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Immersive virtual reality for studying volcano-tectonic features: A case study from the northern active rift zone of Iceland

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Very often, geologists are unable to access some outcrops because of their location in remote or dangerous areas and associated hard logistic conditions. To overcome such difficulties in sites investigation, the Aerial Structure from Motion is a helpful technique that allows a very high-detailed 3D model reconstruction of relevant outcrops, providing also the possibility to cover very wide areas. Even though this approach is nowadays widely used in Earth and Environmental Sciences, we think that an advancement in data collection from 3D models as well as in the exploration of 3D reconstructed environments is needed. This is why we tested the use of immersive virtual reality for studying volcano-tectonic features such as normal faults, extensional fractures, dykes and volcanic vents. The key area for this test is the active Northern Volcanic Zone of Iceland where several outcrops have been reconstructed in the framework of the Italian Argo3D project (http://argo3d.unimib.it/). In particular, the areas we focused our attention on are the Theistareykir and Krafla Fissure Swarms, both of which experienced fracturing, volcanic unrest and eruptions in Holocene and historical times.
The resulting reconstructed ambient were explored using different modalities: on foot, as is often the case during field activity, moving like a drone, above and around the target, as well as flying like an airplane. Thanks to these modes of exploration we were capable of better understanding the geometry of extension fractures, scoria cones and normal faults. We measured systematically, in the virtual environment, the opening direction and the amount of dilation along the extensional fractures, the direction of magma-feeding fractures underlying cones and volcanic vents, as well as the amount of vertical offset along normal faults. The quantification and mapping of these features was accomplished through some tools tailored for virtual field activity in the framework of Argo3D and 3DTeLC Erasmus+ projects (https://sites.google.com/port.ac.uk/3dtelc/).
Thanks to this approach we collected thousands of data and we were capable of defining the Holocene spreading vector direction and the stretch ratio in the area with an unprecedented level of detail; moreover, we provided a more complete picture of the deformation processes that have been taking place in this sector of the Icelandic rift.