Theory of Colours: How to Interpret an Earthquake Visually

Mario Savini, University of Camerino, Italy

The European Conference on Arts & Humanities 2025
Official Conference Proceedings

Abstract

Can an earthquake be visually interpreted and associated with a specific colour? This research adopts a cross-disciplinary approach, merging artistic and scientific perspectives, to explore how seismic events can be represented through chromatic scales. The project employs a mathematical algorithm that integrates the pH scale - commonly associated with chemical analysis - to assign earthquakes unique HEX colour codes based on their magnitude and depth. The pH scale, comprising 15 colour boxes, is used in two opposing directions: one maps the earthquake's magnitude (Richter scale), while the other represents its depth (in kilometres). Each coloured box contains 100 colour parts, enabling precise calculations to establish a visual link. The algorithm generates a graphical representation correlating these colours with their Light Reflectance Value (LRV), revealing patterns: earthquakes with high magnitudes and shallow depths appear as low-LRV shades (e.g., purple-red), signifying greater impact. In contrast, deeper and less intense quakes produce high-LRV colours (e.g., green), indicating lesser damage. A Web App facilitates these calculations, offering an innovative visual framework for seismic data. By transforming quantitative data into chromatic representations, the project bridges science and art, encouraging new ways to interpret natural phenomena. This research highlights how technology and human creativity can converge, fostering interdisciplinary dialogue and making complex scientific concepts accessible. The study not only opens new avenues for data visualization but also challenges how we perceive natural forces, inviting further reflections on their aesthetic and cultural implications.

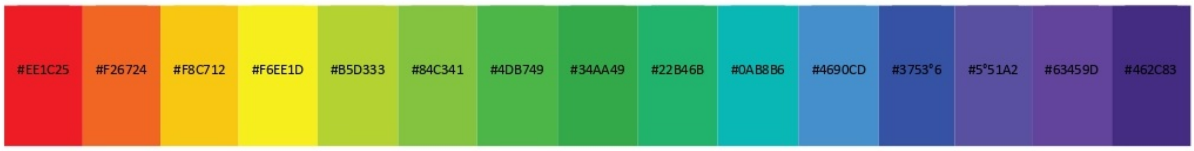
Keywords: data visualisation, interdisciplinary art, seismic data, colour theory, algorithmic aesthetics

Introduction

The theory of colours aims to provide a visual interpretation of an earthquake and is based on the pH scale universal indicator, which ranges from 0 to 14 and consists of 15 coloured squares. Each colour has its own specific HEX code (Figure 1).

> The pH scale measures how acidic or alkaline a substance is. […] A pH of 7 is neutral. A pH less than 7 is acidic, and a pH greater than 7 is basic. Pure water is neutral, with a pH of 7.0. When chemicals are mixed with water, the mixture can become some level of either acidic or alkaline. (United States Environmental Protection Agency, 2024)

