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PARAMETRIC METHODS TO VISUALIZE AN EXCEPTIONAL PARIETAL SCULPTURE.

The revelations of the Poisson engraving

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Abstract. There are only a dozen representations of fish in parietal art in the world. The one in the Fish Shelter is said to be the oldest of all. This fish figure is so rare and precious that it was almost cut up and sold. This engraving is complex to understand, many details leave researchers perplexed. A new survey campaign, the first in 30 years, was conducted between 2016 and 2019 to obtain a very detailed geometric model of the shelter, fish and other archaeological evidence present. Just for fish engraving, the photogrammetric model has a resolution of 16 polygons per square millimeter, which enables us to digitally investigate every detail. For this article, we will show how we use Grasshopper, a parametric software well known in architecture, to create two types of maps: a depth map and an incidence map. These two pieces of information are essential to understand how the engraving was made.

Keywords. Archeology; Grasshopper; Parametric; Parietal; Engraving.

1. Archeological background

While the neighbouring Abri Lartet was discovered in 1863 by É. Lartet and H. Christy, it took nearly thirty years, i. e. 1892, before Paul Girod and his collaborator with Elie Massénat discovered and searched the Abri du Poisson, which was probably entirely hidden by sedimentary deposits (Girod 1906). He called it "Gorge d'Enfer B" (meaning the Hell Pit) and recognized an Aurignacian level under 1m50 of stones of various sizes. This "Aurignacian formation" consists of a continuous whole of 0m80 where it is impossible to trace divisions. So there is a great homogeneity in the deposit. However, its section seems to contradict it,

as D. Peyrony has already pointed out, since we can see a zonation in its horizon. It is important to note that at that time excavations were not carried out: workers were employed to collect the pieces and observations on the archaeological layers were often second-hand. Similarly, the limestone blocks were not examined for possible ornamentation (Peyrony 1952). After Dr. Girod's visit, several excavations followed one another, including those of Gabriel (or François) Galou, around 1898. The manager of a restaurant called Le Paradis, located nearby Fort de Tayac, resumed excavations in front of the shelter. Above the vault, it meets a row of hearths dug in the scree ground, associated with split-base bone points, awls, smoothers, pierced teeth, "all types of flint of the Aurignacian..." (Peyrony 1932) and a muskox skull studied by E. Harlé, from Bordeaux (Harlé 1901). Except for this last piece, there is no publication of the results of his excavations.



Figure 1. Location of the Abri du Poisson, Manaurie, 44.9445457,0.9930259.

In 1912, Jean Maurice Marsan obtained from the owner Simon Souffron a lease of the land to continue the research. He was the one who discovered "Le Poisson" (the Fish) at the very beginning of August 1912, when he was resting, lying on his back, inside the shelter. The discovery immediately gained fame and was offered for sale by Jean Maurice Marsan, as evidenced by a postcard from the Galou café-restaurant where you can see a sign displaying "drawing on rock. To visit please ask Mr. Marsan in Manaurie" (« dessin sur roche. Pour visiter s'adresser à M. Marsan à Manaurie ») (Delluc 1997, White 2006). It was also very shortly (August 7, 1912) offered for sale to Dr. Carl Schuchhardt, Director of the Museum für Vor- und Frühgeschichte in Berlin. Jean Maurice Marsan died at the end of the same year, on December 11th, 1912, after having transferred his tenant rights to his cousin Amédée Delprat in September. He was the one who followed the negotiations with Dr. Schuchhardt, who had visited Périgord in the autumn of 1912. No results of Jean Marsan's work have been published. After agreeing on an acquisition price, it was necessary to organize the work of detaching the block, find and pay the workers capable of doing so. It seems that the actual cutting operation did not begin until 1912 December the 7th. On December 9th, D. Peyrony learned that extraction work was in progress and informed Mr Henri Hubert, curator of the Musée des Antiquités Nationales and member of the Historical Monuments Commission. He wrote to the Under-Secretary of State for Fine Arts, who asked the Prefect of the Dordogne to stop the work and affix the seals, which was done on the evening of the 11th of December.

