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A numerical approach for the evaluation of hydrogeological changes of the Sibillini hydrostructure after the Mw 6.5 Norcia earthquake

Zullo E.[1], Albano M.[2], Saroli M.[1,2], Moro M.[2], Testa G.[1], Bonora N.[1], Petitta M.[3], Reimann T.[4]

[1] *Dipartimento di Ingegneria Civile e Meccanica, Università degli Studi di Cassino e del Lazio Meridionale*
[2] *Istituto Nazionale di Geofisica e Vulcanologia INGV-Roma*
[3] *Dipartimento di Scienze della Terra, Università degli Studi di Roma "La Sapienza"*
[4] *Institute of Groundwater Management, Technische Universität Dresden, Germany*

The 2016 Central Italy seismic sequence, which resulted from the rupture of different segments of the Vettore-Bove normal fault system, drastically changed the hydrodynamics of the carbonate aquifer system of the Sibillini Mts. Significant hydrogeological variations were observed at the springs and along the main drainage system after the M_w 6.5, 30 October main shock (the Norcia earthquake). A sustained increase in discharge occurred in the Nera River basin, located in the western sector of the Sibillini Mts., whereas a strong discharge reduction and water-table decrease affected the eastern side.
The "aquifer fault rupture" mechanism was invoked to explain the observed permanent hydrogeological variations, suggesting an eastward shift of the piezometric divide of Vettore Mt. after the Vettore fault rupture (Mastrorillo *et al*., 2020).

In this work, we aim at assessing the hydrodynamic response of the fractured carbonate aquifer system of the Sibillini Mts. to the coseismic dislocation of Vettore fault. To this purpose, we used a numerical approach to develop a geomechanical model, calibrated using the interferometric SAR data, which simulates the Vettore fault rupture, coupled with a hydrological numerical model for the simulation of the groundwater flow before and after the earthquake.
We collected geological and hydrogeological data from the available literature. We first defined a hydrogeological conceptual model, and we created a simplified 3D geometric model at surface scale (up to 2 km depth) to define the spatial relations between the main tectonic structures and the boundaries of the hydrogeological complexes. Then we performed a numerical analysis to create a regional scale hydrogeological model. We simulated the groundwater flow, in steady-state conditions, in two different scenarios:

i) at the pre-rupture stage, we considered faults as hydraulic barriers with a lower permeability than that of the carbonate aquifer system;
ii) at the post-rupture stage, we assumed an increased permeability for the Vettore normal fault.

The computed distributions of the hydraulic head and the directions of groundwater flux are qualitatively consistent with the water-levels observations and discharge values measured before and after the earthquake. Future work will be devoted to the development of a full 3D geomechanical model for the simulation of the Norcia earthquake and the estimation of the crustal stress and strain changes. The latter will be exploited to assess permeability changes in the crust and to calibrate the post-earthquake hydrological model.

References:

Mastrorillo L., Saroli M., Viaroli S., Banzato F., Valigi D. & Petitta M. 2020. Sustained post-seismic effects on groundwater flow in fractured carbonate aquifers in Central Italy. Hydrological Processes, 34(5), 1167–1181.