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Integrated geological-geophysical and UAS proximal sensing approach to the study of ground water movement between two open-pit pools in an abandoned mine area.

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The aim of this work is to combine geological/geophysical techniques with proximal sensing based on Unmanned Aerial System (UAS) for advanced 3D modeling, in a possible post-mining landscape recovery of abandoned mine sites. In this framework a test area in central Sardinia (Italy) was studied. In this area, several talc-chlorite-feldspar bodies have long been mined in open pit operation greatly modifying the original landscape. At present the rearrangement of the mining site and particularly the open pit works that have been occupied by newly formed pools filled with waters from aquifers can be considered an overall project of landscape recovery. The project team have focused on developing a UAS proximal sensing technique for the acquisition of high-definition digital images and by means of photogrammetric algorithms (CMPMVS) in order to generate a dense 3D point cloud and successively high-resolution digital models (DSM and DTM). The proximal sensing survey was performed at different flight heights to obtain a Ground Sample Distance (GSD) according to the scale of investigation. The availability of a detailed topographic dataset is fundamental to characterize a complex morphology and is a basic support for integration with the data resulting from the geological-geophysical survey conducted in the abandoned mine area. Based on this a geophysical investigation by the electromagnetic very low frequency (VLF) method was carefully planned and carried out to localize potential structural discontinuities that can guide groundwater circulation between the newly formed pools encased in the crystalline basement rocks. The VLF method has a high-resolution power in detecting lateral variations in the electrical properties (i.e., conductivity) of the rock formations related to the presence of underground geological structures. To facilitate the interpretation of the VLF-EM anomalies the Karous–Hjelt linear filter was applied on the EM data. Thanks to the application of this filtering procedure, it was possible to obtain the current density pseudosections along the profiles crossing the basement rocks. The pseudosections provide a representation of the various current concentrations in depth and hence the spatial arrangement of subsurface geological features such as faults, fracture zones and geological contacts. The VLF data were also quantitatively interpreted with a 2D code for the VLF data inversion. Both in the pseudosections and in the 2D resistivity models two main conductive zones are present. These conductive zones

could be the signature of a preferential path of the water circulation between the newly formed pools encased in the basement rocks. The application of the integrated geological-geophysical and UAV photogrammetric survey approach proved successful in characterizing the basement rocks of the investigated area and allowed to localize structural discontinuities that can guide the groundwater circulation. The results of this study can represent the indispensable knowledge base to contribute to constraining the hydrogeology numerical model needed for the mine site rehabilitation and reasonable planning of the possible post-mining landscape recovery. The methodological sequence used in this study can be reproduced in other similar abandoned mining sites thus giving an important contribution to an efficient and cost-effective performance of the restoration project.