Exploration of natural hydrogen in the Lower Engadine window, Switzerland

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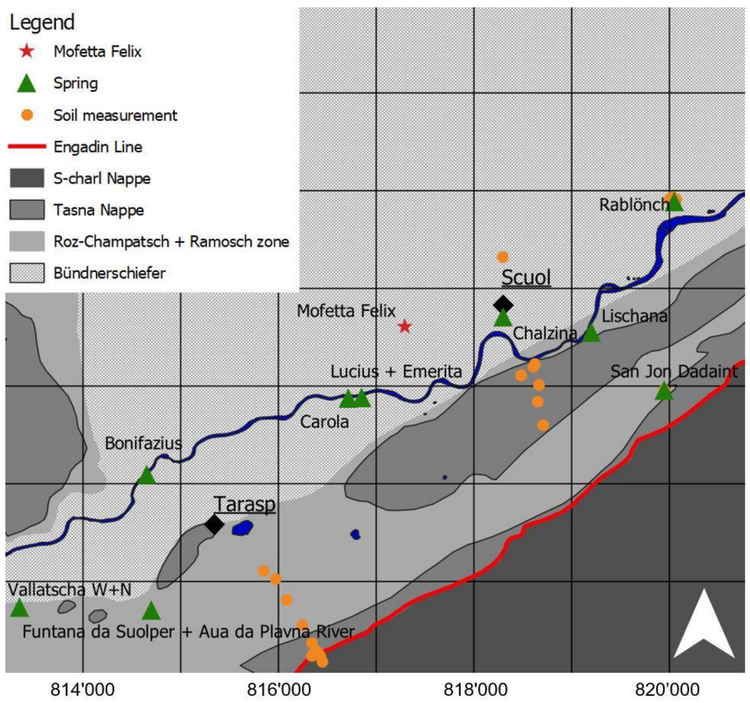
Introduction and location of field work

The area around Scuol, (Grisons, Switzerland), was chosen for a first hydrogen exploration because of the presence of a deep strike-slip fault, the Engadine line, associated to serpentinite. The area lies within the tectonic window of the Lower Engadine.
A special feature of this area are the carbogaseous spring waters and the dry CO_2 exhalations (mofettes) in the Scuol region. The $\delta^{13}C_{CO2}$ of exhaled gases (-4‰) is consistent with a deep mantle origin but could also be explained by other processes (Wexsteen et al., 1988). The concentrations of hydrogen in the gas mixture of the outgassing springs and the dry exhalations have never been studied.



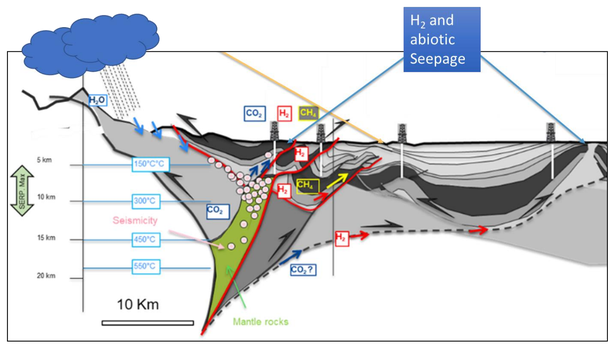
Geological structure of the study area (Swiss Topographic Grid, unit: meters). Modified after (Bissig et al., 2006)

Methods

Two methods were applied for the hydrogen exploration:

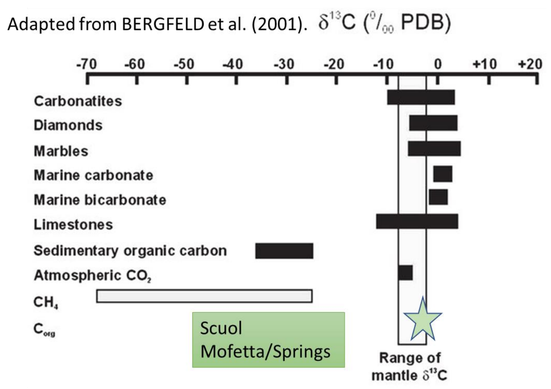
- The analysis of soil gases with a mobile gas analyzer. For this purpose, holes with a depth of about 1 meter were drilled into the soil with a percussion drill and then the gas composition (O_2, CO_2, CO, CH_4, H_2S and H_2) was measured.
- The sampling of springs and the determination of their chemical composition by means of on-site measurements, ion chromatography and ICP-OES.

