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# Exploring the Perception of Mining Landscapes Using Eye Movement Analysis

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**Abstract.** Mining activities are notorious for altering the landscape, further causing increased visual impact. However, research regarding the perceived intrusion of mining remains mostly qualitative. In this paper, the gaze of fifteen university students was recorded using eye tracking experimentation while observing a set of mining landscape photographs. Pertinent analyses were applied to visualize, quantify and interpret their viewing patterns. First findings show the overwhelming dominance of the quarry area within the photographs, while other factors such as the relative position of the quarry appear to exert a major influence.

**Keywords.** Landscape Photograph Perception, Mining Landscape Perception, Attention/ Focus Maps, Landscape Eye Tracking Metrics

## 1. Introduction

Human visual experience seems to significantly vary across landscapes. Mining landscapes are distinct and extreme landscape types exhibiting certain characteristics which differentiate them from other, more common cases such as agricultural, forest or urban landscapes (Sklenicka & Molnarova 2010). One of these distinctive characteristics is the increased chromatic contrast between the quarry excavation area (bare rock) and the surrounding landscape (Dentoni & Massacci 2015, Menegaki et al. 2015). The texture and the shape of the excavated area are also differentiated. These great differences are deemed to cause equally distinctive observation patterns.

Recently, landscape research is supported by eye tracking methods and techniques. Dupont et al. (2014) have employed eye movement analyses to gain a deeper understanding of how different landscapes influence observers' viewing behaviors. More specific experimental work has been carried out to investigate the differential viewing responses to landscapes exhibiting different urbanization degrees (Dupont et al. 2017). The important privilege ensuing from landscape eye tracking experimentation is the objective recording and measurement of the human observation process (Dupont et al. 2014), contrary to other methods in landscape research that are purely qualitative and subjective (e.g. questionnaires). Several metrics developed in eye tracking studies (see e.g. Poole & Ball 2005) have also been introduced into the landscape research domain (e.g. Dupont et al. 2014). In such experimentations, landscape photographs<sup>1</sup> displayed for a given time are viewed (in free-viewing conditions) from observers-participants.

In this nascent field where landscape visual perception is approached utilizing eye tracking techniques, the distinct mining landscape has not been yet introduced. This lack needs to be addressed for both practical and scientific reasons. Surface mining activities are linked to major landscape alteration (Dentoni & Massacci 2015) inducing significant geomorphological and aesthetic effects (Menegaki & Kaliampakos 2006). In order to get a deeper understanding and a better approximation of the factors influencing real observers' visual perception and preferences/ assessments when visually experiencing mining landscapes, further scientific research is required. To this end, the need for quantitative specification of criteria and thresholds in visual impact assessment (Misthos et al. 2017) should be supported by eye movement experimental methods and analyses. Provided that mining activities are "*significant landscape offenders*" (Menegaki & Kaliampakos 2006: 185) inducing increased visual nuisance, i.e. subjective impression of disturbance (Misthos et al. 2017), gaze recordings can be used as a surrogate for estimating the visual impact/ nuisance. This direction has been explicitly supported by recent literature: Dupont et al. (2016: 17) emphasize the potential contribution of eye movement analyses and focus maps visualizations to the visual impact assessment since "*the visual impact of an object is reduced when its visual perception decreases*".

In this paper (part of an ongoing research), eye tracking methods are employed for the first time – to the best of authors' knowledge – to explore the visual perception of mining landscapes represented in a set of photographs. More precisely, we investigate whether the excavated surface of the mining landscapes affects the extent to which the attention is drawn.

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<sup>1</sup> Landscape photographs are utilizable, assuming that they constitute reliable substitutes of real landscapes (e.g. Palmer & Hoffman 2001).

## 2. Data & Methods

### 2.1. Experimental Design and Procedure

Three mining landscape photographs of the northwestern aspect of the Merenta quarry (Attica, Greece) were purposefully captured with a DSLR camera and using a tripod to ensure stability and a constant shot height of 170cm. In these photographs, the main excavated surface was ‘placed’ in different positions within the ‘visual frame’. As Svobodova et al. (2014: 146) stress out, there is a lack of “*studies focusing strictly on landscape photographs from the standpoint of the composition of landscape elements.*” In addition, “*very few studies focus on the preference for one of four possible positions of the [Rule of Thirds] in the picture, or on the character of the key object*” (Svobodova et al. 2014: 146). Therefore, exploring the effect of the position of a quarry, in particular, on three of the four ‘power-points’ delineated by the *Rule of Thirds* (see Section 3.1. and *Figure 1*) is anticipated to provide further insight in the landscape research domain and to inform open pit mining project design and landscape/ land use planning.