The fish sculpture was therefore discovered twenty years after the first excavations in the shelter. D. Peyrony's intervention allowed, on December 9th of the same year 1912, to interrupt the cut-out work on the sculpture. On December

11th, the locks were placed on the screened entrance door (Delluc 1997). This is how *"this work of art could only be preserved in place if it was of real scientific value only in the context and environment in which it was designed and executed"* (Peyrony 1932). Also in the same year, D. Peyrony discovered several engraved and painted blocks in the excavation backfill, one of them bearing a deer design (Peyrony 1952). He had the shelter classified as a Historic Monument on the 23rd of March 1913. He also expropriated the land for the benefit of the State and closed the shelter with a wall. On August the 6th 1913, Henri Breuil came to trace the figure of the fish (Breuil 1960, p. 118). He did not publish it until 1927 (referenced as Breuil and Saint-Perier 1927, fig. 1; Figure 15-a, p. 25). At that time, on the ceiling of the shelter were identified the following motifs: the fish, the relief under the fish's head, the series of seven vertical lines, the small cups and the two rings on the fish, the unintelligible engraved lines, some decorated blocks and fragments detached from the vault (without knowing what D. Peyrony's criteria of discrimination between these two categories were), which are both engraved and painted. In 1917, D. Peyrony undertook protective work at l'Abri du Poisson (Fish Shelter), clearing the shelter and building the fence wall and began archaeological excavations in the Lartet Shelter. He excavated the Abri du Poisson in 1918, where he was able to distinguish five sedimentary groups, including two archaeological levels, an Aurignacian level I with split-based bone points and a Gravettien level with Noailles burins, separated by a sterile level (Peyrony 1932). His observations therefore contradict P. Girod's conclusions.

In 1973, Max Sarradet noticed a horse engraved on the ceiling engravings (Sarradet 1975). Taking an interest for the first time in the presence of colour on the fish sculpture and on the ceiling, A. Roussot spotted a black negative hand in December 1975, in the company of C. Archambault (Rigaud 1976, Roussot 1981, 1984a-b). After having found some of the Peyrony blocks preserved at the Musée des Eyzies (Delluc 1978a), Brigitte et Gilles Delluc began in 1983 a technological study of the engravings and sculptures on the ceiling of the Fish Shelter and a number of blocks (Rigaud 1984, Delluc 1991). They interpreted one of the engraved signs of the large collapsed block as a vulva and found a fingerprint sign on another of the blocks preserved in situ. They also tried to map the ceiling, grouping the different reliefs, cracks, calcined areas, flakes in the process of disbonding, engraved lines, red paint plates and rings.

No archaeological work took place after 1918, with the exception of the rock art survey operation of B. and G. Delluc in 1983. Only conservation work, for which we will have to specify the nature in the future, is carried out on an ad hoc basis. Among them is the microbiological monitoring of LRMH (Touron et al., 2008-2009). The Fish Shelter was visited as part of our PCR on 4 July 2013 (Cretin et al. 2013, pp. 54-60 and p. 135) and assessed the good potential of information held by the site, on the ceiling, on the blocks or in its sedimentary deposit. Finally, a preliminary study, in September 2016, by Lydia V. Zotkina, determines the good potential for techno-traceological information of the ceiling as well as the possibility of discriminating between anthropic traces and subsequent alterations. In fact, it is possible to consider new representations (Zotkina and Cleyet-Merle 2017), this is what will now be presented.

