures for cultural heritage, unique, shared and persistent identifiers are needed. Forming a unique identifier by using a predefined schema for identifiers is a first step, but in addition, additional data is needed that uniquely distinguishes the object or feature to be identified. Additional data can be added to this basic dataset such a link to a thematic portal that contains images and other descriptive data about the site.

In order to define unique identifying data sets for images and groups of images on the Astuvansalmi rock surface, a coordinate based solution came up as one solution. A georeferenced 3D model together with suitable software can be used to generate 3D coordinates for any features of the model. Coordinates can be created for a single image or for a group of images. As an image or a group of images practically covers an area on the rock surface, it cannot easily be represented with only one coordinate point. A decision about the exact point location is needed.

The solution was to draw a bounding box, i.e. a rectangle, exactly around an image (the group of images) and use the centre of the rectangle as a unique point. Actually, the rectangle produces a plane in three dimensional space, so also the depth coordinate is taken into account. As a result, there is only a very slight possibility that two separate images happen to produce exactly the same point. The coordinate point of a single image is also always inside the bounding box of image group in question, i.e. they are nested. However, this information could not be used if the dimensions of the bounding box or the corner coordinates of the image group are not known. Also other systemically followed rules could be used, such as "the lower left corner of the box", or to use all of four corner points.

The bounding box method has some major drawbacks. Interpreting the limits of the image is not a simple task and there might be several opinions. It is a time consuming procedure without possibilities to automate the process. The clearance of images and the quality of taken photographs have a strong influence on the workload as well as the amount of images.

Different methods may be used to represent the coordinates of images and image fields. Whatever method is selected, it is necessary that these coordinates are made public as a part of a descriptive dataset and associated with a unique identifier string (URI) that is made globally available. Publishing identifiers with descriptive data is a collaborative challenge for the research and cultural heritage community. Regional networks of interested parties could publish datasets with identifiers and associated descriptive datasets including coordinates.

Unique, shared and persistent identifiers can act as nodes to which new sets of data can be linked. These datasets can contain links to resources in museums, libraries and archives as well as digital collections and services.

Developing a metadata schema for rock art – setting the scene

Unique, shared and persistent identifiers enable semantic enrichment of data. In addition to shared identifiers, a common conceptual model for prehistoric rock art is required so that information can be added systematically. Experience has shown that a shared metadata schema is not enough. Common metadata schemata tend to lead to impoverished information because only a minimal amount of descriptive data is published with the help of the schema. Another problem with using a common metadata schema is that the schema is open for different interpretations and usually leads to inconsistent ways to add data to the system.

The Astuvansalmi project does make pretences to provide a patent solution to these problems. Instead of a rapid solution time has been given to reflection and charting the problem in order to find a solution later in time. The future solution should encourage the publication of rich and varied data centered around unique, shared and persistent identifiers.

One of the difficulties in the area of cultural heritage documentation is the multitude of different standards and recommendations. To some extent these guidelines are overlapping, but many of them serve different and complementary functions. In order to bring some order into this multitude of standards and recommendations the following graph has been developed to serve as an overview of the field:

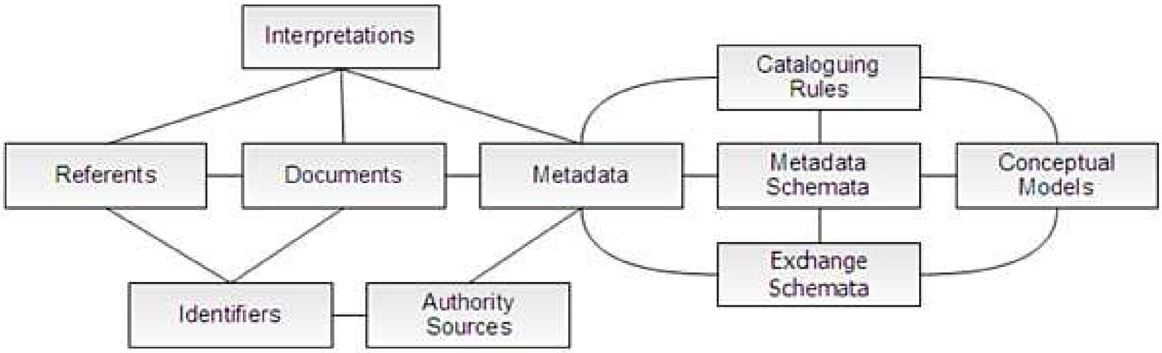


FIGURE 1: Components of cultural heritage documentation. The graph is simplified for readability.

Documents as physical things

The term 'document' in Figure 1 is used here in a broad sense. It denotes any kind of material object that bears witness to past events. This includes museum objects as well as written records and works without regard to the medium on which these records or works are stored. A rock painting or engraving can be regarded as a document in this broad sense.

In this paper (and the model depicted in Figure 1) documents are regarded as physical items (corresponding to CIDOC CRM E18 Physical Thing) with a physical form that carries (P128) an intellectual content (E73 Information Object). A document in this sense differs both from CIDOC CRM E84 Information Carrier which is explicitly designed to carry information as well as from E31 Document that denotes an immaterial item.

The reason for using the concept 'document' in this material sense arises from (1) the interest to associate an identifier to each specific physical document and study the interrelations of each specific instance; (2) the interest and need to focus on the physical features of the object – a specific reason for this is that the object may be only partly preserved; (3) the interest to study the physical context of the document. (4) The meaning of very ancient objects is uncertain. Because of this it is necessary to make a clear distinction between the physical properties of the object (which are known) and the meaning of the objects (which may be unknown or uncertain). (5) A final reason for this kind of definition is an attempt to align the used terminology with the Saussurean distinction between signifier and signified as well as the Ogden – Richards semiotic triangle (hinted at in Figure 2). Approaching all kinds of artefacts from a communications point of view (not only those intentionally designed for communication) is in line with Semiotic theory.

