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edited by
Fabrizio Marignetti – Salman Ali – Romolo Di Bernardo




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# The hydrogeological response of the Sibillini hydrostructure to the $M_w$ 6.5 Norcia earthquake: conceptual model and numerical analysis

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**Abstract**

Keywords: earthquake, Groundwater, numerical modeling

The Sibillini Mts. hydrostructure is characterized by the coexistence of a shallow and a basal regional aquifer [1] whose spatial distribution, recharge area and groundwater dynamics are strongly controlled by a complex regional tectonic framework.
The 2016 Central Italy seismic sequence, which resulted from the rupture of the Vettore-Bove normal fault system, drastically changed the hydrodynamics of the carbonate aquifers of the Sibillini Mts., causing sustained variations in groundwater flow and resulting in several issues for the local water supply system. Significant hydrogeological changes occurred especially after the Mw 6.5, 30 October main shock (the Norcia earthquake), the most important of which include: i) a surplus of groundwater discharge at springs bordering the western side of the Sibillini Mts. and along the main drainage system of the Nera River basin; ii) the reappearance of Torbidone spring in the Norcia plain, dry since 1979 [2, 3] and iii) a strong discharge reduction and water-table decrease at the Adriatic springs located at high altitude, on the eastern side of the Sibillini Mts.
Considering previous recent studies [4] and according to Mastrorillo *et al.* [5], the "aquifer fault rupture" mechanism better explain the observed permanent hydrogeological variations, coupled with the general increase in bulk crustal permeability, related to the dynamic stress induced by the seismic waves' propagation [6].

In this work, we aim at assessing the hydrodynamic response of the fractured carbonate Basal Aquifer of the Sibillini Mts. to the coseismic dislocation of the Vettore fault by using a multidisciplinary approach and numerical analysis as a main tool.
To this purpose, we collected geological and hydrogeological data to first define a hydrogeological conceptual model, which represents the supporting structure of numerical analysis. We created a simplified 3D geometric model at surface scale (up to 2 km depth) to reconstruct the Basal Aquifer bottom surface and to define the spatial relations with the main tectonic structures.
Then we performed a numerical analysis to create a regional scale hydrogeological model to simulate the groundwater flow, in steady-state conditions, in two different scenarios:

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

The computed distributions of the hydraulic head and the directions of groundwater flow are qualitatively consistent with the water-levels observations and discharge values measured before and after the earthquake.
Future work will be devoted to the calibration of the models. We are going to perform an automatic calibration of the hydrogeological models in order to estimate the hydraulic parameters, by using the available discharge values and water table measurement as calibration targets. In addition, a full 3D geomechanical model for the simulation of the Norcia earthquake will be developed, calibrated using a fem numerical inversion of interferometric SAR data available for the 30 October earthquake, to estimate the crustal stress and strain variations. The coseismic volumetric strain changes obtained by the simulation of the seismogenic fault dislocation will be exploited to assess the permeability changes in the crust. This latter will be compared with the results obtained from the calibrated hydrogeological model.

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