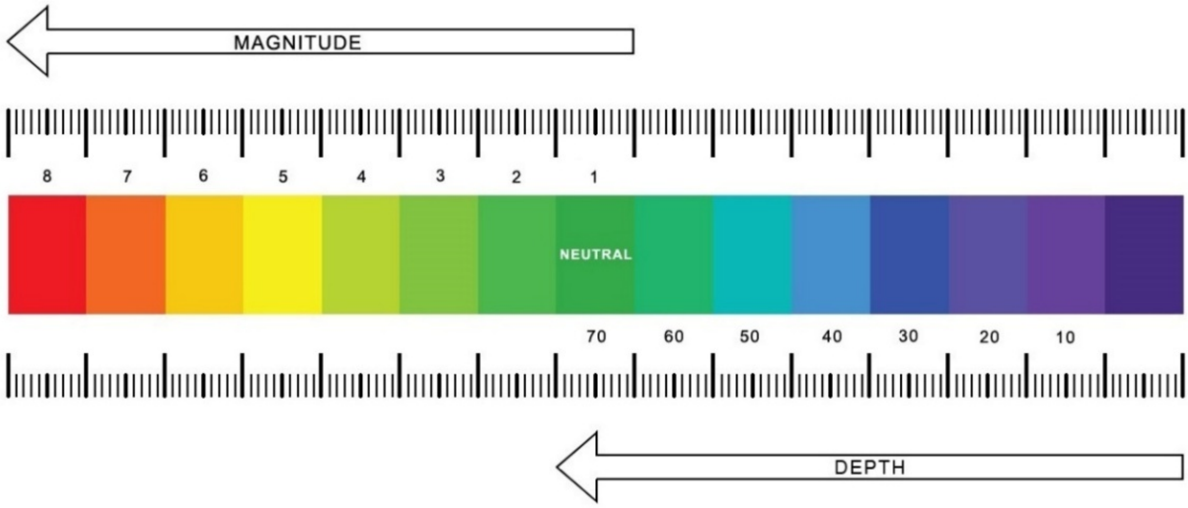
Figure 1
pH Scale Universal Indicator



In the case of a "critical" situation created by an earthquake, the colours to take into consideration are located at the extremes of the indicator.

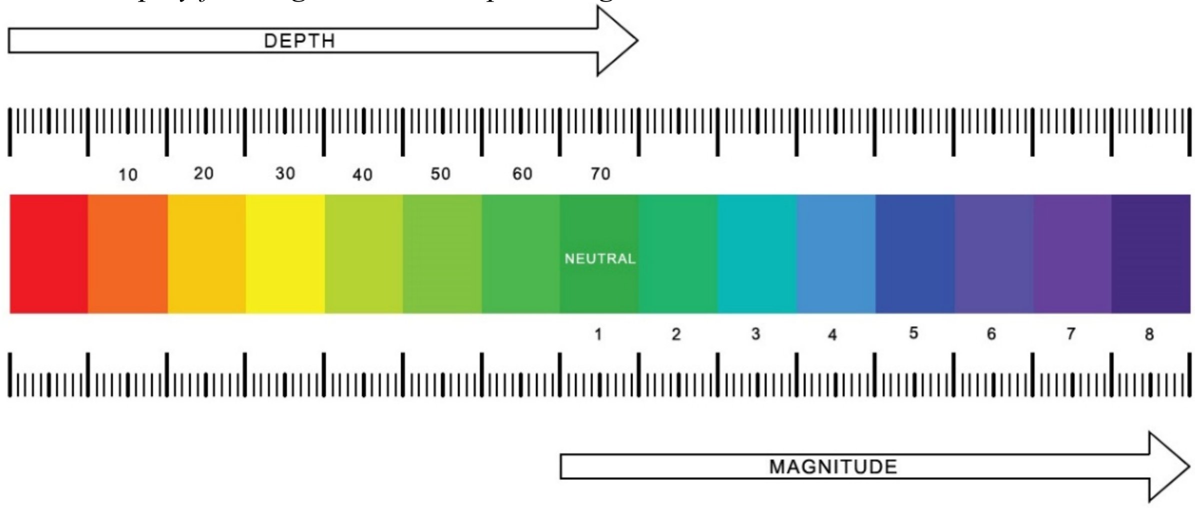
This scale can be read in two opposite directions: one to describe the **magnitude of an earthquake in the Richter scale** – from square 1 leftward – and the other to describe its **depth in kilometres** – from the right edge to point 70 in the middle of the scale (Figure 2).

Figure 2
Colour Display for Magnitude and Depth in Left Direction



The scale is also used following the opposite direction and, therefore, a cross calculation will be required: for the **Richter magnitude**, the scale will be read from square 1 toward the right, while for the **depth in kilometres** we start from the left edge and we move toward point 70 (Figure 3).

Figure 3
Colour Display for Magnitude and Depth in Right Direction



While for the **magnitude** every coloured square is equal to an increase of **1 in the Richter scale**, for the **depth** every square is equal to **10 km**. As a result, this scale can represent earthquakes up to a Richter magnitude of 8.0 (after which the colour will not vary) and up to 70 km of depth (after which the colour will not change): in case the Richter magnitude is 8.1 or above, 100% of the colour of square 8 will be used (as if the Richter magnitude were 8); if the depth is 71 km or more, 100% of the colour in square 70 will be used (as if the depth were of 70 km).

The directions of the calculations of magnitude and depth are opposite because, in the reality, although the two events occur simultaneously, they have "opposite" meanings: the higher the magnitude, the greater the damage caused; the higher the depth value, the lighter the damage.

