Three dimensional documentation of cave Sönghellir, Iceland

3D Scanners Lab
Institute of Archaeology,
Digital Humanities Laboratory,
University of Warsaw

Marta Bura, Janusz Janowski

Warsaw 2016

FS603-15331

Forsíðumynd/Front cover
Scanned image showing inscriptions in Sönghellir
By 3d Scanlab

Bárugata 3
101 Reykjavík
Telephone number: +354 551 1033
Faxnumber: 551 1047
Email address: fsi@instarch.is

Þrívíddarskönnun á Sönghelli, Snæfellsnesi.

Sumarið 2015 fór leiðangur vísindamanna til Snæfellsness í þeim tilgangi að þrívíddarskanna Sönghelli og ristur sem í honum eru. Var þetta gert til að varðveita aldagamlar ristur á tölvutæku formi auk þess að gera rannsóknir á þeim auðveldari.

Leiðangurinn samanstóð af fornleifafræðingum frá Fornleifastofnun Íslands ses og 3d Scanners Lab hjá Fornleifastofnun Varsjárháskóla.

Verkið tók sjö daga, þar sem skannað var á vettvangi en jafnóðum unnið úr hráum skönnunargögnum til að gera nothæfar skrár til frekari úrvinnslu á ristum.
Fornminjasjóður styrkti verkefnið auk Varsjárháskóla.

Eftirfarandi er skýrsla um tæknilegan hluta verksins. Öll frekari vinna sem felur í sér rannsókn á ristum hellisins bíður betri tíma.

Reykjavík 12.03.2016,

Lilja Björk Pálsdóttir

Three-dimensional documentation of cave Songhellir, Iceland

Documentation means to acquire a picture, as precise and neutral as possible, of a given item, with all its attributes. Thanks to documenting all spatial aspects of a given object, we can mirror it digitally in an *almost* ideal fashion. 3D documentation is currently the most precise method of documentation. The method avoids distortions resulting from the perspective (as in photography), interpretations in both descriptions and drawn documentation, or the influence of the human factor, the most "erratic" of them all.

The most precise mirror image of an object is a dense cloud of points, which visually creates a virtually constant surface of the object. Such documentation, carried out properly, is complete and sufficient. The point clouds can be obtained in different ways, from extrapolating them from diagonal photos, through scans triangulating structural light, up to laser scans: stationary, mobile, underwater, aerial or satellite borne.

Depending on the size of the object, we employ different scanning techniques, with appropriate detail. The effect is a point cloud spatially mirroring the documented object. This cloud has certain attributes, including density and accuracy. By density we understand the number of points acquired from a given scanned surface, while the accuracy concerns the appropriate location of a point within the cloud in relation to the measured object. The density of the cloud of points matches the precision of the mirrored objects.

Such a cloud is a complete documentation on one hand, on the other it constitutes raw material for future research. It can be the object of various forms of processing or morphing, the creativity of the scientist being the only limit. The process of modifying clouds of points is long and time-consuming. It is estimated, that the mere scanning, that is the acquisition of the point cloud; constitutes about 10-20% of the entire work necessary for standard documentation.

The acquired point cloud can perform a number of operations. The first one is usually a combination of clouds from different locations scanner - registration; it has to create one large complete set of points obtained in the whole project. Used for this purpose arranged on the ground reference points can be round target with checkerboards on it or sphere (Fig. 1), it's important that the system can flawlessly interpret such a centre marker and at least a few distancing scanner. Registration diagnostic of our scans is showing 0.023 m of mistake.

Documentation of Songhelli Cave was performed with laser scanner P30 from Leica Geosystems. Speed approximately 1 million points on 1 s and a red laser beam characterize it. The range of this device is 120 m. It is also equipped with a camera with a 4-megapixel sensor mounted coaxially with a mirror scanner. The scanner performs measurements whole sphere in the centre of which stands 360 degrees horizontally and 270 degrees vertically. The scanner cannot see what is beneath it, and leaves an empty space under them so-called "dress"; the size of it depends of course on the height mounted on a tripod.

