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Origin and flux of a thermogenic gas seep in the Northern Alps (Giswil, Switzerland)

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Natural gas seeps in the Alpine region are poorly investigated though they can provide useful information on hydrocarbon potential of the sedimentary Alpine units and on related geofluid migration, which is typically controlled by pressurized gas accumulations and tectonics. A gas seep located near Giswil, in the Swiss Northern Alps, has been quantitatively investigated for the first time in terms of molecular and isotopic gas composition, methane flux to the atmosphere and gas flux variations over time. The seep is located $\sim$10 km south of the Northern Alpine front, in a creek within thin Quaternary deposits that cover Penninic Flysch units. It is close to the contact to underlying Ultrahelvetic and Helvetic units and lies near a major and seismically-active alpine transverse fault (Sarnen strike-slip fault system).

Our analysis indicate that the gas is thermogenic (CH_4 >96%; $\delta^{13}C_1$: -35.46‰ to -40.1‰) and that it shows indications of subsurface petroleum biodegradation (enriched $\delta^{13}C_{CO2}$,very low C_{3+} concentrations). The source rock is of marine Type II kerogen, which is probably the same source providing the thermogenic gas previously encountered in a nearby well that was accidentally discovered few years ago upon a shallow drilling campaign. With a maturity of 1.6-1.7 (Ro) and its marine origin, the source rocks are located either in the deeper buried Mesozoic limestone and shale units or in the more shallow and younger Flysch units. Gas flux of the Giswil seep, measured by a closed-chamber system, is relevant, escaping from at least two main vents zones. Additionally, a significant diffuse gas exhalation from the soil occurs over an area of at least 115 m^2. Total CH_4 output is conservatively estimated to be >16 ton/year. Gas flux variations, monitored over one month by a special tent and flowmeter installation, show daily meteorological oscillations, but also an intrinsic "pulsation", with periods of enhanced flux values that each last 2-6 h and that occur every few days. These pulses are likely related to episodes of gas pressure build-up and discharges along the seepage system, but to date, no relation to the seismicity of the active Sarnen strike-slip fault system could be established. Only a refined seismic network with sensitive stations nearby the seep will be able to determine whether or not the periods characterized by methane spikes coincide with microseismic activities of the Sarnen strike-slip fault system.

The results of this study provide a useful reference for future studies on gas seepage and petroleum potential in the Alps. They have provided new flux data to be considered for the definition of the emission factors of geological methane seeps, today recognized as a major natural source of methane for the atmosphere.