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Advective heat transport associated to regional Earth degassing in central Apennine (Italy)

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The main springs of central Italy Apennines were investigated, in order to compute the amount of heat transported by groundwaters and to compute the fraction of heat due to the geothermal heat flux. The 46 investigated springs represent a significant portion of the permeable structures of the Apennine being characterised by a cumulative flow rate of 130 m^3/s, i.e. $\sim$ 50% of the water discharged in this sector of the Apennines. The groundwaters are characterised by relatively low temperatures, but the occurrence of an heat anomaly is evident when the differences between the temperatures of springs and recharge waters are compared with the corresponding altitude difference. A total amount of heat of $\sim 2.1 \times 10^9$ J/s has been estimated to be transported by these groundwaters. Most of this heat (57%) is given by geothermal warming while the remaining 43% is due to gravitational potential energy dissipation. The computed geothermal warming implies very high heat flux, with values higher than 300 mW/m^2, in a large sector of the Apennines which was considered to date be characterised by normal to low conductive heat flux. The same area is affected by high fluxes of CO_2 from a deep source and the strict correlation between the geothermal warming and the input of deep CO_2-rich fluids is testified by the fact that all the thermally anomalous groundwaters are also affected by the input of deeply derived CO_2 contrary to those not thermally anomalous which display any input of deeply derived CO_2. This correspondence reasonably suggest the geothermal heat is transported from depth by CO_2 rich fluids, which enter the aquifers and mix with infiltrating waters. The amount of geothermal heat transported by central Apennine cold groundwaters is in absolute very high. It results the double than the hydrothermal heat discharge of the US Cascade Range ($\sim 1 \times 10^3$ MW) and is about the half of the total heat discharged at Yellowstone, one of the largest hydrothermal system of the world (5-6 $\times$ 10^3 MW). The large heat flux anomaly highlighted by this study opens a new vision of the Apennines belt and requires the existence of a thermal source such as a large magmatic intrusion at depth. Recent tomographic images of the area confirm the presence of such intrusion visible as a broad negative velocity of seismic waves. In addition, our results indicate that the thermal regime of tectonically active areas of the Earth, where meteoric waters infiltrate and deeply circulate, should be revised on the base of mass and energy balances of the groundwater systems.