Fig. 1. Scanner in the cave and sphere target (fot. M. Bura)

In the same range of photos are taken (260) make up the entire sphere. Thanks to this cloud of points in addition to the values for the intensity of the reflection may have RGB values taken from the captured images. In addition, to improve the quality of images to the scanner can be mounted external camera. This allows generating a Colorado orthoscan on any surface of the object, something that would be hardly possible using traditional methods.

Thanks to the technology, we acquire measurements in a scale of 1:1, which allows us to perform all measurements directly within the point cloud or during the virtual visit, without the need to reduce the scale, as in the case of photography.

Laser scanning allowed also for a detailed documentation, independent of the lighting conditions, and also brought material for an objective analysis as to which signs are natural and which made by humans.

The warp reference points consisted of 4 HDS targets spaced on the measured area. Documentation lasted 3 days and at that time made 21 scans (Fig. 2), which allowed optimally cover measurements for the documentation area. Scan resolution was in each case adjusted to the place of deployment scanner (from 0.8 mm to 10 mm inside the cave to 3.1 mm 10 m out).

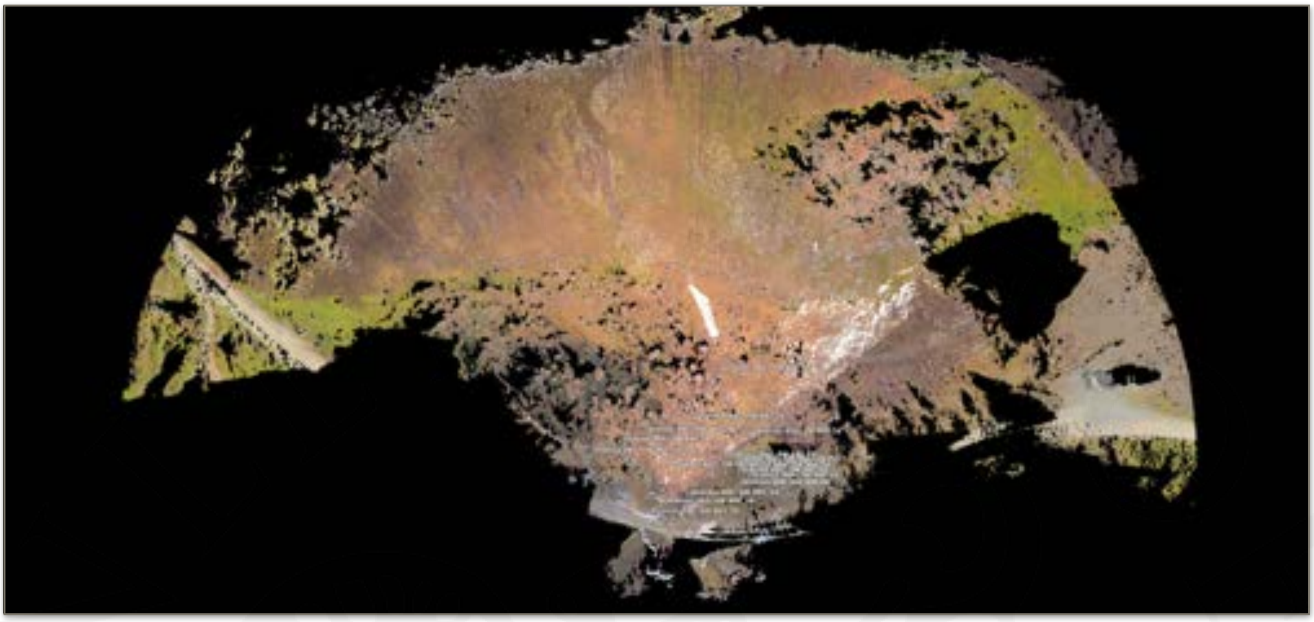

Fig. 2. Point cloud after registartion with position of scaner.