This study addresses a fundamental question: how can the vulnerability caused by earthquakes be communicated in a way that resonates with both the scientific community and the general public?

It responds by proposing a cross-disciplinary model that brings together art, science, and mathematics, making seismic data not only measurable, but also visually accessible and emotionally meaningful.

Context and Audience

The visualisation model targets two primary audiences:

Scientific Community: By providing a unique representation of seismic activity, the tool offers a complementary approach to conventional data representation.

General Public: The chromatic translation makes complex seismic data visually accessible, raising awareness of earthquake dynamics and the fragility of human environments.

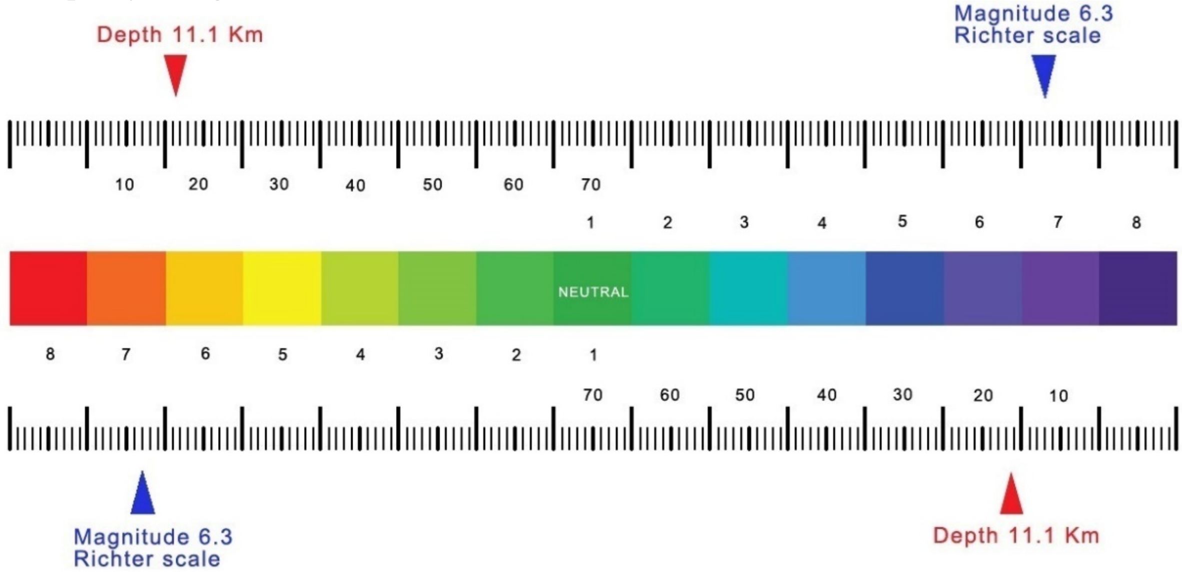
The broader implications of this work include its potential use in education, disaster communication, and environmental studies, where visualizing vulnerability enhances preparedness and understanding.

How to Use and Read the Scale

Regarding Magnitude, the whole number indicates the square to take into consideration while the decimals indicate the number of marks in the following square. Each square is divided into 10 equal spaces. Example: a 6.3 magnitude will be found in the 7th square on the 3rd mark (between 6 and 7 of the Richter scale).

Regarding Depth, the whole number indicates the square to take into consideration while the decimals indicate the number of colour units to use from that square. Example: for a depth of 11.1 Km, the indicator is on the first mark between values 10 km and 20 km (Figure 4).

Figure 4
Example of Using the Chromatic Scale



How to Calculate the Exact Hex Code of the Colour Associated With an Earthquake

In the numbers indicating the magnitude and depth of the shock, the whole number and the decimals indicate the squares to take into consideration and, therefore, the colours to choose. Each square consists of **100 colour units** and different calculations will be done for the magnitude and depth.

