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# Origin of the $CO_2$ rich deep fluids in Italy and associated thermal energy transfer.

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Central and southern Italy are affected by an active and intense process of $CO_2$ Earth degassing in both volcanic and non volcanic environments, as revealed by the presence of many $CO_2$ rich gas manifestations, and by large groundwater systems intensely affected by the input of deeply derived $CO_2$. The gas is released by two regional $CO_2$ degassing structures named TRDS (Tuscan Roman Degassing Structure) and CDS (Campania Degassing Structure). The central and western parts of such structures coincides with the Tuscan Roman Quaternary magmatic province (TRDS) and with the active volcanoes of Campi Flegrei and Vesuvio (CDS) while the eastern part is occupied by the Apennine chain. Chemical and isotopic compositions of the gas emissions located in the volcanic zones resemble the composition of fluid inclusions in olivines and pyroxenes of the volcanites pointing to an origin similar to that of the fluids involved in the genesis of the magmas. Nitrogen and noble gases concentration and isotopic compositions (3He/4He and 40Ar/36Ar) change in the gas emissions moving from west to the east. In particular the gas emitted in the eastern sectors (i.e. in the Apennines) are the richer in crustal He and Ar suggesting a residence time in the crust much longer than in the Tyrrhenian sector. For the first time we show that the transfer towards the surface of the $CO_2$-rich deep fluids is accompanied by a relevant heat transfer that is responsible of significant thermal anomalies that characterizes the large aquifers located in the two degassing structures. This "convective" heat flow, which has been computed for numerous springs, results much higher than the actually estimated conductive heat flow, modifying significantly the heat flow map of Italy.