On the first day made 9 scans documenting the entrance to the cave and its interior with an accuracy of 0.8 mm at 10 m to 1.6 mm at 10 m. 4 targets used HDS and 2 spherical balls to connect the individual scans (Fig. 3).

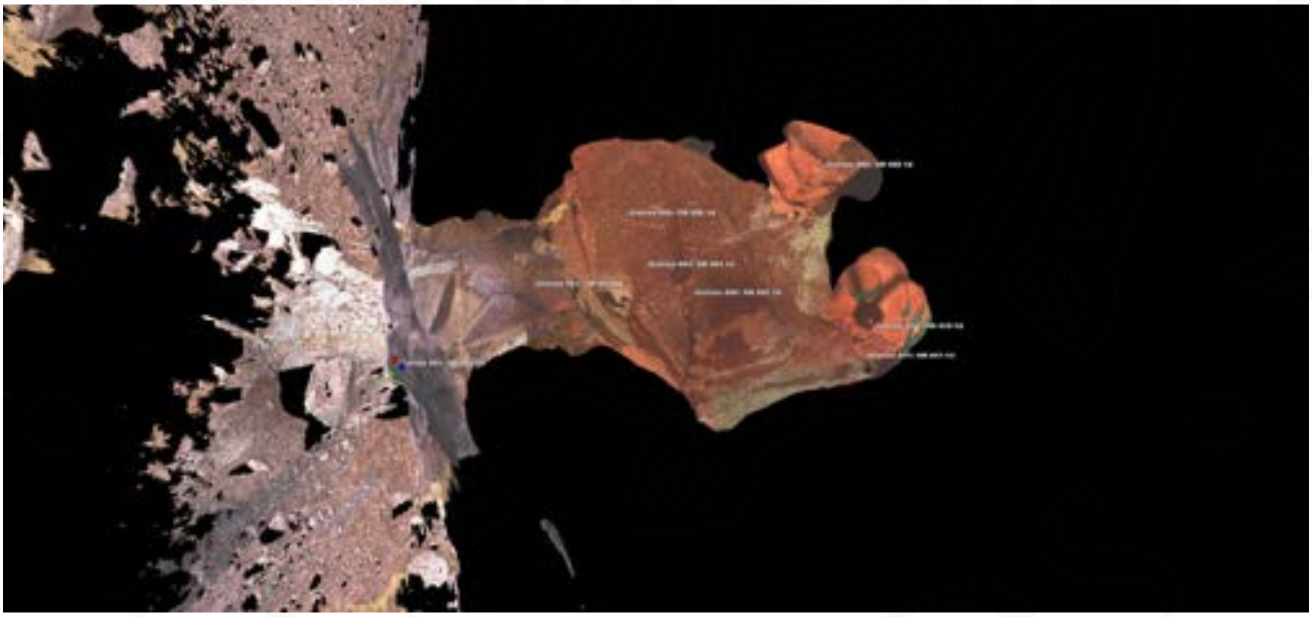

Fig. 3. Point cloud after first day of scanning.

Second day made 6 scan of the cave environment with an accuracy of 3.1 mm to 10 mm (Fig. 4).