2. The 3D survey

The first objectives of digitizing the shelter are to estimate the volume of the shelter and to provide a support for the surveys and inventory of the works, the shelter ceiling and the collapsed block that rests on a separate surface. This allows more accurate 3D models to be integrated, if possible into the entire shelter model, otherwise on a sector, ceiling, block etc. The objects identified as interesting are the carved fish, the rings (N = 8 to 11), the collapsed block. The 3D also makes it possible to locate stratigraphic surveys and test hypotheses concerning the geometry of the fill and the collapsed block reassembly on the shelter ceiling.

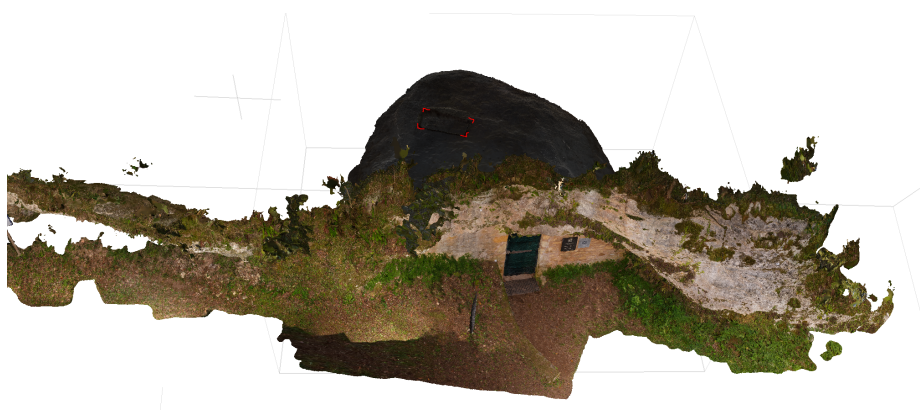


Figure 2. Abri du Poisson, photogrammetry of the main facade + volume of the shelter, Cretin, Lescop, Camille Medjkouh Boulain 2017.

For the shelter, 119 photos in JPG, CR2 and TIFF formats were taken and a first model obtained 880,923 aligned points, a dense cloud of 53,883,473 points and a mesh size of 58,725 faces. In this first geometry the hidden parts are missing. It should be noted that shooting in the shelter is particularly uncomfortable, that it is very difficult to compose light to help photogrammetry and that areas are so narrow that it is difficult to slip someone with a camera in.

The representation of a fish is exceptional in parietal art, both in France and around the world. There are only about ten of them in total. The engraving described here is dated 25,000 years ago and it seems to be the oldest ever found. The figure is very realistic, the fish is as if caught in the motion. The size of the sculpture is 1.05 metres, which represents a plausible real dimension. Realistic details give precise indications of the species and the period during which the fish was caught. He was probably fished in the nearby Vézère river. The details that can be noted are the curved jaw that indicates that it is a Bécard type salmon. The lower jaw is curved in a hook shape, which indicates that it is a male fish and that it was caught after spawning, i. e. the period of egg fertilization. There are 7 lines above the fish that have been interpreted as the representation of the dorsal fin, but it is generally accepted that it is morphologically inconsistent. However, separation from the body can give way to other interpretations.

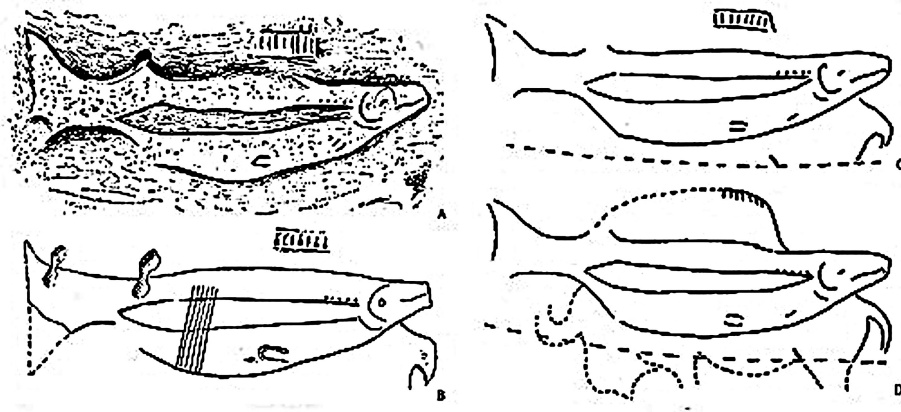


Figure 3. Interpretations of the fish figure in bas-relief, by H. Breuil (a), D. Peyrony (b), and A. Leroi-Gourhan (diagrams in *l'Atlas des grottes ornées*, 1984, p. 156).



