Nature and origin of fault-controlled fluid seepage across the Maltese Islands

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The Maltese Islands are intersected by two major fault systems associated with two diverse rifting episodes affect the islands. The first and most widespread system is Early Miocene to mid-Pliocene in age, and consists of faults that are orientated ENE-WSW. The most distinct of these faults is the Great Fault (known also as the Victoria Lines Fault). The younger system of faults (Late Miocene-Early Pliocene) is still active and consists of faults striking NW to SE that often cross-cut the first generation of faults. The most extensive of these faults is the Maghlaq Fault, located along the southern coastline of the Maltese Islands.

The objectives of this study are to characterise active fluid flow systems across the Maltese islands, identify their origin and infer the mechanisms by which fluid is transferred to the seafloor. To fulfil these objective we merge seismic reflection profiles (boomer, multichannel and sub-bottom), high-resolution multibeam echousounder and CTD data, water and seabed samples, stratigraphic logs (that were calibrated with the seismic lines), aerial data (to determine methane and carbon dioxide concentrations in the atmosphere) and terrestrial data (i.e. water geochemistry interpretation, dissolved gas geochemistry and soil gas measurements).

Fifty-eight pockmarks with sub-circular planform shapes and U/V-shaped cross-sections have been. Their mean axis is about 12 m in diameter and the wall slope gradient is 3-4°, while their mean depth is 4 m (over the range 3-15 m). In the water column, gas flares attributed to the occurrence fluid escape and showing anomalous amplitude peaks have been mapped at the top of the pockmarks. A number of gas chimneys extending up to seafloor have been identified using the boomer and the multichannel seismic lines in the sub-seafloor. The CTD data showed some local anomalies where a major decrease in conductivity is observed without a larger change in depth. The geochemical analysis of the water samples collected at the top of the pockmarks showed for the first time in this area data on the presence of CH_4, CO_2, He and other gases dissolved in the bottom seawater. Dissolved gas and soil gas measurements allows us to recognize the presence of atmospheric (N_2 and O_2) and non-atmospheric gas species (such as CO_2, CH_4 and He).

We identify two main fluid flow systems. The first consists of a shallow system where fresh-water actively seeps at the seafloor, likely through a connection with terrestrial aquifers. The second type comprises deep fluids that ascend through the Early Miocene to recent faults and gas chimneys, forming pockmarks at the seafloor. Considering the good correlation between tectonic structures and gas-seepage signatures (pockmarks, gas chimneys and gas flares), we suggest that fluid migration and expulsion are at least driven by extensional and transtensive tectonic structures affecting the Maltese Islands.