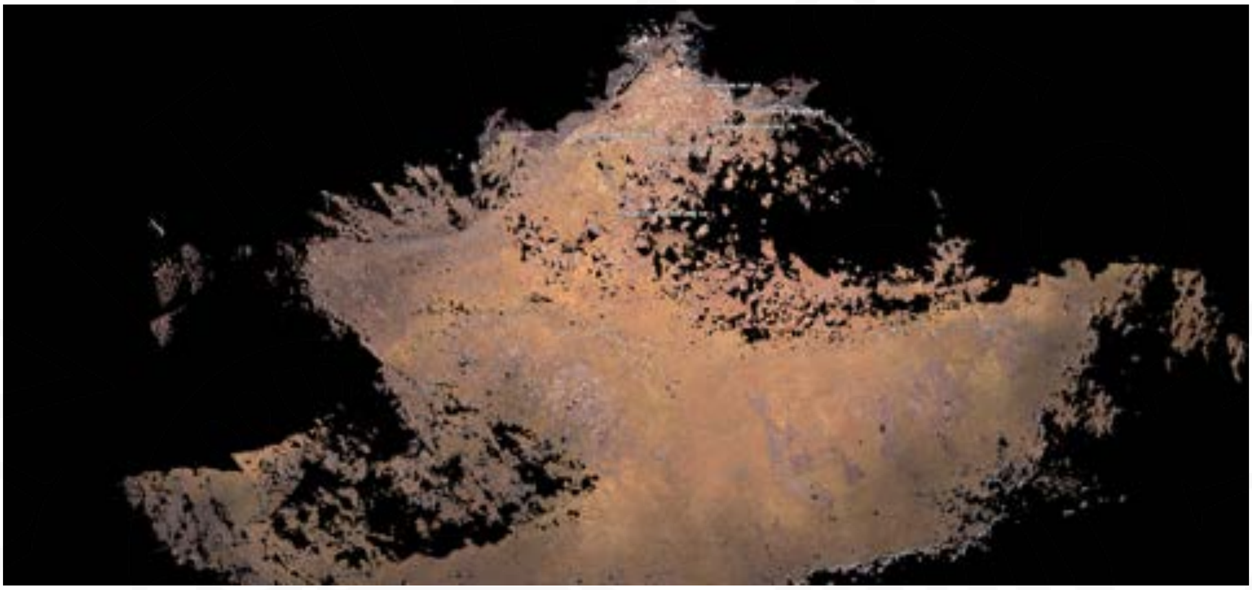

Fig. 4. Point cloud after secound day of scanning.

On the third day we made two sessions measurement, one on the document in the rock shelters located above the cave (Fig. 5a). Three scans with an accuracy of 3.1 mm to 10 mm. These measurements are extremely difficult to do because of the weather conditions, especially very strong wind. The second session was aimed at, documented upper surface of rocks where there was a cave (Fig. 5b), and the area around it, helping to locate based object in a wider perspective. Then made two scans with similar parameters (3.1 mm.10m), but in order to obtain better images of the cave environment used an external camera Canon E60 lens Sigma 8 f / 3.5 EX DG Circular Fisheye.