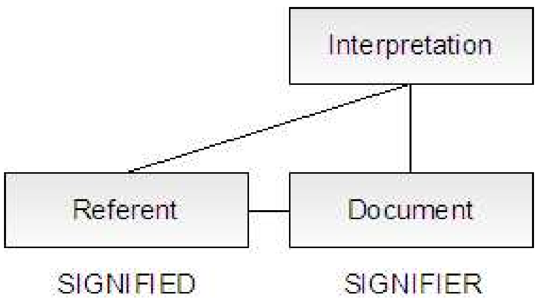


FIGURE 2: Alignment of the used concepts with Semiotic theory

Selecting a terminology that differs from the CIDOC CRM does not imply a criticism of CIDOC CRM – on the contrary, CIDOC CRM is used to express the semantics of the selected usage – more specifically, the intensions of the used concepts are described in terms of the CIDOC CRM.

Taking into account interpretations

The finds obtained so far from Astuvansalmi raise a number of interesting questions. Were the figurines with human faces made at the site? Were they possibly amulets worn around the neck on a leather or sinew strap, ornaments belonging to ritual dress, or fragments of sculptures depicting deities or spirits? Was there a connection of meaning or cause between the amber objects and the rock-painting site, which itself resembles a human face? Was the bear´s head linked in some way to the foot and prints painted on the rock, or did some of them possibly depict the tracks of a bear? Special for Astuvansalmi rock paintings are rare paintings of a woman with a bow, paw prints of a bear and two bear whelps.

Interpreting rock paintings can be challenging because paintings are done at different times and image fields form different interpretations. The circumstances in nature vary and therefore the pictures taken show different results. Rainwater separates silicon oxide from the rock surface and forms a protective and unfortunately covering layer. Also air pollutions and lichens have influenced the condition of the paintings. Recent explanations have given insight to interpretations. Image processing has brought to light new data hidden for the eye.

PICTURE 4: Head-shaped amber pendant.

Adding metadata to a document is an act of interpretation. In some cases the interpretations can be founded on a well known set of properties which allows for a predictable interpretation irrespective of who is responsible for associating metadata with the document. In many (if not most) cases interpretation requires background knowledge, and even then the interpretations may vary among experts and professionals. One way to remedy this problem is to have an arsenal of aids such as detailed cataloguing rules to assist in the adding of metadata. Another way of raising the quality of metadata is to ground the metadata schema in a conceptual model such as the CIDOC CRM, that explicitly formulates the meaning and context of elements in the used metadata schema.

Formal, referential and cognitive meaning

The meaning of of a document is dependent on the meaning of the individual symbols, their combination and context. 'Meaning' can be subdivided into three broad categories: formal, referential and cognitive.

(1) The meaning of some symbols can be determined formally e.g. based on definitons or rules associated with them. Mathematical concepts such as “primes” are examples of this category. Whether a symbol or expression belongs to some category can be determined formally by specifying a set of necessary and sufficient conditions for membership in this category. These conditions form the intension of the concept.

(2) Referential meaning occurs when a symbol or expression refers to an identifiable object or some other subject that is in the focus of attention. The meaning of the concept 'car' can be determined intensionally by determining what necessary and sufficient conditions for membership in the category 'car'. The meaning of 'my car' however refers to a specific car and is normally decoded or understood in some specific context of use. The expression 'cars' denote some determinate or indeterminate set of cars. This set represents the extension of the expression 'cars' – they represent a set of real occurrences in space and time, not abstract concepts.

(3) A third layer of meaning are the mental states a symbol or expression evokes in the human cognitive system. Mental states include sensations, emotions, attitudes, and thoughts. Some mental states are conducive to action and can be associated to patterns of behaviour. If a person is lost in the countryside and sees the lights of an approaching car, these lights representing the car evoke a strong emotional response and triggers a pattern of action e.g. to wave in order to stop the car. The primary meaning of “car” in this situation may be “rescue”.

Interpretation in cultural heritage documentation can involve all three kinds of meaning.

In formal systems the meaning of a symbol of expression can commonly be unequivocally determined. Interpretation can even be done by computers. In some cases the set of properties forming the intension of the property is not unequivocal. In such cases there is room for parallel interpretations.

In some cases the referential meaning of a concept is ambiguous such as in the case of place names, where several places may have the same name. Referential disambiguation is required here. In the case of place names, coordinates provide a means to determine the location of the place unequivocally. Other means to disambiguate place names is to give a broader context for the place, such as a county.

The cognitive aspect of meaning is the most difficult one to account for. One strategy is to bypass this layer of meaning totally. In the case of art, however, this layer cannot be bypassed, as art to a large extent is produced with the explicit intent of evoking broad associations, nuanced sentiments and, sometimes, strong emotions.

Cognitive meaning is always bound to an individual experiencer. This opens up the possibility do document how an experiencer describes his experiences and interpretations. In an information system this can be facilitated by enabling comments, notes or links to external sources that contain interpretations of an object. In the case of rock art these interpretations may reside in books, articles or reports, i.e. bibliographic or archival sources. As interpretations of a certain object or item change over time, this means that the history of interpretations is one significant path of investigation.

A rich documentation practice takes into account all these interconnected and complementing layers of meaning.