H_2-Kitchen , Migration paths, Seals and Traps



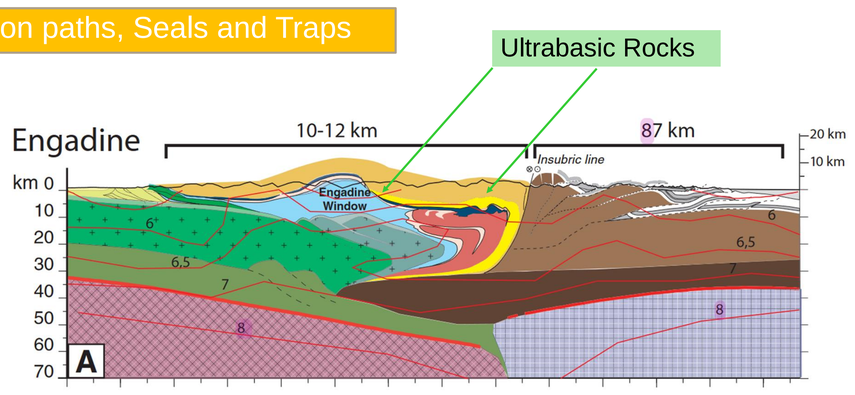
Pyrenees Concept

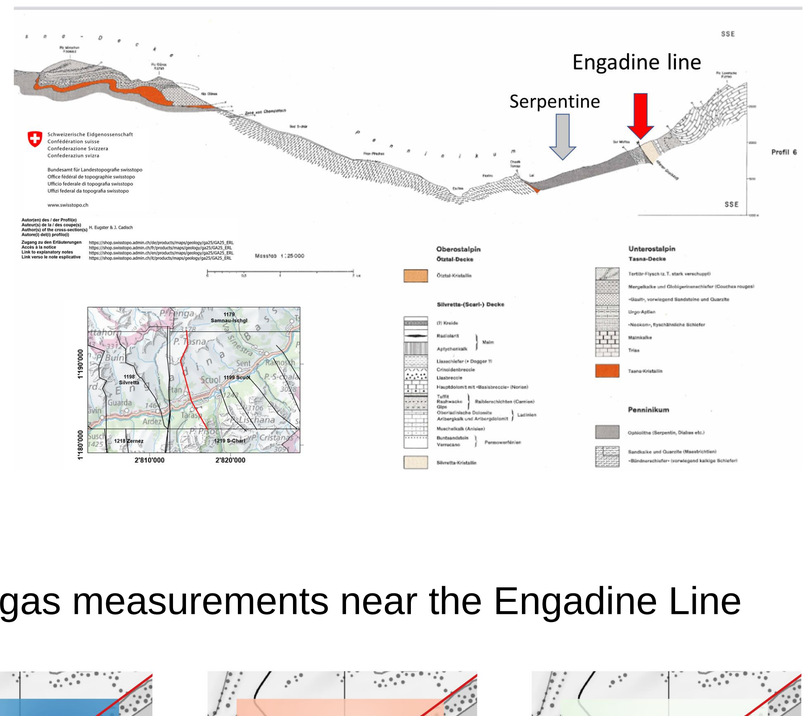
Water entry in the system due to the high hydraulic gradient (mountain)
H_2 -kitchen at (T>180°C) with serpentinization => H_2 production
Lefeuvre et al., 2022



δ ^{13}C of around - 4‰
$^3He/^4He$ (R/Ra): 0.1 => 1% Mantellic

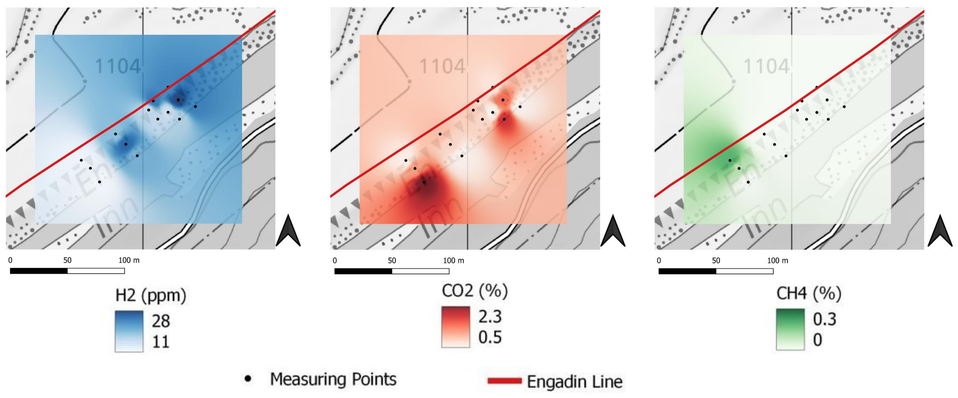
Application in the Engadine Area Swiss Alps





Soil gas permanent monitoring Mofetta Felix

Soil gas measurements near the Engadine Line



Results

In Mofetta Felix, a high flux of almost pure CO_2 contains reproducible concentrations of H_2
Max 320 ppmV