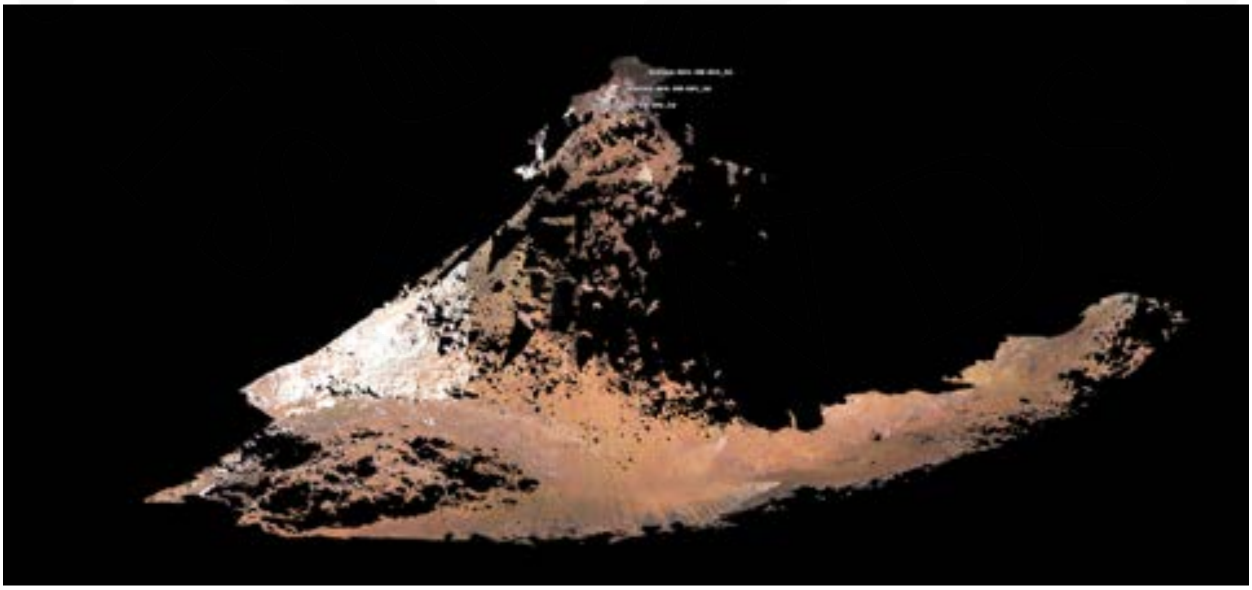

Fig. 5a. Point cloud after third day of scanning - shelters.

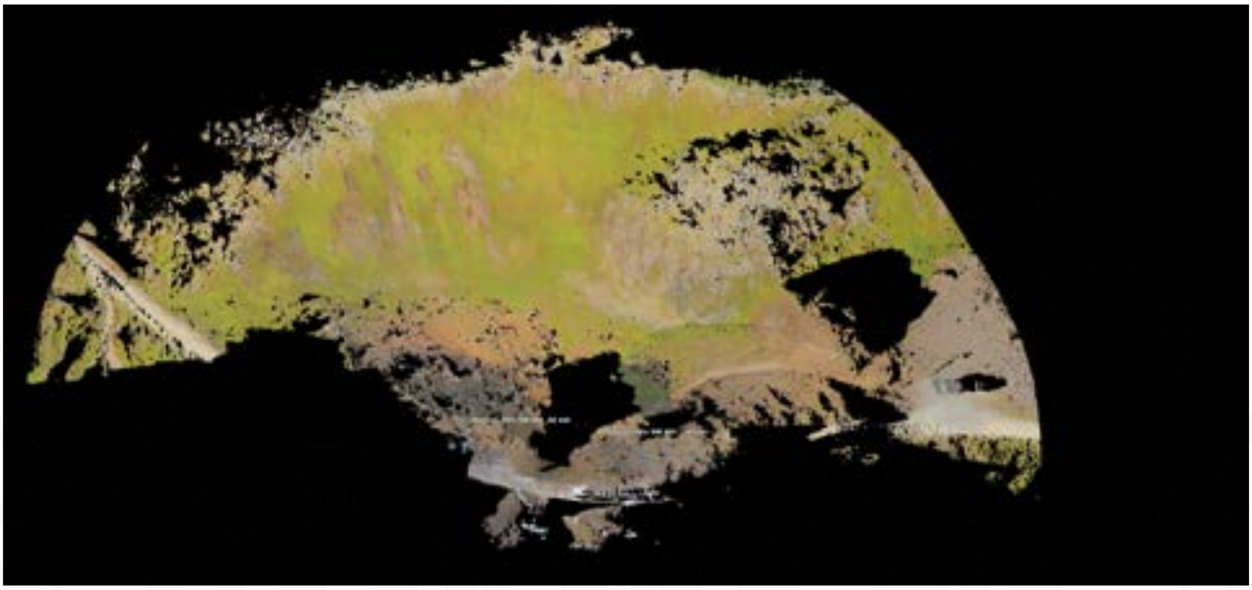

Fig. 5b. Point cloud after third day of scanning - upper surface of rock with external camera.

The combination of scans obtained in Cyclone, allowed to carry out a number of analyses. Among other things, the exact location of the cave in the rock (Fig. 6), make a series of measurements (Fig. 7), contour plans cave vertically and horizontally at different heights (Fig. 8a, b), it's precise dimensioning, preparing ortoscans of individual cave walls.

Extremely valuable result of three-dimensional scanner documentation is documenting the inscriptions that are in a cave in various techniques visibility. The cloud points usually uses colour information from images taken during the scan, but often documented objects are hardly visible with the naked eye, the same for the camera. Scanner recording also information about the intensity of the reflection we see elements that until now were difficult to perceive.

