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Gas geochemistry and tectonics around the Sea of Marmara

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During two fluid sampling campaigns in 2013 and 2014, around 60 thermal and mineral water springs/wells in the wider Marmara region were visited jointly by INGV, TÜBITAK and GFZ scientists in the frame of MARsite (MARMARA Supersite, 7th FP EC-funded project, grant n° 308417). Gas samples were collected and analyzed for the main chemical composition as well as their isotopic composition (He and C).
Gases were taken from thermal and cold springs located in coincidence of segments of the Northern and Southern branches of the Northern Anatolian Fault Zone (NAFZ). Bubbling gases were collected when available, in all the other cases the gas phase was extracted from water samples collected on that purpose.
The results confirm that over the Marmara area the majority of the gases are a binary mixture of atmospheric and deep originated volatiles. CO_2 is normally the main gas species. Its concentration decrease, due to GWI (gas-water interactions), increases the relative concentration of N2 and other less soluble gases. A high CO_2 content indicates minor interactions, thus, the easier and faster is the path from the deep layers toward the earth's surface, the lower are the interactions. The volatiles keep their pristine composition. Faults represent a preferential way for rising volatiles due to local high permeability.
The 3He/4He ratios ranging from 0.1 to 4.8Ra (Ra=3He/4He atmospheric ratio) indicate the presence of mantle contribution. The highest ratio was found at the eastern end of the Ganos fault. Mantle degassing is not obvious in non-volcanic areas, however the measured helium isotopic ratios indicate mantle degassing possibility through lithospheric faults. All the information indicate that the fluids circulating over this area are the result of fluid mixing at variable extents of three end-members: mantle, crust and atmosphere.
We propose that while the composition of shallow fluids is a matter of the local geology (for example the hosting rocks where thermal waters equilibrate or where ground waters interact with gases namely up to a depth of 3-5 km), the composition of the deep fluids is is related to tectonic processes.
Considering a fluid circulation model where the brittle/ductile transition zone is the area that ideally separates two different fluid domains, we may detect changes in the fluid composition (shallow/deep mixing proportion, for instance in the case of normal faults, before a rupture) in the sector where dilation occurs with deformation recorded by geodetic measurements. Nothing should change on the locked fault until the rupture occurs, and then the contribution of deep fluids will increase due to crustal relaxation of the brittle crust.
To interpret the geochemical features of the circulating fluids in the frame of a tectonic-related circulation model may provide additional tools to support risk-mitigation initiatives in the future.