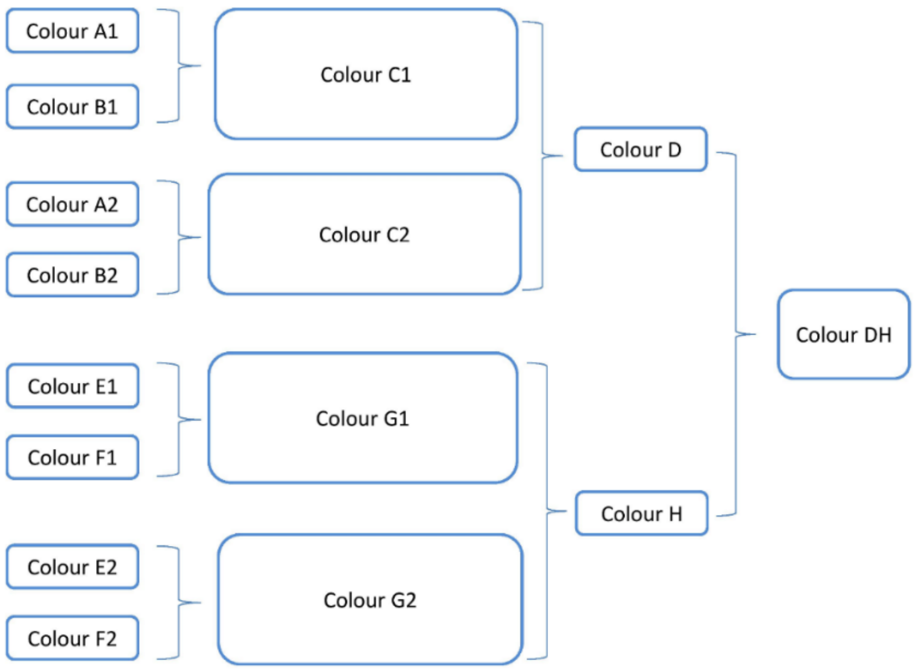
For the **magnitude**: based on the whole number and the decimals, a point in the scale and the colour units are chosen. If the number indicating the magnitude includes decimals, these are multiplied by 10. Therefore, if the **magnitude** is 6.3, 30 colour units (see highlighted decimal number) from the seventh square will be added to 70 colour units from the sixth square (the previous one) so that there is always a mix of 100 units of magnitude and 100 of depth. The whole number is always equal to 100 colour units: if the magnitude is 6, then 100 units from the sixth square will be used.

For the **depth**: based on the whole number and the decimals, a point in the scale and the colour units are chosen. If the number indicating the depth consists of a whole number and decimals, the last two figures will be used to find out the amount of colour to use; this amount will be then added to the colour units from the previous square to reach the total of 100. For example, if the depth of an earthquake is 11.1 km, 11 colour units from the third square (see the highlighted figures) will be used and then added to 89 colour units from the previous square. If the depth is 10.1 km, 1 colour unit from the third square will be added to 99 units from the previous square. Again, if the depth is 9.5 km, 95 colour units from the second square will be added to 5 units from the first. In case the number does not include decimals, the unit number will be multiplied by 10. For instance, if the depth is 12 km, the unit number will be multiplied by 10 (2 X 10 = 20): as a result, 20 colour units from the third square will be added to 80 colour units from the second. If, as a further example, the depth is 5 km, the multiplication will be 5 X 10 = 50, which means that 50 colour units from the second square will be added to 50 colour units from the first.

To calculate the HEX code of an earthquake's colour, 5 steps are required.[1] In the following graph (Figure 5), colours are identified by the first letters of the alphabet. Colours A1 and B1 are the colours from the two squares which are mixed following the rules explained above. The same rules apply for colours A2, B2, E1, F1, E2 and F2:

1. To find colours C1 and C2 (magnitude and depth) - direction from right to left on the scale. For the **depth**: based on the indicator on the scale, N number of colour units from a square will be added to the units from the previous square, in case that is necessary to reach the total of 100 units. For the **magnitude**: based on the indicator on the scale, N number of colour units from a square will be added to the units from the previous square, in case that is necessary to reach the total of 100 units.
2. To find colours G1 and G2 (magnitude and depth) – direction from left to right. See point 1 above, but follow direction from left to right on the scale.
3. To find colour D, add 50% of colours C1 to 50% of colour C2.
4. To find colour H, add 50% of colour G1 to 50% of colour G2.
5. To find colour DH, add 50% of colour D to 50% of colour H.