Figure 4. Photogrammetry of fish engraving, photo Zotkina, 3D Zotkina and Lescop.

The photogrammetric survey used here was carried out in 2019 following a previous series of surveys that did not give good results. A series of 99 photos were taken at 6032x4032 resolution with a Nikon D750, an exposure time of 1/100 seconds and the focal length at F/14, the focal length being 60mm. The flash was not used. The calculation in MetaShape yielded 3,669,909 vertices and 7,332,415 faces. So it's a very high resolution model. By resolution we can indicate that the engraving area is 0.46 m², which represents 460,000 mm². Considering that we have 7,332,415 faces at the end of the calculation, that is 16 faces per square millimetre. The risk in photogrammetry is always to be at the scale of the grain of the rock, which disrupts the modelling by creating a kind of noise where there is detail. It goes without saying that despite everything, the model will be simplified to carry out the experiments that will follow.

3. Procedural interpretation

Experiments now becoming established (Lescop et al. 2013) using deviance analysis have shown their effectiveness in highlighting details that are difficult to detect with the naked eye. The method does not have the effectiveness of revolving lights to determine the chronology of the engravings, but is nevertheless effective for a detailed exploration of the topography. However, the examples identified (Sanz et al. 2010 for example) work only on depth and as far as possible on fairly flat geometries. Our project here is to be able to control the slightest adjustment concerning the position of the reference plane, the number of gradients and their representation. In a second step, we will add another information that seems to us fundamental to understand the geometry of the engravings, it is the slope. The slope can provide information about the carving process by indicating the angle of attack, the use of the right or left hand, the hardness of the tool and the continuity effects.

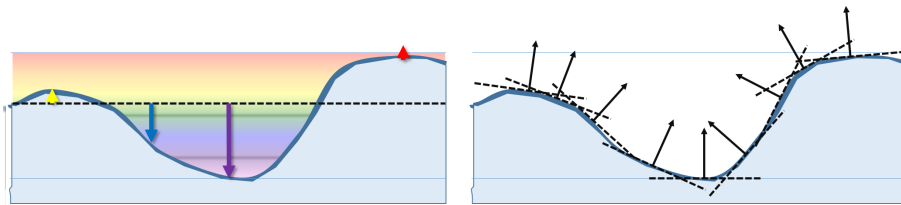


Figure 5. Deviance map and slopes, ill. Lescop.

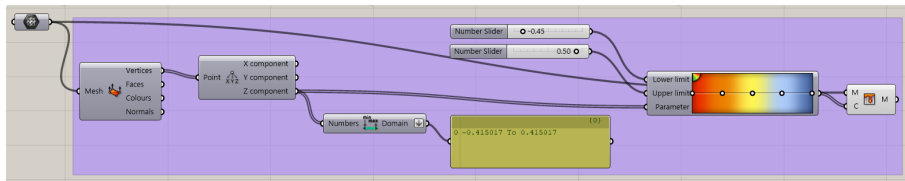


Figure 6. Grasshopper definition for depth.

To design the parametric model for interpreting the engraving of the Fish, we will use the Grasshopper software. Grasshopper is a development environment associated with Rhino software and, more recently, Autodesk Revit architecture software under the name Dynamo. Grasshopper is not the only parametric development environment, but over the years, since its creation in 2007, it has acquired a reputation that ensures an active community of developers and many examples that can be used as training materials. Grasshopper falls into the category of visual programming languages with applications in architecture and engineering, but also in art, our proposal is also to introduce it in archaeology.