For the aims of this paper, the gaze recordings from eight male and seven female undergraduate and postgraduate students – engineers and environmental scientists – of the National Technical University of Athens were used. The participants were informed that they would participate in an experimental research study in which their gaze movements would be recorded while observing some landscape photographs. Yet, there was no implication that the landscapes to be examined were mining landscapes and no details were given about the specific aims of the research. The participants were simply asked to *freely* observe the visual stimuli, without having to perform any specific cognitive task, e.g. to spot the edges of the quarry and without having any prior knowledge of these stimuli. *Free-viewing* is a prerequisite to simulate the way people observe landscapes in real life – i.e. without any specific purpose (Dupont et al. 2014). Mining landscapes are connected to the additional bias of past negative experiences with mining activities (see Misthos et al. 2017); hence, the participants should not be familiar with the respective stimuli.

### 2.2. Data Processing and Analysis

The raw data gaze recordings were collected (sampling frequency: 60 Hz) utilizing the Arrington Research’s Viewpoint Eye Tracker® experimental equipment. These data were analyzed with the OGAMA open source software (Voßkühler et al. 2008) after being converted into a compatible format.

Attention (focus) maps were produced to provide qualitative evidence about the observation patterns of the fifteen observers for the three mining landscape photographs. This evidence was provided by the visualization of the

attention distribution inside/ outside the excavated area and by the comparison of the three landscape photographs' attention maps. Moreover, the excavated surface (quarry) was delineated (as AOI) in OGAMA and several metrics were calculated. One of the metrics considered was the *time to first fixation within the quarry*: faster times connote that the AOI-element has better attention-catching properties (Byrne et al. 1999, Poole & Ball 2005). In addition, two other metrics – *Mean Number of Fixations Ratio (MNFR)* and *Mean Fixation Time Ratio (MFTR)* – were derived:

$$MNFR (\%) = \frac{\text{Mean Number of Fixations at AOI}}{\text{Complete Mean Number of Fixations}} * 100 \quad (1)$$

$$MFTR (\%) = \frac{\text{Mean Fixation Time at AOI}}{\text{Complete Mean Fixation Time}} * 100 \quad (2)$$

MNFR is related to the metric of fixations per AOI; this metric signifies that for higher values the AOI is more noticeable or more important to the observer, compared to other AOIs (Poole & Ball 2005). More precisely, MNFR (being a ratio – %) indicates the degree to which an AOI is more noticeable than another. On the other hand, MFTR pertains to the metric of gaze (fixation) duration per AOI; this metric suggests that for longer durations, viewers experience greater difficulty in extracting information from the AOI element, or that they find it somehow more engaging (Poole & Ball 2005). Thus, MFTR indicates the degree to which an AOI is more difficult to be processed.

### 3. Results

#### 3.1. Presentation and Description

The produced attention maps for the three mining landscape photographs show that the attention of the participants is mainly allocated within the quarry AOI (*Figure 1*). Nevertheless, there are differences in the visual attention distribution. When the quarry was placed in the lower left part of the photograph (left map), the gaze patterns were much more clustered, whereas somewhat and significantly more dispersed patterns occurred when the quarry was in the lower right and upper right parts of the photographs, respectively (i.e. right and center attention maps).

The metrics derived (*Table 1*) show that the fixations (number and duration) occurring within the quarry are much greater than those occurring in the rest of the photographs, considering the small area percentage of the quarry (column 5). Moreover, the quarry is spotted more quickly by the observers in the first photograph, while observers delay to execute their first fixation in the quarry when viewing the third photograph. MNFR/ MFTR get their highest value in the first photograph, while MNFR gets the lowest value in the third and MFTR in the second photograph.

### 3.2. Interpretation

The qualitative and quantitative eye movement analyses reveal that the excavated surface in all three photographs is a very dominant and important landscape element which draws the attention – more than any other element. The position where the quarry attracts the attention the most is the lower left one. For the same position, the quarry is very probable to be spotted much faster, while at the same time it is more noticeable and/ or more important. When placed in the upper right position, the quarry acquires the worse attention-catching properties and is rendered less engaging or important.



**Figure 1.** Attention (focus) maps of the fifteen participants for the three mining landscape photographs. Left: 1<sup>st</sup> photograph; center: 2<sup>nd</sup> photograph; right: 3<sup>rd</sup> photograph.

	Mean Time to first Fixation in AOI (ms)	MTNR (%)	MFTR (%)	AOI Area/ Total Photo Area (%)
1 <sup>st</sup> photograph	1339.33	21.50	22.69	2.88
2 <sup>nd</sup> photograph	2233.07	19.18	21.01	2.88
3 <sup>rd</sup> photograph	4238.40	17.66	21.88	2.88

**Table 1.** Derived eye movement metrics for the fifteen participants.

## 4. Conclusion and Further Research

Eye movement analyses seem to be excellent for exploring the way people perceive mining landscapes. The qualitative and quantitative eye movement analyses implemented in this preliminary research revealed that the excavated surface within all selected photographs was a most dominant and engaging landscape element. Furthermore, the position of the quarry within the landscape photographs is shown to be a factor influencing the attention-attracting properties of the quarry itself. The lower left position renders the quarry an even more important landscape element, especially when compared to the case where the same quarry is placed in the upper right position. Yet, further research is required to investigate whether for a larger participants' sample the same findings and conclusions are also true, extending the

applied analyses, and whether and in what ways the visual perception of mining landscapes is associated to the visual impact/ nuisance.

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