Radon and CO_2 tracer for radioxenon subsurface sampling in the On Site Inspection

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The detection of anomalous concentration of Xenon radiosotopes in the subsurface gases during an On Site Inspection (OSI) is a strong indicator of a suspicious underground nuclear explosion. This implies that the sampling methodology ensure the collection of a reliable representative subsurface gaseous sample, avoiding the mixing with atmospheric gases. Radioxenon sampling in shallow layers can provide good and reliable results for desert areas, but different local geological features could result in more complex migration of subsurface gases to the very near superficial layers affecting the representativeness of the sample.

Radon is currently used as tracer to check the effective sampling of gases form the deep surface, so its measurement is done simultaneously to the collection of radioxenon subsurface gases.
The detection of radon anomalous concentration in subsurface gases could indicate different causes:

- high radon content in subsurface caused by the accumulation in an underground and confined cavity;
- low radon detection in subsurface can be indicative of the absence of an underground cavity or the presence of rocks in the cavity absorbing radon.

High Radon content in subsurface could be caused to the presence of:

- uranium-rich rocks (volcanic products, bituminous clays, black schists etc.),
- natural storage chamber
- hypogea confined cavity where the gas could be accumulate.

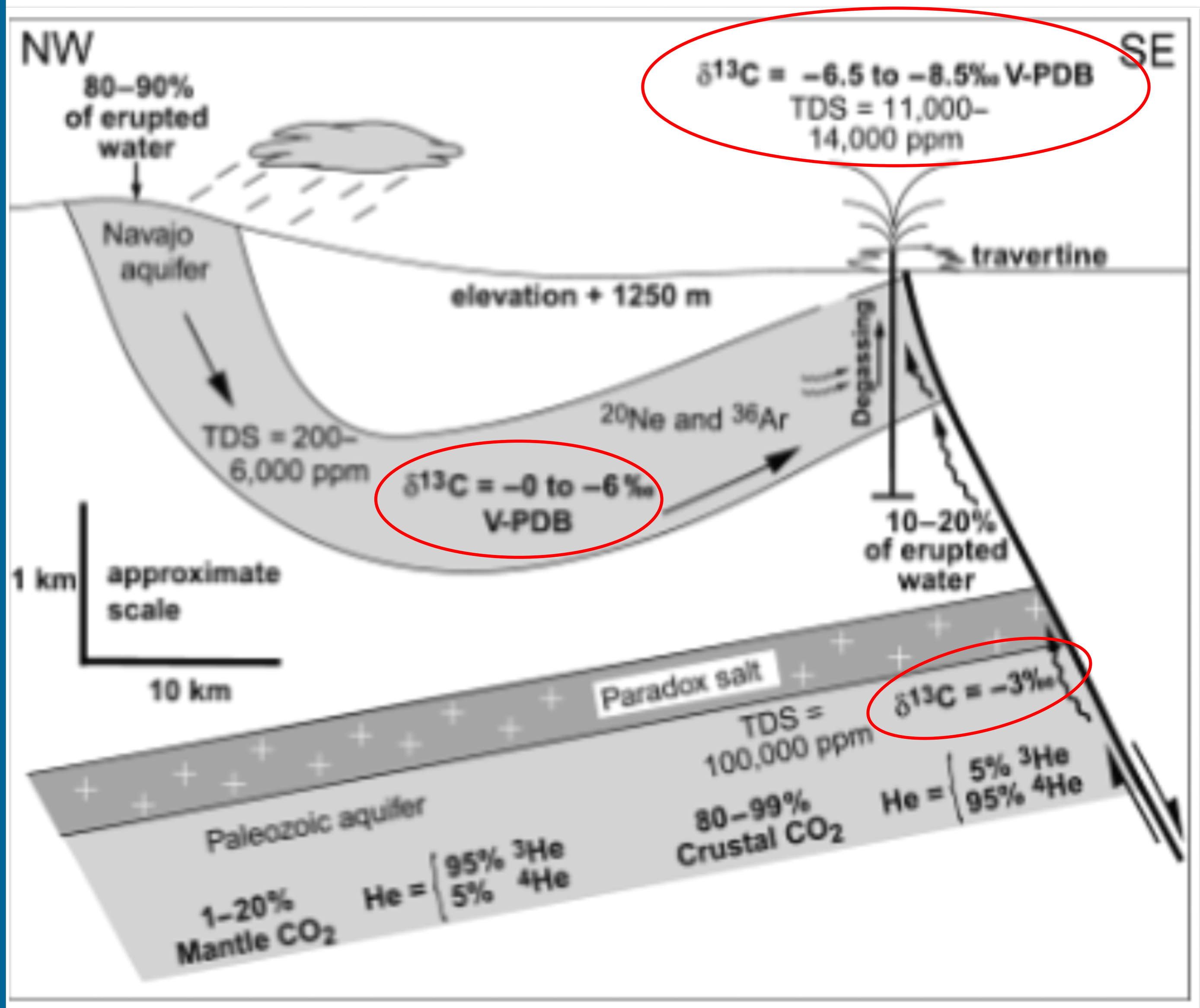
Example of uranium rock

On the other side, **low radon detection** in subsurface can be indicative of:

- low concentration of uranium in the rocks
- presence of zeolite,
- thick layers of clay and other lithology that can absorb radon and other endogenous gases.

