Research activity

Hydrogeological monitoring for assessing the interaction between changes in groundwater and tectonically active areas

General objective: The identification of the main processes that drive the hydrogeological and hydrogeochemical changes in groundwater of central Apennines, seismically active area, by the analysis of the monitoring results based on the new national monitoring network di ISPRA-INGV and the collaboration with the PNRR project RETURN.

Specific objective: Identifying the possible interaction between groundwater anomalies and seismic events: observing and studying any changes in chemical-physics properties of spring and groundwater during seismic events in central Italy.

State of the art: The study of hydrogeological and hydrogeochemical anomalies is raising a great interest from the scientific community to broaden knowledge related to seismicity. From a physical point of view, there is the possibility that processes that occur inside the earth's crust, tens of kilometers deep and which release large quantities of energy, are preceded by some signals recognizable at terrestrial surface level [1]. In literature, different studies confirm how some properties of rocks change drastically during the preparation processes for a seismic event. Scientific community interest is focused on hydrogeochemical anomalies connected to seismic-tectonic activity, since geoscientists are trying to find out, if it exists, a relationship between variations in deep fluid flows and seismic events [2]. The difficulty in following this approach is due to the fact that the changes in the chemical-physical state of groundwater do not derive only from seismic or pre-seismic activity [1]. From a hydrogeochemical point of view, in the seismic field, there are some evidences of changes in the isotopic composition and in dissolved and free gases [3], in the values of pH and electrical conductivity [4] and in radon activity [5]. Most interpretations agree in conferring the hydrogeochemical anomalies to the mixing of groundwater between different aquifers under the guidance of crustal dilation caused by seismic event [3]. The hydrogeological effects, that could occur during a seismic cycle, mostly during a strong earthquake, are being studied and documented as they can be observed even at great distances [6]. Among them, it is important mention the appearance and/or disappearance of springs, the variations of flow rate and variation in the static level in wells [7]. Moreover, it goes underlined how the variations in the flow rate of underground fluids are recorded not only during the period co-seismic and post-seismic, but also during the interseismic and pre-seismic phase [8]. The change in flow rate can induce the variation of pore pressure which could explain the increase or decrease of the water table and the variations of chemical composition of fluids. During a seismic cycle, deep fluids, driven by variations of pore pressure and the permeability, can rise on the surface some weeks or months before medium or strong earthquakes and produce a mixing between waters with different chemical properties. In Iceland, from 2000s, 2 wells are under monitoring (HA01 and HA02), located 20 km from Húsavik, a zone characterized by earthquakes more than 5 M_W. Studies have highlighted geochemical anomalies from eight months to a month before the 2014 Bárðarbunga eruption, during which an increase of metal ions as B, Al, V, Li and Mo have been recorded [9]. There was a further increase in Ga and V, starting from a few months to a few days before the eruption itself. An increase in trace elements was also noted, including Li, B, Sr, Rb first of the seismic event of magnitude Mw 5.0

recorded approximately 80 km from the HA01 well. In Italy, however, the Monte Morrone Fault was monitored, near Roccacasale (AQ), in Abruzzo, for about a year before the Amatrice earthquake of August 2016 of magnitude Mw 6.0 [10]. During the monitoring of the springs in the central Apennines a change in pH and an increase in As, V and Fe were recorded before the start of the seismic cycle. In November, the same elements recovered the pre-earthquake concentrations [11]. So, similarly to what happened in Iceland, deep fluids containing hydrothermal elements (enriched with the aforementioned chemical elements) have ascended along the new fissures created during the seismic cycle reaching the shallow groundwater and mixing with them.

Activity: The research activity is part of a collaboration of Sapienza with ISPRA (The Italian Institute for Environmental Protec□on and Research) and INGV (The National Institute of Geophysics and Volcanology). The research work is based on studying of data from multi-parameter continuous observatories for seismic activity, geophysics properties and geochemical parameters. The analyzed parameters will be the piezometric level, the temperature, electrical conductivity, chemical and isotopic composition of groundwater and dissolved gases. The innovative nature of the project is to consider the processes driving the change in the chemical-physical properties of groundwater in two different tectonic contexts: a compressive tectonic environment (Conero Mount) and an extensional one (Matese area) and create a comparison.

Work plan: The research work is based on studying of data from multi-parameter continuous observatories for seismic activity, geophysics properties and geochemical parameters. I will take samples for the selected springs and wells in the periodic campaigns for major and minor elements measurement and for the chemical composition of dissolved gases and isotopic analysis (^{2}H, ^{18}O, SO_4, ^{13}C, Sr, B, He, Ne, Ar), to understand processes that can modify water chemistry during seismic cycle. Following sampling, analyses will be conducted at the Sapienza geochemistry laboratories and in partner labs. The analyzed parameters will be the piezometric level, the temperature, electrical conductivity, chemical and isotopic composition of groundwater and dissolved gases.
During the last year, I will focus on the processing, comparison and interpretation of data acquired from the monitoring networks and during the last months of the third year, I will write the PhD thesis. The processing will allow to identify periodicity, trends and relations with local, seasonal and anthropic conditions and potential characteristic trends that occur in relation to crustal strain. Moreover, the sensitivity of each parameter can be defined with this multi-parameter filtering and the connection to the seismic cycle of some metals and metalloids in solution, dissolved and free gases, can be confirmed or not. In the three years of PhD, the bibliographic study will be continuously updated in order to better develop the research project. In addition, publications in scientific journals and learning activities are planned through the attendance of master university courses, conferences and seminars.

Research activity	First year		Second year		Third year	
	I semester	II semester	I semester	II semester	I semester	II semester
University classes	x		x			
Bibliographic studies	x	x	x	x	x	x
Monitoring and processing	x	x	x	x	x	x
Spring screening	x	x				
Mobility to italian research institute		x				
Mobility abroad				x (6 months)		
Analysis and comparison			x	x	x	
Final data interpretation					x	x
Pubblications		x		x		x
Seminary and conferences	x		x		x	
Thesis						x

References

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