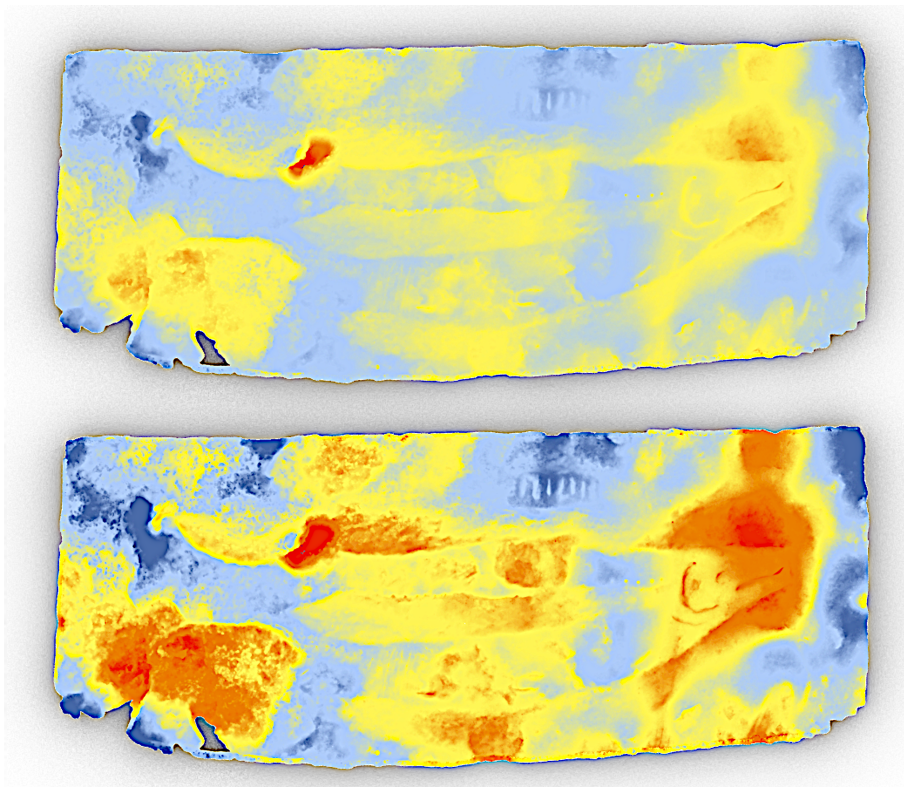


Figure 7. Result for depth map with 2 filtering, above with the total bounding box, below with two closer values, more details appear.

To develop our process, we started by creating several resolutions of the basic model: a resolution at 7000 polygons, then 70,000, then 700,000. The 7 million polygon model proved too heavy to use. Depth analysis is rather simple to set up. First, it is a matter of extracting all the coordinates of all the points of the mesh. From this list, only the (z) values, the heights, are considered. From this collection of values, we determine the domain, i.e. the lowest value and the highest value, which gives us both extremes. The last step consists in constructing a gradient between the extreme values. However, in the context of archaeological analysis, it may be interesting to filter values and play with low and high values to highlight details. In this case, a Slider is created that will allow to vary the high and low reference planes. The details will therefore appear more finely and at the same time, we will have precise information on the thickness of the slice for further analysis.

The figuration of the depths gives interesting interpretive elements, among other things, the continuity levels of the figures, however the highlighting of the tracings remains rather weak. This will be corrected by slope analysis. The slope analysis is slightly more complex and interesting. It can be done either by drawing

the contour lines, but the density of the lines can end up interfering with the reading, or by color gradient, which we will present here.

