# Using alternative methods to promote geoheritage: the Koziakas Mt., central Greece, case study

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## 1. INTRODUCTION

Koziakas Mt. in central Greece is an example of impressive geological formations, offering significant opportunities for both scientific research and the promotion of geoheritage. Its mountain range forms the edge of Pindos in the western part of Thessaly and rises imposingly from North to South.

Geologically, the area is located at the eastern boundary of the Pindus zone and at the western boundary of the Sub-Pelagonian zone, including the important ophiolitic formations of Koziakas. The Koziakas unit, belonging to the Sub-Pelagonian, is the transitional stage from the Pindus to the Pelagonian zone.

The advent of GIS software suites has revolutionized the way geological data is collected, analyzed, and visualized. Open-source GIS programs, provide cost-effective, efficient and user-friendly platforms to create models and visualizations. These tools are instrumental in overcoming challenges associated with communicating geological information. Nonetheless, the effective communication of such data frequently encounters obstacles, such as the complexity of geological concepts, the limitations of impractical and intricate visual editing software, and the absence of user-friendly scientific data presentation platforms. The latter is of particular importance for the effective promotion of geoheritage.

This paper explores how open-source tools, plugins and innovative visualisation techniques can address these challenges, using Koziakas Mt as a case study.

## 2. METHODOLOGY

The initial input to the area analysis is the geological maps and field data. For selected study areas, field data are collected, consisting of rock samples, images, linear, planar and point data such as rock formation dip planes, faults and locations of fossil finds. In addition, the input includes satellite orthophotos and Digital Elevation Models from the Hellenic Cadastre (Digital Elevation Model -DEM from the LSO25 project 25 m and LSO25 25 cm orthophotos, Hellenic Cadastre), the paths of the area from hellaspath.gr and OpenStreetMap for accessibility purposes (OpenStreetMap contributors, 2015).

The above, combined with the pre-existing geological knowledge for the area, results in the geological output data consisting of the West to East geological cross sections across the mountain (Figure 1), smaller scale flysch cross sections along the western valley, and fault raster and vector layers. Processing the data in QGIS results in the creation of background layers such as hillshade, slope aspect, contours and multispectral satellite layers, as well as vector layers such as the hydrology network.

For the visual results, the input data consists mainly of the above geological and geomorphological outputs. This is followed by processing through QGIS to create well presentable information layers, and later through the qgis2threejs plugin to structure the data using the three.js JavaScript framework and WebGL technology into a locally running 3D web view model. The layers containing the model's data were selected via the plugin's menu, utilizing also the data from the National Cadastre. Furthermore, a custom plane was incorporated to facilitate altitude experiments, concurrently serving as a water level surface to simulate local flooding scenarios (Figure 6). To enhance comprehension of the broader area's orientation, geological planes, and azimuth measurements, the north arrow option was enabled. The map's boundaries were defined using a polygon layer, and the model's background was set to resemble the sky. To enable the user to have multiple layers open simultaneously, one focused on the specific study area and another providing a broader context, the background raster images were separated into two layers: surroundings and background.

The visual outputs are divided into two categories: static and dynamic. The static output comprises 2.5D perspective images (Figure 2, Figure 7), which interpret the geological setting and geomorphology. These images can be used to accompany a digital or printed file. The dynamic output consists of a 3D interactive web model, which showcases all the study's data in multiple layers (Figure 3). This model can be accessed either locally or on the web (as outlined below). The 3D web model can be uploaded for online access, facilitating optimal practicality, via export to an HTML file. Then it can either be uploaded to an online drive service platform and published via Drive2web's free serverless hosting, or published directly through Netlify and viewed through a link on any web browser. The workflow involved in the publication process can be seen in Figure 5.

## 3. RESULTS AND CONCLUSIONS

The geological outcomes of the implemented methodology, which are directly associated with the geological aspect of the study, consist of the 2.5D static images, incorporating the geological cross-sections, as seen in Figure 2. As demonstrated in Figure 7, the integration of the two 2.5D static images in a single illustration serves to emphasize their position in relation to the Koziakas mountain range. The visual results include the most significant element of this study, the 3D web model (Figures 3 to 9).

