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Groundwater geochemical anomalies in Mt. Conero area (central-eastern Italy) related to the pre- and post- 5.2 and 5.5 Mw Marche offshore seismic events (November 9, 2022)

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It is well established in geosciences that $M_w > 4$ earthquakes are expected to produce changes in the geochemistry of the waters circulating close to epicentral area. Therefore, such modifications are commonly considered as precursory signals and strictly related to the earthquake preparation processes and seismic cycles. Since most of these changes are transitory and site-sensitive, the identification of possible and suitable seismic precursors represents one of the major challenges for geoscientists. Consequently, the development of multi-parametric water monitoring networks located in earthquake-prone areas is a fundamental step toward a better understanding of the relationship between the seismic cycle and the occurrence of possible tracers.

The northern offshore area of the Marche Region was hit by 5.2 and 5.5 M_w earthquakes (Lat. 43.9830, Long. 13.4240, 5 km depth) on November 9, 2022 during which no fatalities or serious damages were recorded. In this work we report the preliminary results obtained from a pre- and post-seismic monitoring focused on waters collected from three piezometers (with a depth ranging from 15 to 30 m) located in the Mt. Conero Area (central-eastern Italy): Monte Acuto (MAC), Vallemiano (VAL), and Betelico (BET), situated ca. 40-50 km from the epicenter. All waters were sampled within 48 hours from the mainshock and periodically (on a monthly or quarterly basis) collected for one year after the event. The water chemistry of BET sample was available from May to October 2022, i.e., up to six months before the event. While the water samples MAC and VAL did not show any relevant chemical and isotopic variations, those collected from BET displayed strikingly significant modifications. The geochemical facies, characterized by a calcium-bicarbonate and a TDS (Total Dissolved Solids) < 1000 mg/L, typical of shallow aquifers, indeed became sodium-chlorine with TDS > 3500 mg/L, since the end of June 2022, i.e., about four months before the mainshock. About a week after the main events, the water chemistry returned to be Ca-HCO_3. Boron, Li, Sr and Rb concentrations also showed significant increments starting from June whereas those of Fe, Mn, Ni, Cu, Zn and Pb displayed overwhelming increases (up to 50 times their pre-seismic values) in those samples collected in the days following the mainshocks.

Consequently, particular emphasis was placed on addressing the origin of these changes and evaluating their possible relation with the seismic event. We can hypothesize that a mixing process between shallow aquifer and Na-Cl connate (or thermal) waters occurred, the latter being widely reported in the Adriatic foredeep deposits. The observed chemical variations might likely be related to changes in the relative pressure between superimposed and separated aquifers triggered by modifications in the stress rates associated with the seismic cycle. Moreover, variations in the hydraulic heads resulting in a temporary connection between two distinct aquifers would also explain the transitory changes detected at BET. If confirmed, these variations would be among the most strikingly impressive geochemical evidences ever detected before a seismic event or, at least, ever reported in the literature.