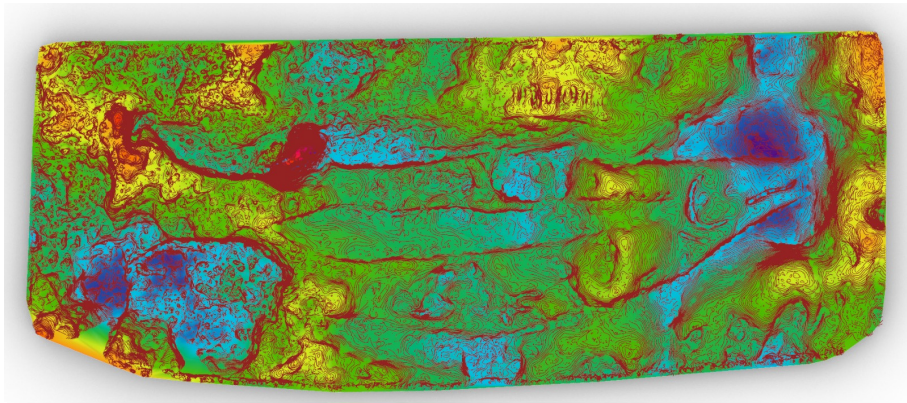


Figure 8. Depth map with contour lines.

The slope calculation will work a bit like a grazing light lamp by revealing the orientations of each polygon to a reference vector, by default the vector (z) pointing upwards. There are many ways to build a Grasshopper definition for this type of calculation, we will present here a simple setup. Each polygon's normal must be taken and each angle compared with the vector (z). From there several solutions, for instance, work in radians that can be converted into percentages or translate the angles into degrees. Then, just limit the domain of study and display the results using a gradient. Finally, the volume must be coloured with the results obtained.

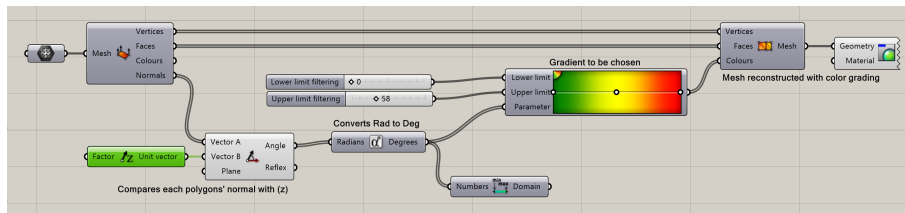


Figure 9. Grasshopper definition for slopes visualization.

In the following examples, the choice was made to use a black and white gradient. The angles were then filtered. For the first image, only angles between 0 and 40° with (z) were selected. We can see that all the details come out more accurately than with the depth map. It is then necessary to distinguish as anthropogenic or not these lines and traces that appear.