Accessible via any web browser, the interactive 3D model provides a detailed visual representation of scientific data while highlighting the geological features of the Koziakas study area. The final model integrates various layers, including geological maps, cross sections, hydrology data, field observations (e.g. fault strike and dip, fossils, faults, and folds), contours, slope aspect maps, hillshade maps, satellite imagery, and nearby hiking trails. The user can create numerous combinations by utilizing all the layers and background data to extract the required information. Hillshade and slope-aspect maps, products from DEM processing from the National Cadastre (Digital Elevation Model -DEM from the LSO25 project (25 m), Hellenic Cadastre), geological maps of IGME (Savoyat and Lalechos, 1972; Karfakis, 1993) and contour topographical map are some of the additional raster layers. Figure 3 displays the model with all information layers activated and Figures 4 to 9 demonstrate different layer combinations, showcasing the diverse range of potential applications.

The Qgis2threejs plugin offers a significant advantage in its ability to export 3D models in the glTF format. This format is a widely recognized standard for 3D computer graphics (3DCG) and 3D printing. This capability opens opportunities for users to move beyond traditional GIS applications, enabling the creation of interactive 3D visualizations or detailed printed physical models, like the example from the Auberge des Dauphins – Maison de Site de la Forêt de Saoû, in France (Figures 10,11).

The visualizations created with this tool facilitate a deeper engagement with geological and cultural heritage sites, providing users with virtual access to areas that may be difficult to visit physically due to geographic or environmental constraints. Moreover, this creates a dynamic way to educate the public about their geological history. Furthermore, the 3D printing allows the physical replicas of geoheritage, and features such as rock formations, fossil sites, faults and folds, to be produced and displayed in educational institutions, museums, or cultural centres (Figure 10,11).

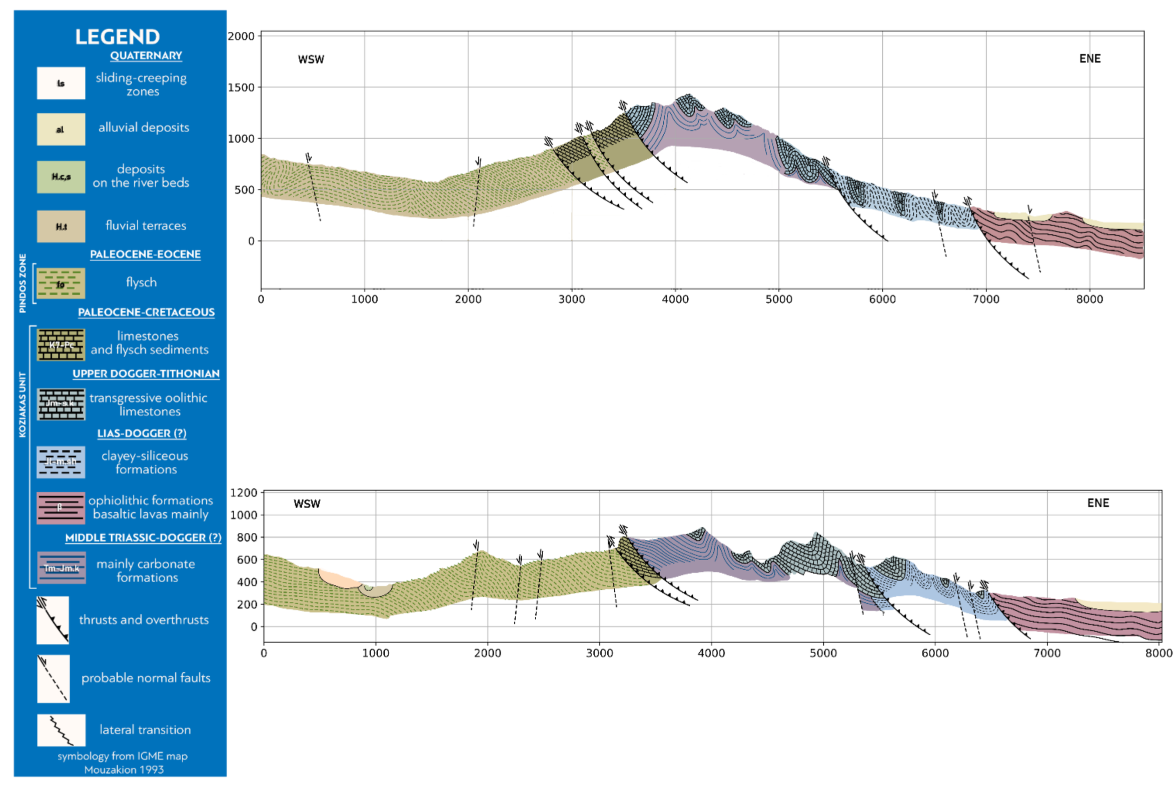


Figure 1. The two geological cross sections of the area, that were created and used for the two 2.5D models (created from data in Karfakis, 1993).