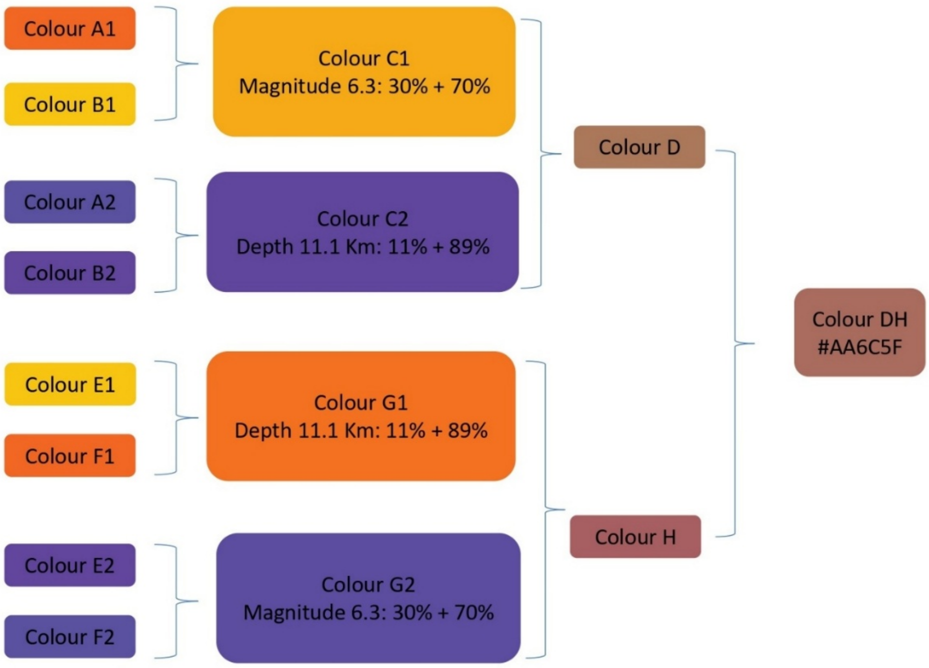
Figure 5
Steps to Calculate the HEX Code of an Earthquake's Colour



[1] A faster calculation can be done using the ColourQuake Web App, available at https://www.colourquake.org (ColourQuake, 2023).

Figure 6 shows an example of a calculation of HEX code for the colour associated with an earthquake of 6.3 Richter magnitude and 11.1 km of depth.

Figure 6
Example of a Calculation of HEX Code



The Mathematical Formula[2]

The calculation is done using the R, G and B components of a colour, which correspond to the hexadecimal colour code. For example, for #123456 the red component is 12 (N_{Red}), the green one is 34 (N_{Green}) and the blue one is 56 (N_{Blue}); the code does not influence the calculation as it is just the way to represent colours on a numerical basis in a digital device. Each component ranges from hexadecimal 00 to FF, which correspond to decimal numbers from 0 to 255.

As a result, there are 256x256x256 different possible colour hues.

The three components of the colours connected with an earthquake's magnitude and depth are calculated starting from the respective, previously identified HEX codes.

Here are the formulas for the Red component; the others are calculated in a similar way, by simply substituting N_{Red} with N_{Green} and N_{Blue}.

From each component of the reference squares, the starting colours (C1 and C2), as shown in the previous graph, can be calculated:

$$C1 = N_{Red}(1 - (Magnitude - int(Magnitude))) + N_{Red\ Next}(Magnitude - int(Magnitude)) \quad (1)$$

[2] In the algorithm, *int* represents the integer part of the magnitude or the depth, isolating the decimal for interpolation purposes. *Next* refers to the value of the next colour in the scale, enabling a smooth transition between two consecutive colours based on the decimal part.