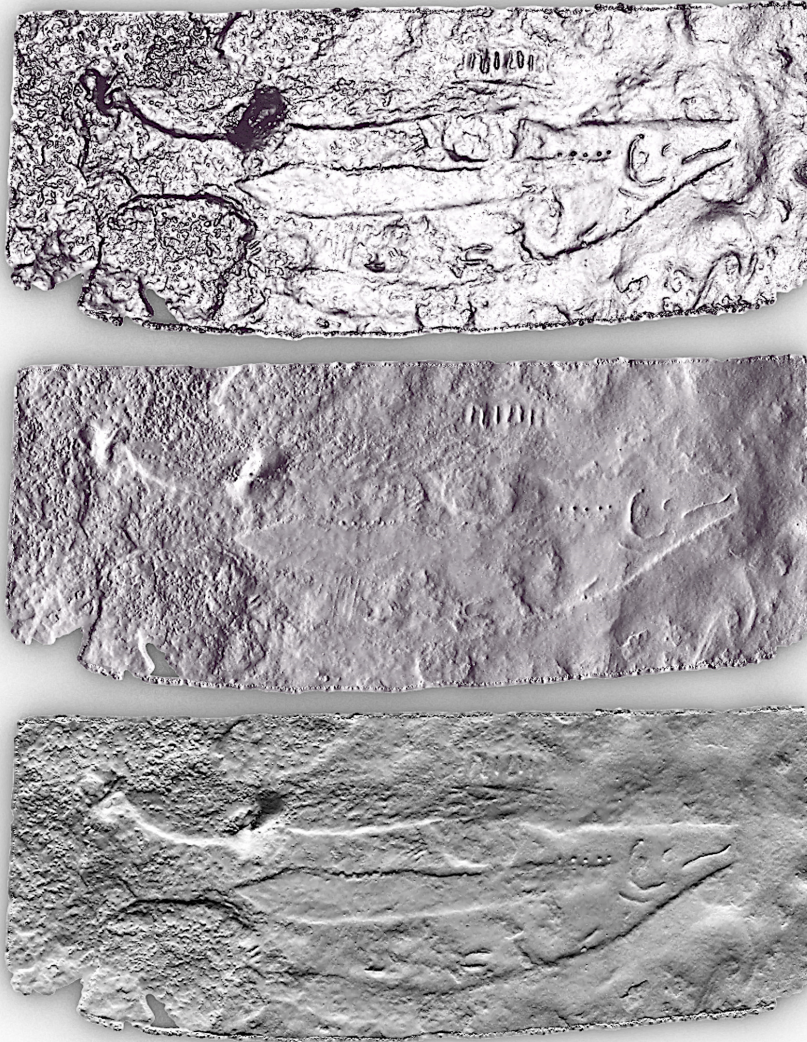


Figure 10. Slopes definition with different vector orientation, top, orientation (z) it gives fine details of the engraving relative depths, middle, orientation (x), it emphasizes the 7 stripes above the fish, down, orientation (y) gives details on the fish's belly.

The second image is taken with the vector (x) as reference and an angle filtering between 45 and 145° . The result is close to a grazing light without being generated by drop shadows. In this image, the 7 lines above the fish's body appear very clearly, while only 6 are visible to the naked eye. Other details also come to mind. Finally, the third image is referenced with the vector (y) and with an angle filtering between 40 and 145 . Here again, the grazing lighting effect works very well, without drop shadows and other details further enrich the analysis.

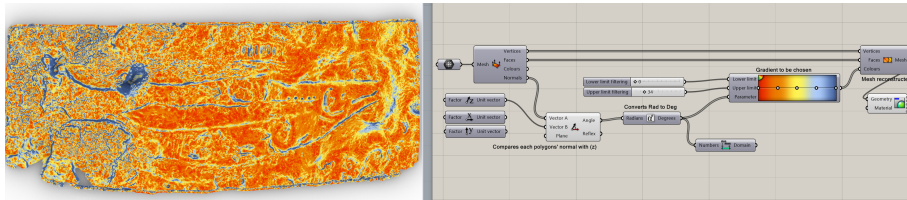


Figure 11. Depth analysis, color version, workspace in Grasshopper.

4. Conclusion

The method briefly presented here is under development in order to obtain ever finer results. The simplicity of the set-up allows the researcher, even if he is not a Grasshopper expert, to be able to vary the settings, to choose the appropriate type of presentation of the results and to always have control over the values handled. The researcher knows at any time what depth he is analyzing or what angle is being visualized. Other investigations can be carried out using the same model, such as cross-sections on the tracings or the length of the ridges, which can give an idea of the time required to complete the figure. The sections on the plots associated with the analysis of the angles according to a selected vector give indications on the tool used, whether it is held with the right or left hand and the angle of attack of this tool. The risk is always to confuse an anthropogenic trace of a natural surface accident (Lescop 2018). Traceology makes it possible to solve these questions. In our approach, we defend the position that no technique is orphan and that their diversity makes it possible to approach the understanding of the subjects as well as possible. However, the method presented here has the advantage of allowing a relatively fast investigation, accuracy according to the geometry quality and allowing to work with other recording techniques.

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