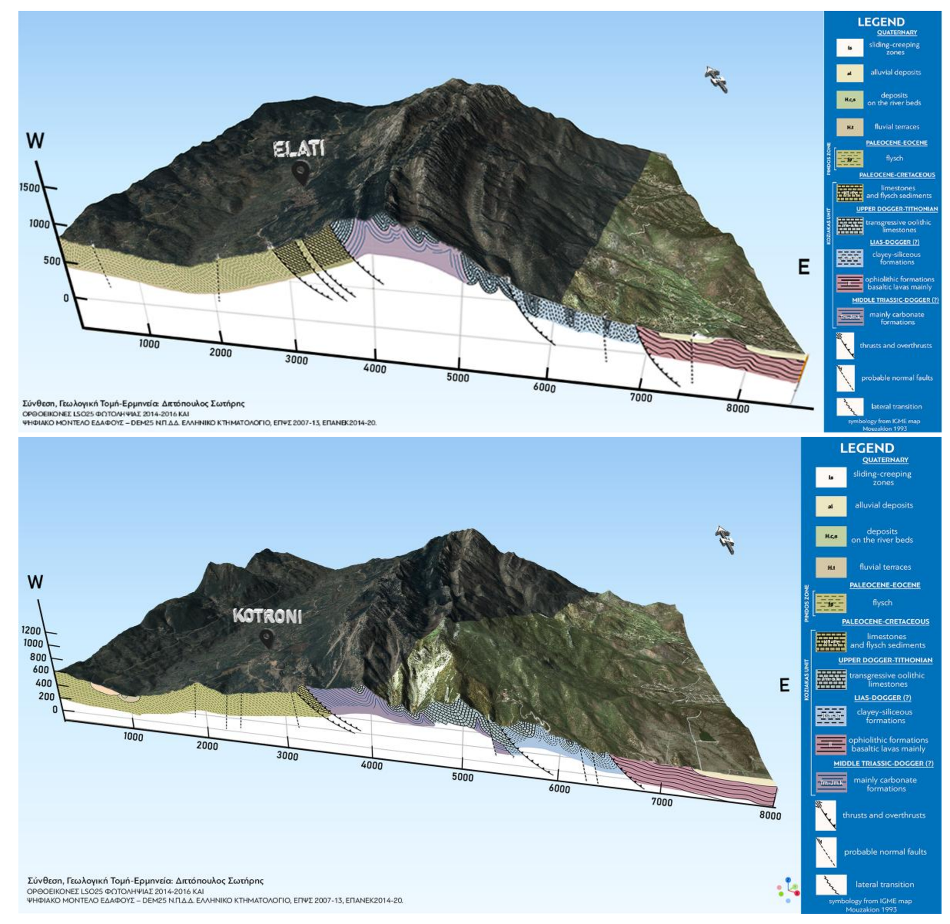


Figure 2. Illustration of the two 2.5D models featuring the geological cross-sections and their respective geological legends. Top: the northernmost geological cross section, located near the settlement of Elati. Bottom: the southernmost geological cross section, located near the settlement of Kotroni. The Qgis2threejs plugin model was utilized to capture the screenshots (Digital Elevation Model -DEM from the LSO25 project (25 m) and LSO25 (25 cm) orthophotos, Hellenic Cadastre).