We see it perfectly comparing the two shots of the same scans the walls of the cave with inscriptions. Scan with information about colours of the camera (Fig. 9a) will show us a similar view as if we had entered the cave with a flashlight. Scan with information about the intensity of the reflection (Fig. 9b) of the laser while showing us the inscriptions (Fig. 10), the existence of which we could only guess.

Fig. 6. Location of the Songhelir Cave in the valley.

Fig. 7. Measurement on point of cloud.

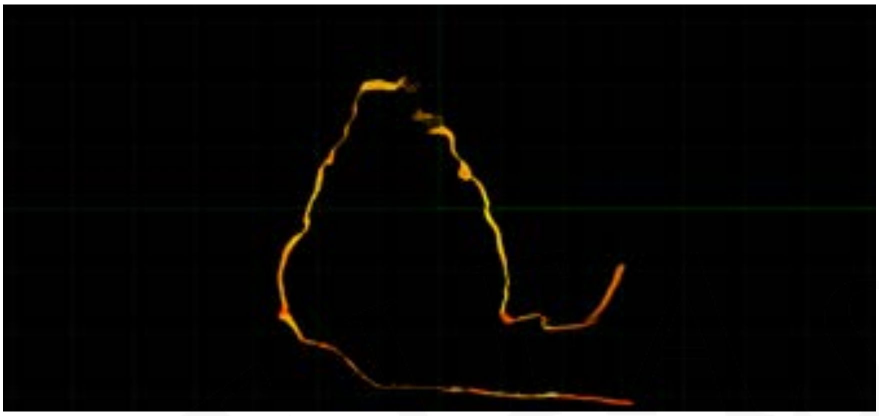

Fig. 8a. Vertically contour plans of cave.

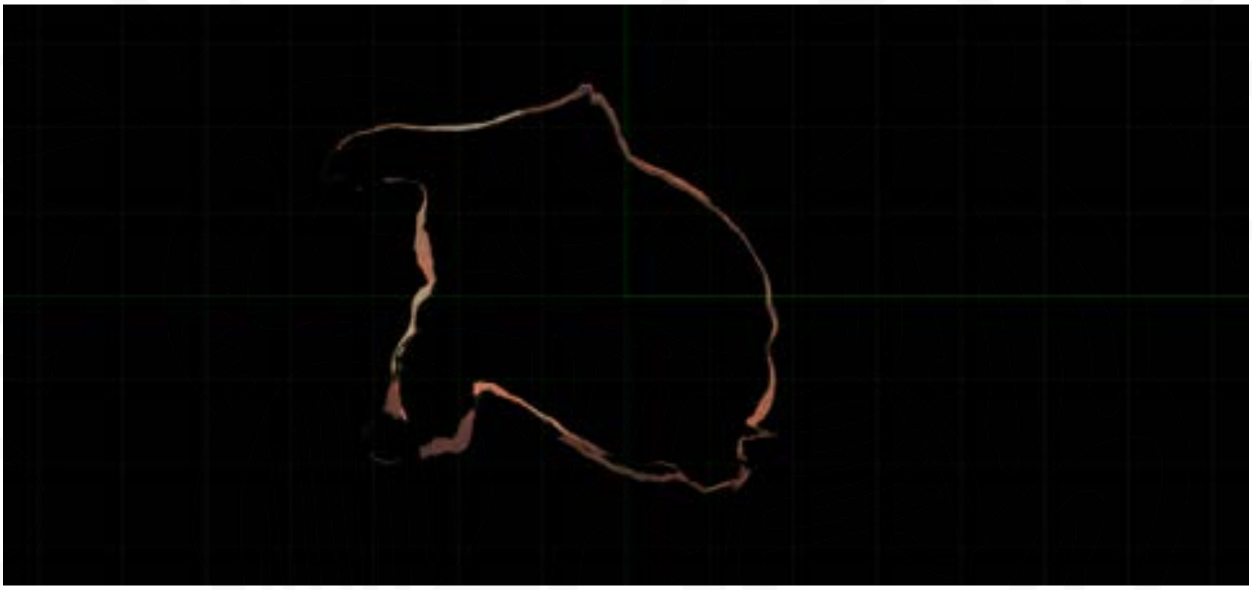

Fig. 8b. Horizontally contour plans of cave.