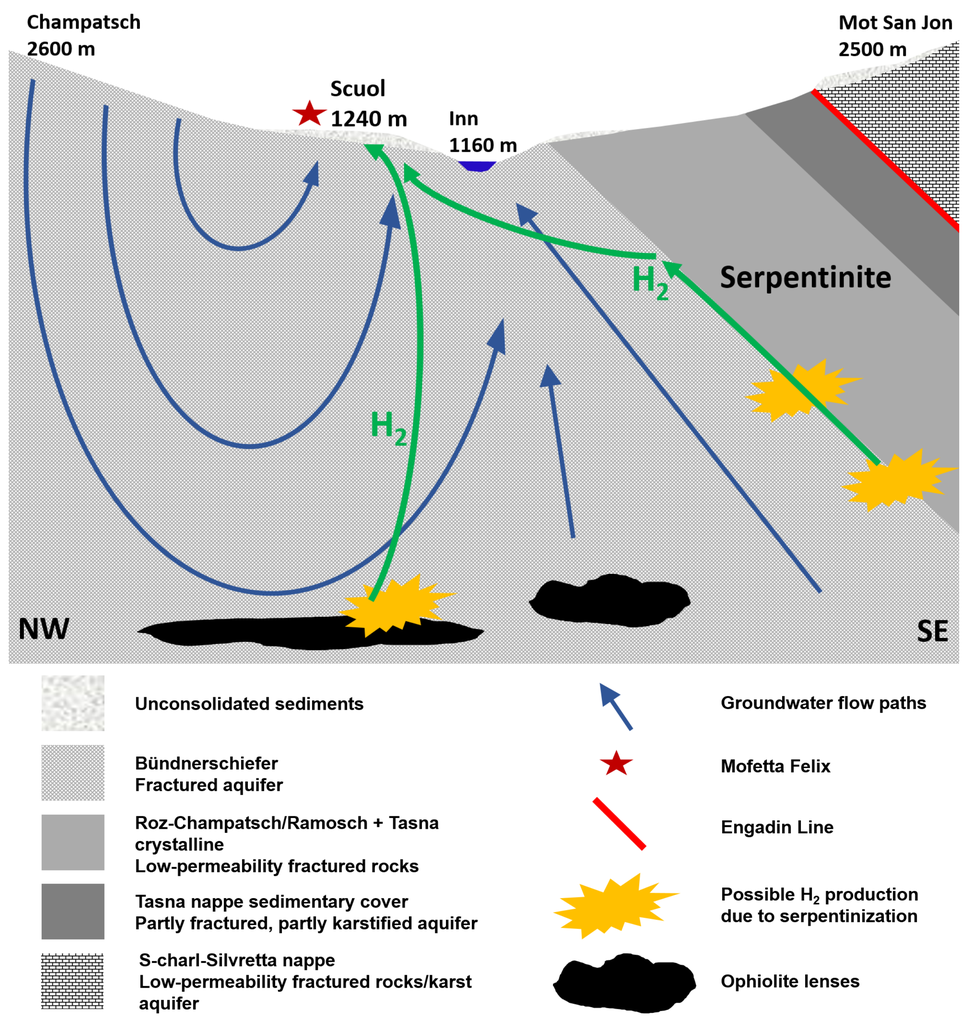
Results

The Engadine line can be detected with anomalies of CO_2 but no significant H_2 values were detected

Conclusion and further actions

The origin of the significant hydrogen amount of the “Mofetta Felix” is unknown but could be related to a deep serpentinization process. The geological composition of the subsurface in the core of the Lower Engadine window is assumed to be the Bündnerschiefer series, which is about 10 kilometres thick (Hitz 1996). The ophiolite lenses trapped in it represent a possible origin of the hydrogen measured at the surface. Due to the high permeability of the Bündnerschiefer, deeper ultrabasic rocks may also be the hydrogen source. The origin and production of the hydrogen will continue to be investigated with a permanent monitoring of the mofettes. The two most probable origins of the hydrogen found are marked in yellow in the figure.

In a next step, the chemical composition of the two possible host rocks will be investigated, and with it their ability to produce hydrogen by serpentinization. Further, all measured springs are degassed with a degasser. The collected gas is analysed and its hydrogen content is examined. Since the springs of the first group are located along the transition zone of the Bündnerschiefer and the Roz-Champatsch/Ramosch unit, increased H_2 concentrations in those springs would indicate a production within the rocks of the Roz-Champatsch/Ramosch unit. If no significant differences of the H_2 concentrations between the two spring groups can be observed, the ophiolite lenses within the Bündnerschiefer or another source as origin is to be preferred.



Conceptual groundwater fluxes and possible H_2 production sites in the underground in the region of Scuol, modified after (Bissig et al., 2006)

References

Wexsteen, P., Jaffé, F.C. and Mazor, E. (1988) Geochemistry of cold CO_2-rich springs of the Scuol-Tarasp region, Lower Engadin, Swiss Alps. Journal of Hydrology 104, 77-92.

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