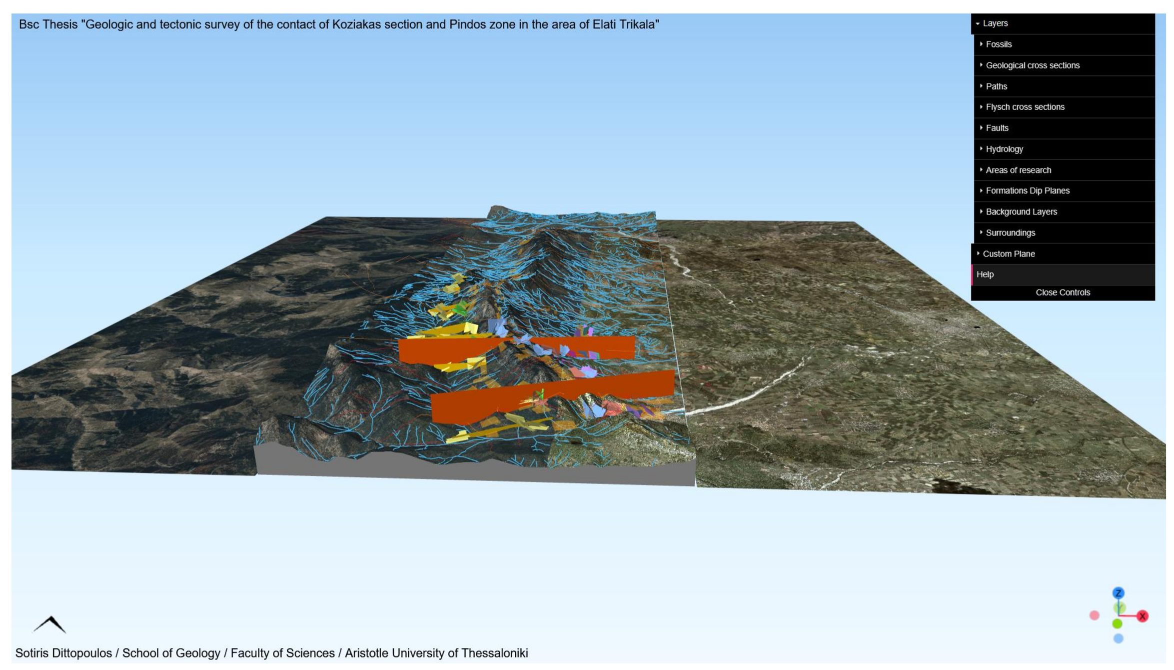


Figure 3. Screenshot of the model while all the different layers of information are activated (Digital Elevation Model -DEM from the LSO25 project (25m) and LSO25 (25cm) orthophotos, Hellenic Cadastre).