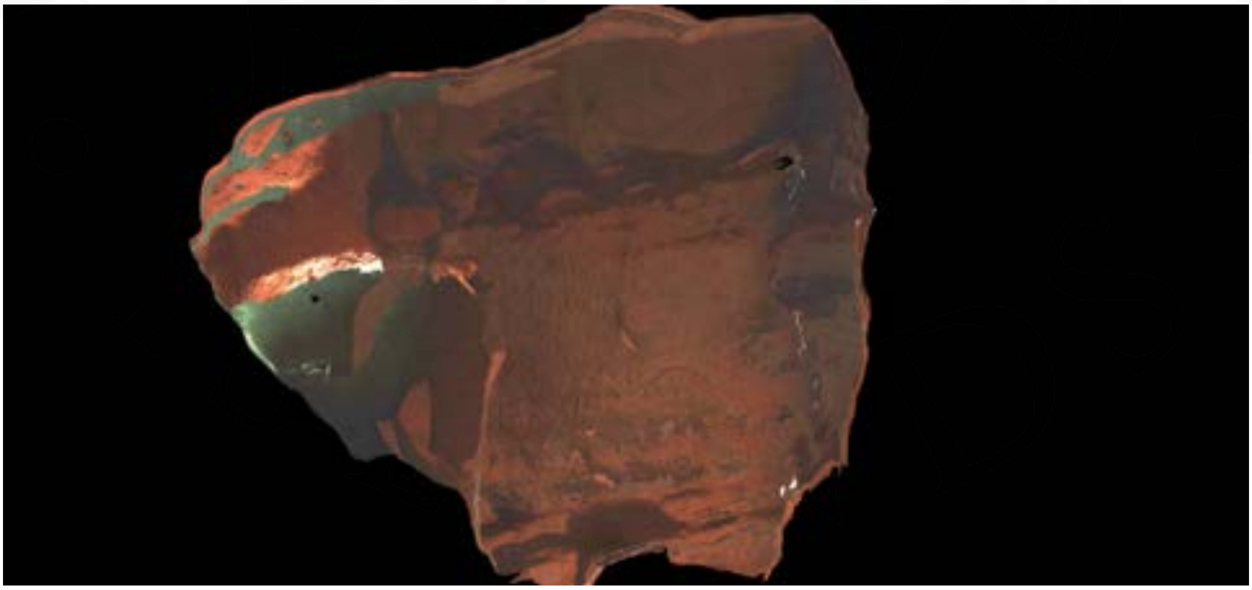

Fig. 9a. Scan with information about colours of the camera.