The same formula applies for colour G1:

$$C2 = N_{Red}(1 - (Depth - int(Depth))) + N_{Red\ Next}(Depth - int(Depth)) \quad (2)$$

The same formula applies for colour G2:

We have now obtained 4 colours, C1, C2, G1 and G2, which are added up (1 and 2 stand for the 2 different directions on the scale):

Component RGB, colour D = (Component RGB C1 + Component RGB C2) / 2 (3)
Component RGB, colour H = (Component RGB G1 + Component RGB G2) / 2 (4)

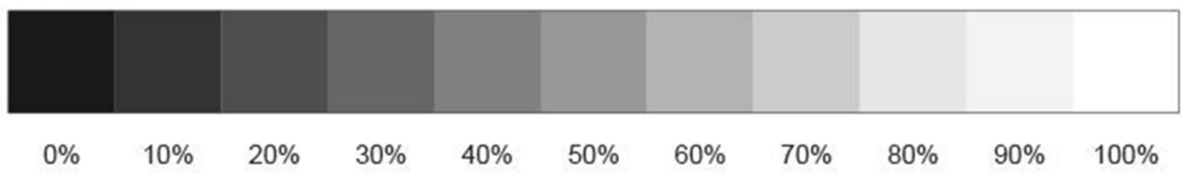
Lastly, the final colour DH is calculated:

Component RGB, colour DH = (Component RGB D + Component RGB H) / 2 (5)

Results

Every colour can be assigned its own Light Reflectance Value (LRV), a measure of the percentage of visible light reflected by a surface. LRV ranges from 0% to 100% with 0% being an absolute black and 100% being a pure, perfectly reflecting white. Absolute black and perfectly reflecting white are colours that do not exist in our everyday life. Roughly speaking, the blackest black has an LRV of 5% and the whitest white reaches 85% of LRV (Jacobsen, n.d.; Figure 7).

Figure 7
LRV Scale



Taking into consideration a number of colours, we can note that the LRV increases whereas the effect of an earthquake (magnitude + depth) decreases: they are two inverse sizes (Table 1).

Table 1 shows the colours of hypothetical earthquakes and their associated LRV. The graph features two “poles”: on the left side, the colours are close to “purple red” and are associated with stronger earthquakes; it is noteworthy to highlight that this area of the graph shows low LRV values. On the right side, the colours tend to fade towards green and the earthquakes associated with them are weaker: in this area of the graph LRV values are higher.

Furthermore, from the graph we can note the presence the value LRV the same which correspond to different couples of depth and magnitude. These values indicate the presence of symmetries on the graph. Therefore, earthquakes with different values magnitude and depth can develop the same effect. Example: an earthquake with magnitude 6 and depth 50 (≈ 32.0%) could have a similar result to an earthquake with magnitude 3.5 and depth 20 (≈ 32.0%).

The progressive increase in LRV values with depth is due to the attenuation of the earthquake's perceived intensity. As depth increases, the surface impact of the earthquake diminishes, resulting in less intense colours and higher light reflectance.

However, in the last column (70 km), a slight decrease in the LRV value is observed, likely caused by the limitations of the chromatic model: at extreme depths, the algorithm tends to stabilize, generating colours that reflect less light (darker or more subdued colours).

The compensation between magnitude and depth can lead to non-linear results, as shown in the table.