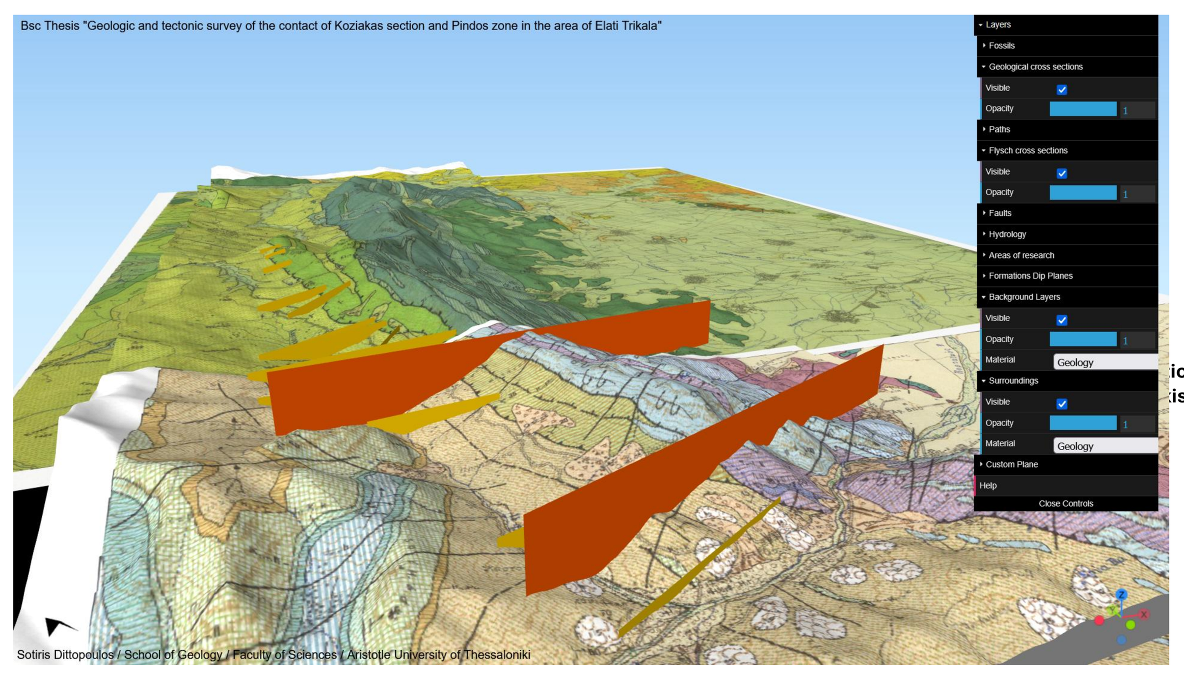


Figure 4. Screenshot of the model, illustrating the information of three layers: locations of flysch cross sections, geological cross sections and background layer: geological map of IGME (Mouzakion and Kalambaka sheets, Savoyat and Lalechos, 1972; Karfakis, 1993).

SCAN TO VIEW THE MODEL

https://koziakas-model.netlify.app/

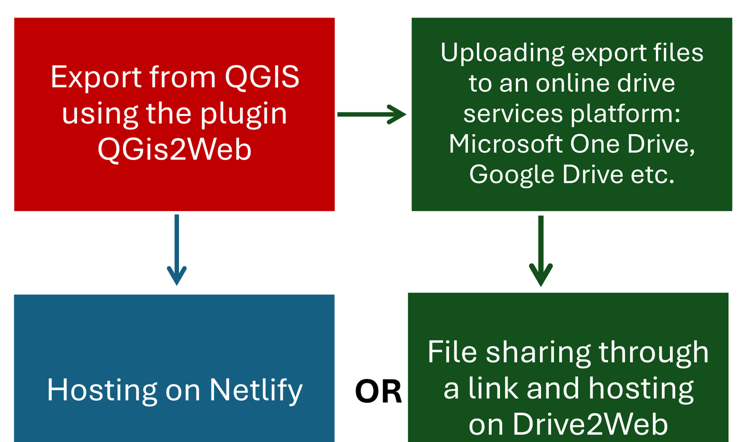


Figure 5. Illustration of the process that was followed from exporting using Qgis2threejs, to the hosting of the model.

