Geophysical Research Abstracts
Vol. 17, EGU2015-11140, 2015
EGU General Assembly 2015

Geochemical variations during the 2012 Emilia seismic sequence

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Several geochemical surveys (soil gas and shallow water) were performed in the Modena province (Massa Finalese, Finale Emilia, Medolla and S. Felice sul Panaro), during 2006-2014 period. In May-June 2012, a seismic sequence (main shocks of ML 5.9 and 5.8) was occurred closely to the investigated area. In this area 300 CO_2 and CH4 fluxes measurements, 150 soil gas concentrations (He, H2, CO_2, CH4 and C2H6), 30 shallow waters and their isotopic analyses (δ13C– CH4, δD– CH4 and δ13C– CO_2) were performed in April-May 2006, October and December 2008, repeated in May and September 2012, June 2013 and July 2014 afterwards the 2012 Emilia seismic sequences.
Chemical composition of soil gas are dominated by CH4 in the southern part by CO_2 in the northern part. Very anomalous fluxes and concentrations are recorded in spot areas; elsewhere CO_2 and CH4 values are very low, within the typical range of vegetative and of organic exhalation of the cultivated soil.
After the seismic sequence the CH4 and CO_2 fluxes are increased of one order of magnitude in the spotty areas, whereas in the surrounding area the values are within the background. On the contrary, CH4 concentration decrease (40%v/v in the 2012 surveys) and CO_2 concentration increase until to 12.7%v/v (2013 survey). Isotopic gas analysis were carried out only on samples with anomalous values. Pre-seismic data hint a thermogenic origin of CH4 probably linked to leakage from a deep source in the Medolla area. Conversely, 2012/2013 isotopic data indicate a typical biogenic origin (i.e. microbial hydrocarbon production) of the CH4, as recognized elsewhere in the Po Plain and surroundings. The δ13C-CO_2 value suggests a prevalent shallow origin of CO_2 (i.e. organic and/or soil-derived) probably related to anaerobic oxidation of heavy hydrocarbons.
Water samples, collected from domestic, industrial and hydrocarbons exploration wells, allowed us to recognize different families of waters. Waters are meteoric in origin and, apart one sample, are not thermally anomalous. Stable isotopes of H and O point out the absence of mixing with connate waters, prolonged interaction with the host-rock at high temperature and/or heavy gas-water exchange at depth. Isotopic carbon composition emphasizes its organic (i.e. shallow) origin; only “La Canonica” site, the deepest well sampled in this study, shows a probable deep(er) provenance of dissolved carbon. Waters trend away from the atmospheric end-member composition, dissolving CO_2 or CH4 depending on their redox state. Dissolved radon activity is very low, likely due to the particular hydrogeological setting of the study area (i.e. the presence of waters with long residence times in the considered aquifers).
Obtained results highlight a different behavior before and after the seismic events, proved also by the different carbon isotopic signature of CH4. These variations could be produced by increasing of bacterial (e.g. peat strata) and methanogenic fermentation processes in the first meters of the soil.