Table 1
Display of Some Combinations of Magnitude and Depth With Associated LRVs

	D 2	D 2.5	D 3.5	D 5	D 10	D 20	D 30	D 40	D 50	D 70
M 8	#9C2A56 ≈ 9.4%	#9D2B56 ≈ 9.6%	#9D2D57 ≈ 9.7%	#9F3158 ≈ 10.3%	#A33E5B ≈ 12.0%	#A25958 ≈ 15.5%	#99635B ≈ 16.5%	#8C6B6A ≈ 17.1%	#717168 ≈ 16.3%	#67674F ≈ 13.1%
M 7.5	#A03659 ≈ 10.8%	#A1375A ≈ 11.0%	#A13A5A ≈ 11.3%	#A33E5B ≈ 12.0%	#A74A5E ≈ 13.9%	#A6655B ≈ 18.2%	#9D705F ≈ 19.6%	#90786E ≈ 20.5%	#757E6C ≈ 19.8%	#6C7452 ≈ 16.3%
M 7	#A4425C ≈ 12.6%	#A5445C ≈ 12.9%	#A5465D ≈ 13.2%	#A74A5E ≈ 13.9%	#AB5661 ≈ 16.2%	#AA715E ≈ 21.2%	#A17C61 ≈ 22.9%	#948471 ≈ 24.0%	#798A6E ≈ 23.4%	#708155 ≈ 19.8%
M 6.5	#A4505B ≈ 14.4%	#A4515B ≈ 14.5%	#A5545C ≈ 15.1%	#A7585D ≈ 16.0%	#AB645F ≈ 18.6%	#AA7F5C ≈ 24.5%	#A18960 ≈ 26.3%	#94926F ≈ 28.0%	#79986D ≈ 27.6%	#708E54 ≈ 23.4%
M 6	#A45D59 ≈ 16.4%	#A45F59 ≈ 16.8%	#A5615A ≈ 17.3%	#A6655B ≈ 18.2%	#AA715E ≈ 21.2%	#A98C5A ≈ 27.9%	#A0975E ≈ 30.4%	#949F6E ≈ 32.2%	#78A56B ≈ 32.0%	#6F9C52 ≈ 27.8%
M 5.5	#9F635B ≈ 17.1%	#9F645B ≈ 17.2%	#A0665C ≈ 17.8%	#A26A5D ≈ 18.8%	#A67760 ≈ 22.1%	#A5925C ≈ 29.3%	#9C9C60 ≈ 31.7%	#8FA570 ≈ 33.9%	#74AB6D ≈ 33.9%	#6BA154 ≈ 29.3%
M 5	#9A685D ≈ 17.6%	#9B695D ≈ 17.9%	#9B6C5E ≈ 18.5%	#9D705F ≈ 19.6%	#A17C61 ≈ 22.9%	#A0975E ≈ 30.4%	#97A162 ≈ 33.0%	#8AA971 ≈ 35.0%	#6FAF6F ≈ 35.2%	#66A656 ≈ 30.8%
M 4.5	#946C64 ≈ 17.9%	#956E65 ≈ 18.5%	#957065 ≈ 18.9%	#977466 ≈ 20.0%	#9B8069 ≈ 23.4%	#9A9B66 ≈ 31.3%	#91A56A ≈ 34.0%	#84AE79 ≈ 36.6%	#69B477 ≈ 37.0%	#60AA5E ≈ 32.0%
M 4	#8E706C ≈ 18.4%	#8E726C ≈ 18.9%	#8F746D ≈ 19.4%	#90786E ≈ 20.5%	#948471 ≈ 24.0%	#949F6E ≈ 32.2%	#8AA971 ≈ 35.0%	#7EB280 ≈ 37.8%	#63B87E ≈ 38.4%	#59AE65 ≈ 33.3%
M 3.5	#81736B ≈ 18.0%	#81756B ≈ 18.5%	#82776C ≈ 19.0%	#837B6D ≈ 20.1%	#878770 ≈ 23.6%	#86A26C ≈ 32.0%	#7DAC70 ≈ 35.0%	#71B580 ≈ 38.1%	#55BB7D ≈ 39.0%	#4CB164 ≈ 33.9%

M: magnitude D: depth in km #N: HEX code of the colour N %: LRV

Conclusion

This theory offers an innovative and interdisciplinary approach to visually interpreting earthquakes, combining science, mathematics, and art. By translating seismic data into a chromatic spectrum, this study makes the complex dynamics of earthquakes tangible and highlights the vulnerability of human environments in a form that resonates with diverse audiences.

This visual approach serves as a powerful tool to communicate risk and fragility in ways that numerical data alone cannot achieve. It transforms abstract information into a perceptual and emotional experience, fostering greater awareness, preparedness, and dialogue on seismic vulnerability.

By integrating visual culture and interdisciplinary methods, this research opens new pathways for incorporating scientific knowledge into public discourse, education, and disaster communication.

In a world increasingly threatened by environmental crises, tools like this become not only innovative but also essential for communicating the fragile balance between nature and humanity.

Publisher's Note

The manuscript contains colour images and texts highlighted in different colors. These have been intentionally kept as they aid in better understanding the paper. Please be aware of this if you intend to produce a printed copy of the manuscript.

References

ColourQuake. (2023). *ColourQuake Web App*. https://www.colourquake.org

Jacobsen. (n.d.). *What is Light Reflectance Value (LRV)?* https://connect.jacobsen.co.nz/knowledge/what-is-light-reflectance-value-lrv

United States Environmental Protection Agency. (2024, November 4). *What is pH?* https://www.epa.gov/goldkingmine/what-ph

Contact email: mario.savini@postinterface.com