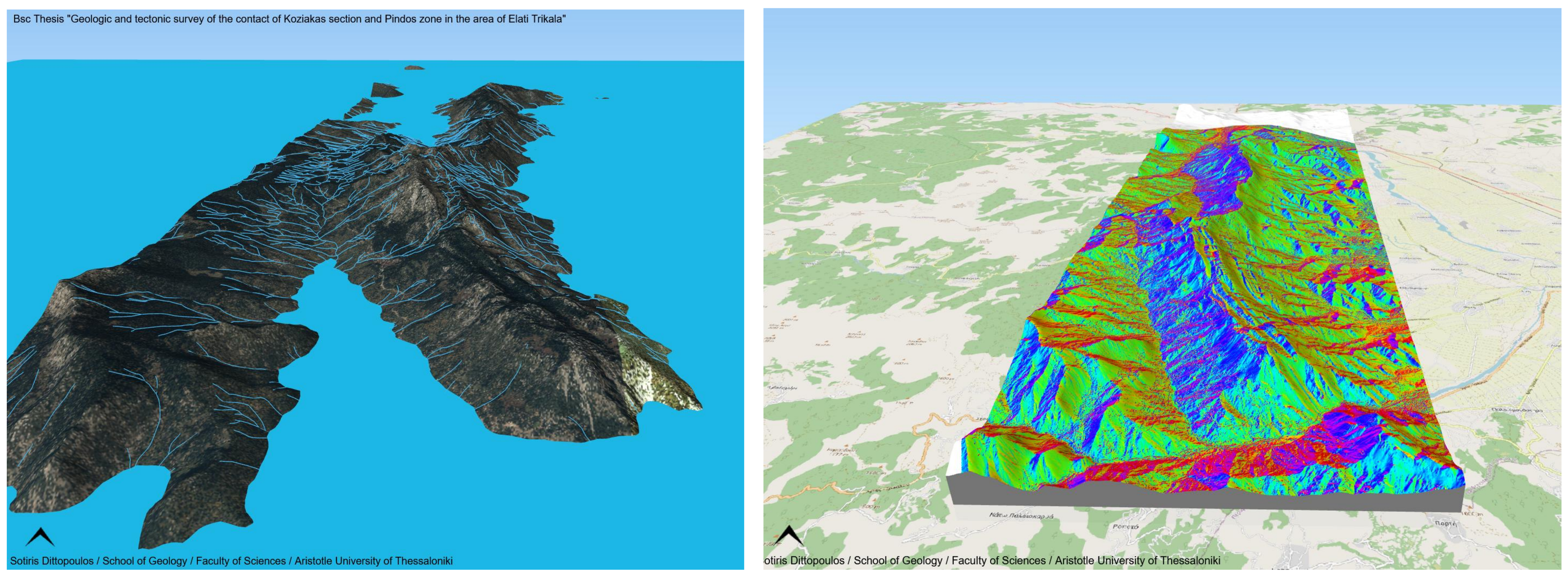


Figure 6 Screenshots of the model. Left: illustrating the information of two layers: background layer: satellite and surroundings layer: custom plane. Right: illustrating the information of two layers: background layer: slope-aspect map and surroundings layer: OpenStreetMap (Digital Elevation Model -DEM from the LSO25 project (25m) and LSO25 (25cm) orthophotos, Hellenic Cadastre).

