DISCHARGE VARIATIONS OF SPRINGS INDUCED BY STRONG EARTHQUAKES: THE CASE OF THE Mw 6.5 NORCIA EVENT (ITALY, OCTOBER 30TH 2016)

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Earthquakes are known to be responsible for modifications of different kind in hydrological systems, such as variations of water wells levels, transient and permanent changes of springs and streams discharge and alteration of water chemistry. Transient or instantaneous increases of spring discharge have been documented in several cases. These are frequently related to co-seismic temporary increase of water pressure and/or to dynamic strain modifications which induce temporary changes in permeability. This kind of variations generally dominate in the far and in the intermediate field. Permanent or long lasting changes of spring discharge are more frequent in the near field, where modifications of the stress state induced by fault movement can cause permeability variations and changes in groundwater circulation. In particular, long lasting spring excess flow is known to accompany major normal faults earthquakes.
On October 30th 2016 a M_W 6.5 earthquake occurred in Central Italy, about 5 km NNE of Norcia, at a depth of about 10 km. This has been the strongest earthquake of a long sequence, starting on August 24th, near Amatrice (M_W=6.0), and continuing for several months with earthquakes of M_W up to 5.9. All the mainshocks of the sequence show a normal fault mechanism, NNW-SSE trending, coherent with the well-known regional extensional field.
The sequence significantly affected the groundwater circulation of the area, particularly after the October 30th event. Right after the main shock, in the Norcia plane the Torbidone spring, which was dry since the 1979 Norcia earthquake (M_W= 5.9), was suddenly re-activated and its discharge continued to rise during the following weeks, reaching a value of about 1500 l/s in January 2017. The Torbidone spring is part of the Nera basin, and feeds the Sordo River, where an additional discharge increase was also observed.
In this study, using a multidisciplinary approach (hydrogeologic, structural, geochemical and isotopic), we analyse the Torbidone spring and its geological framework, with the aim of identifying the possible causes of the observed perturbation and forecasting the possible mid-term / long-term evolution, both in terms of flow regime and groundwater quality.
The main factor, which are thought to be responsible for the observed hydrological perturbation are:

- variations of structural permeability, both localized along the major fault zones and distributed in the hangingwall rock volume;
- variations of hydraulic gradients to be related with differential subsidence of aquifer hosting structures.

In fact, InSAR measurements of ground deformation outlined the presence of a large (about 30 km × 10 km) NNW-SSE elongated, subsiding area, located at the hangingwall of the major causative fault, producing up to 80 cm of subsidence with deformation gradients up to 30 cm/km. A large number of surface fractures were also mapped over a large area, suggesting a general, significant increase of structural permeability.