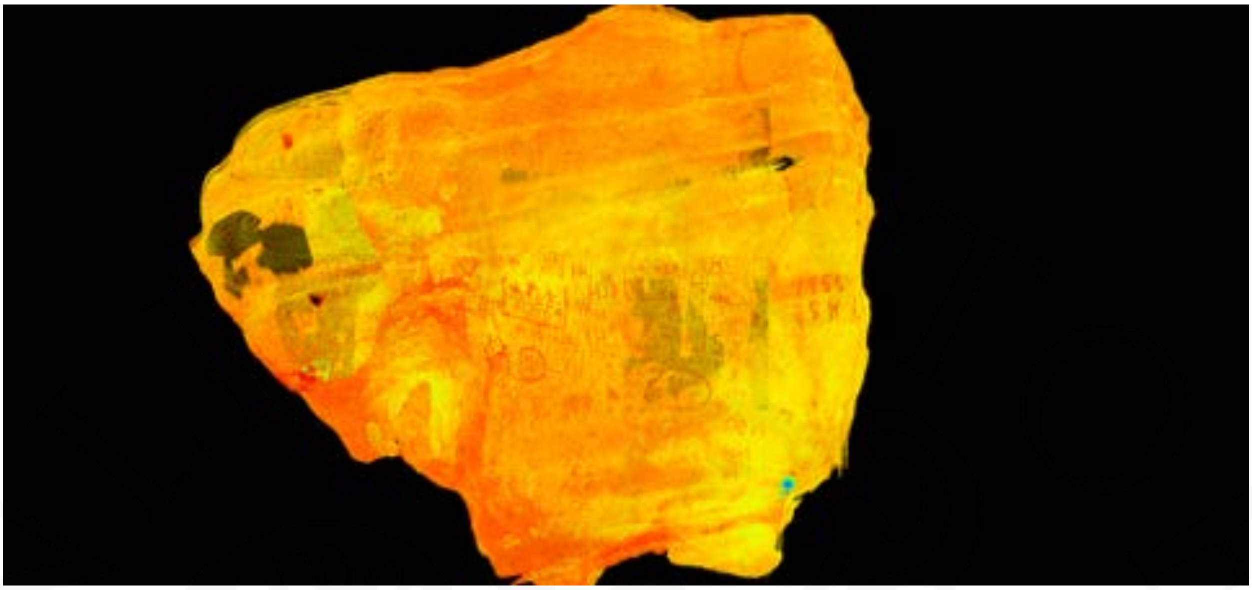

Fig. 9b. Scan with information about the intensity of the reflection.

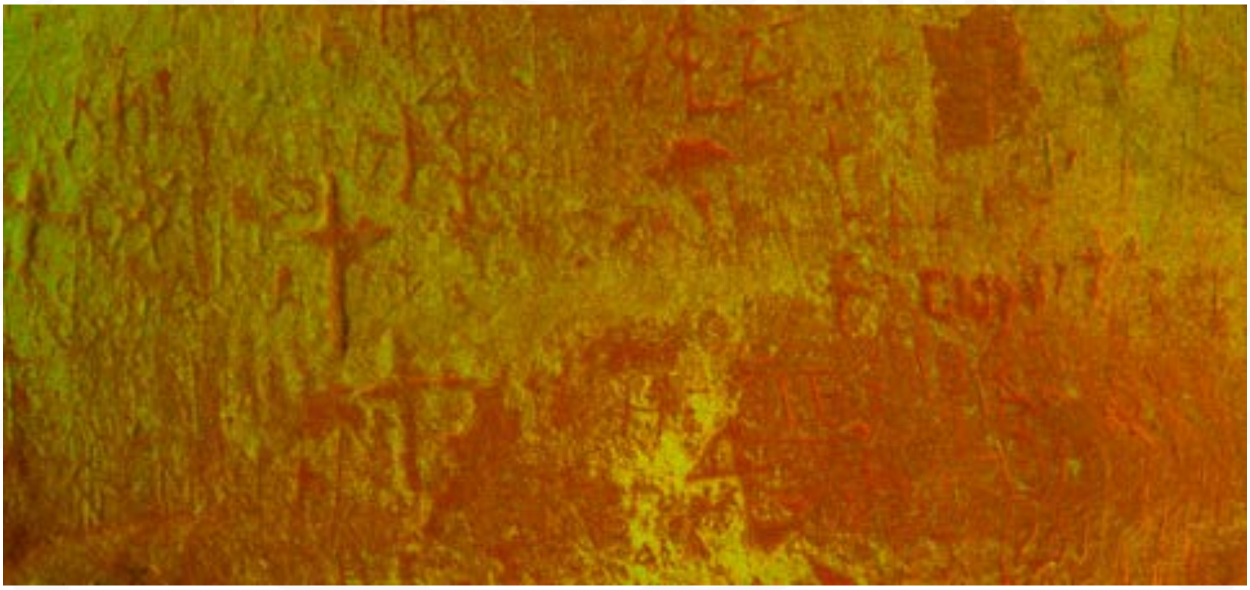

Fig. 10. Inscriptions on point of cloud.