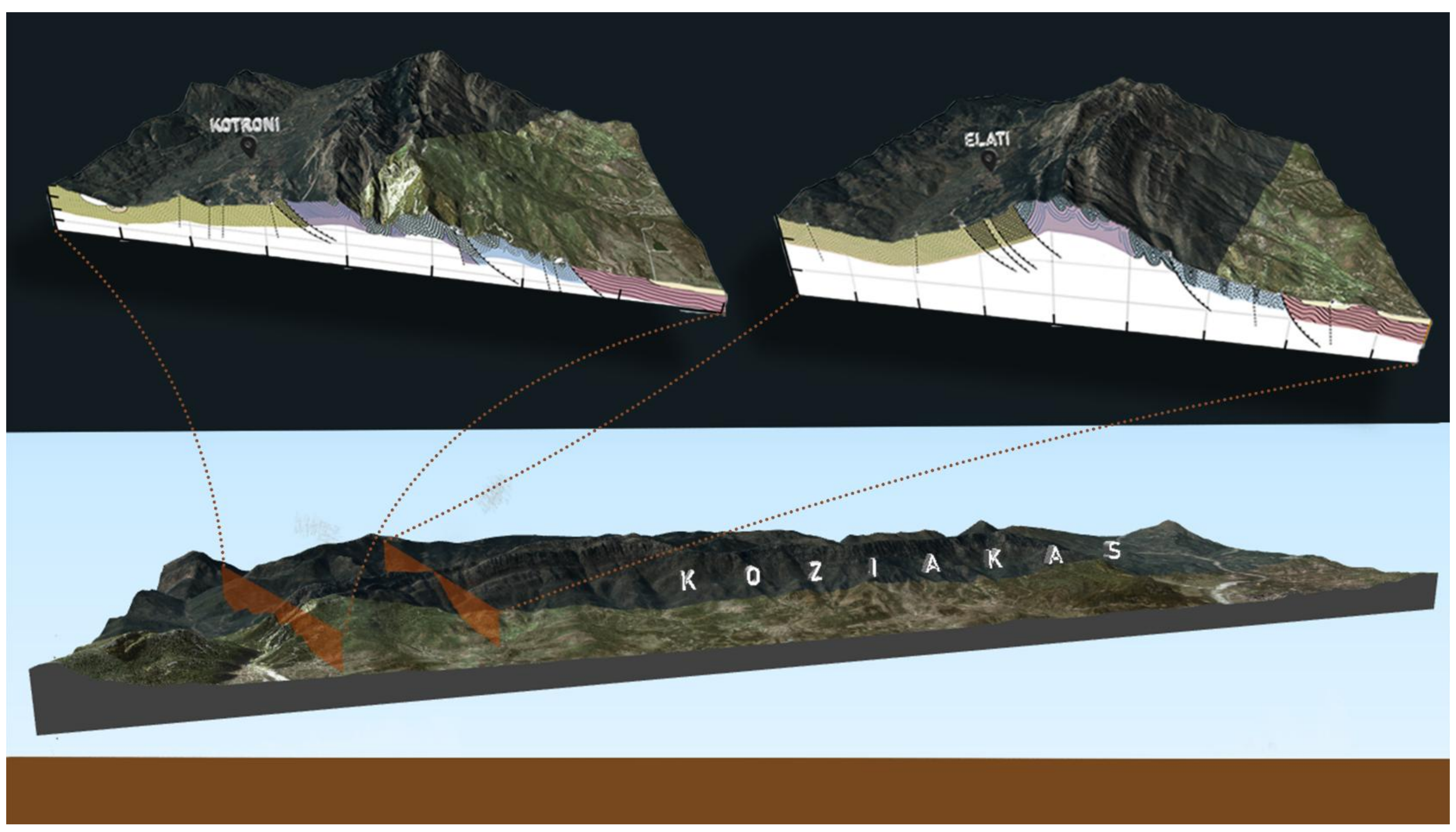


Figure 7 Illustration of the two 2.5D models featuring the geological cross-sections and their position in relation with the Koziakas mountain range. The Qgis2threejs plugin model was utilized to capture the screenshots (Digital Elevation Model -DEM from the LSO25 project (25 m) and LSO25 (25 cm) orthophotos, Hellenic Cadastre).

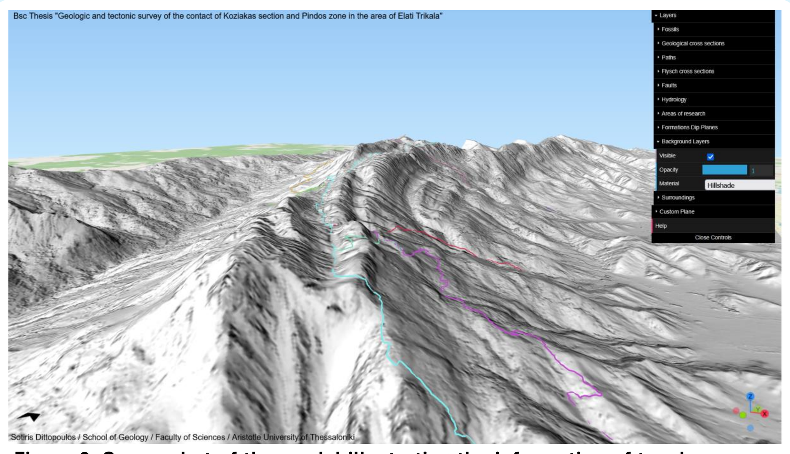

Figure 8. Screenshot of the model illustrating the information of two layers: background layer: hillshade and paths (Digital Elevation Model -DEM from the LSO25 project (25m), Hellenic Cadastre).

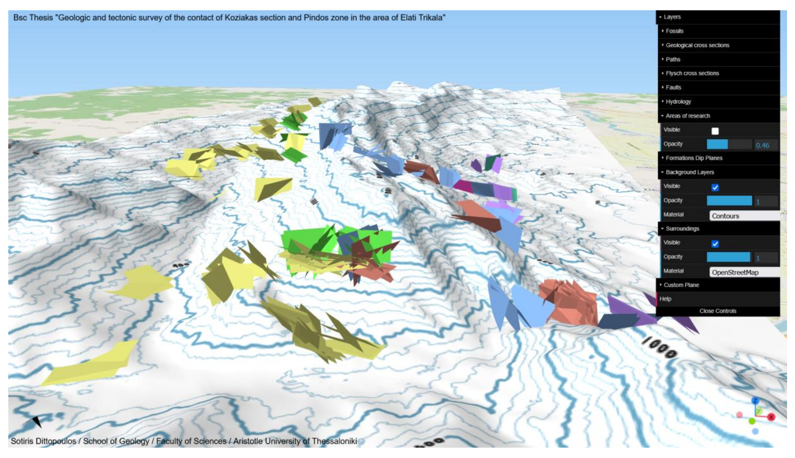

Figure 9 Screenshot of the model illustrating the information of two layers: background layer: contours and formations' dip planes.

Figure 10. Example of how a 3D model can be printed and exhibited. Museum: Auberge des Dauphins – Maison de Site de la Forêt de Saoû, France.

Figure 11. Example of how a 3D model can be printed and exhibited. Museum: Auberge des Dauphins – Maison de Site de la Forêt de Saoû, France.

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Tools

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Digital data

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