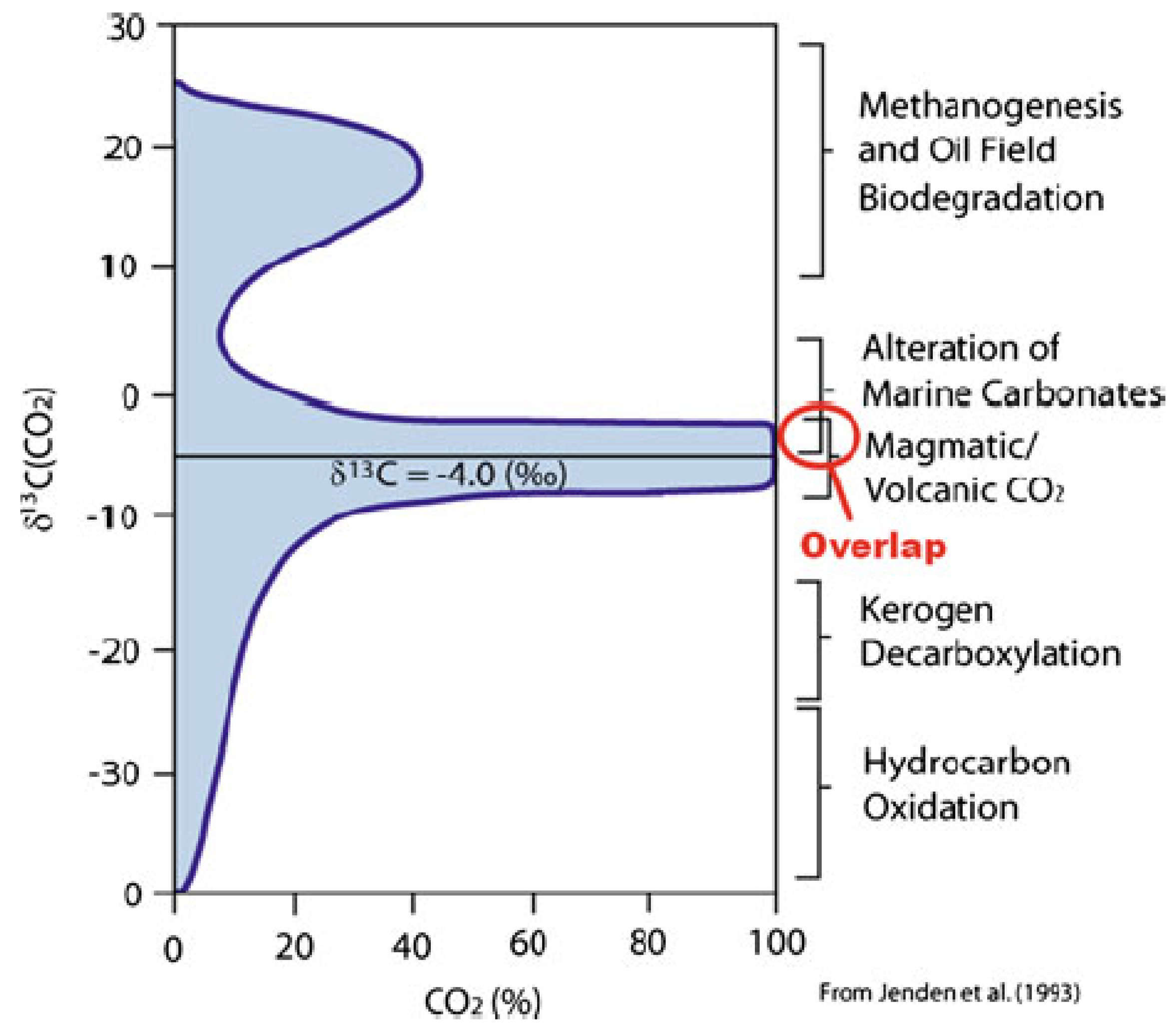
Example of zeolite rock

This leads to the consideration that radon is <u>not</u> a univocal tracer for Xe subsurface sampling in the OSI.



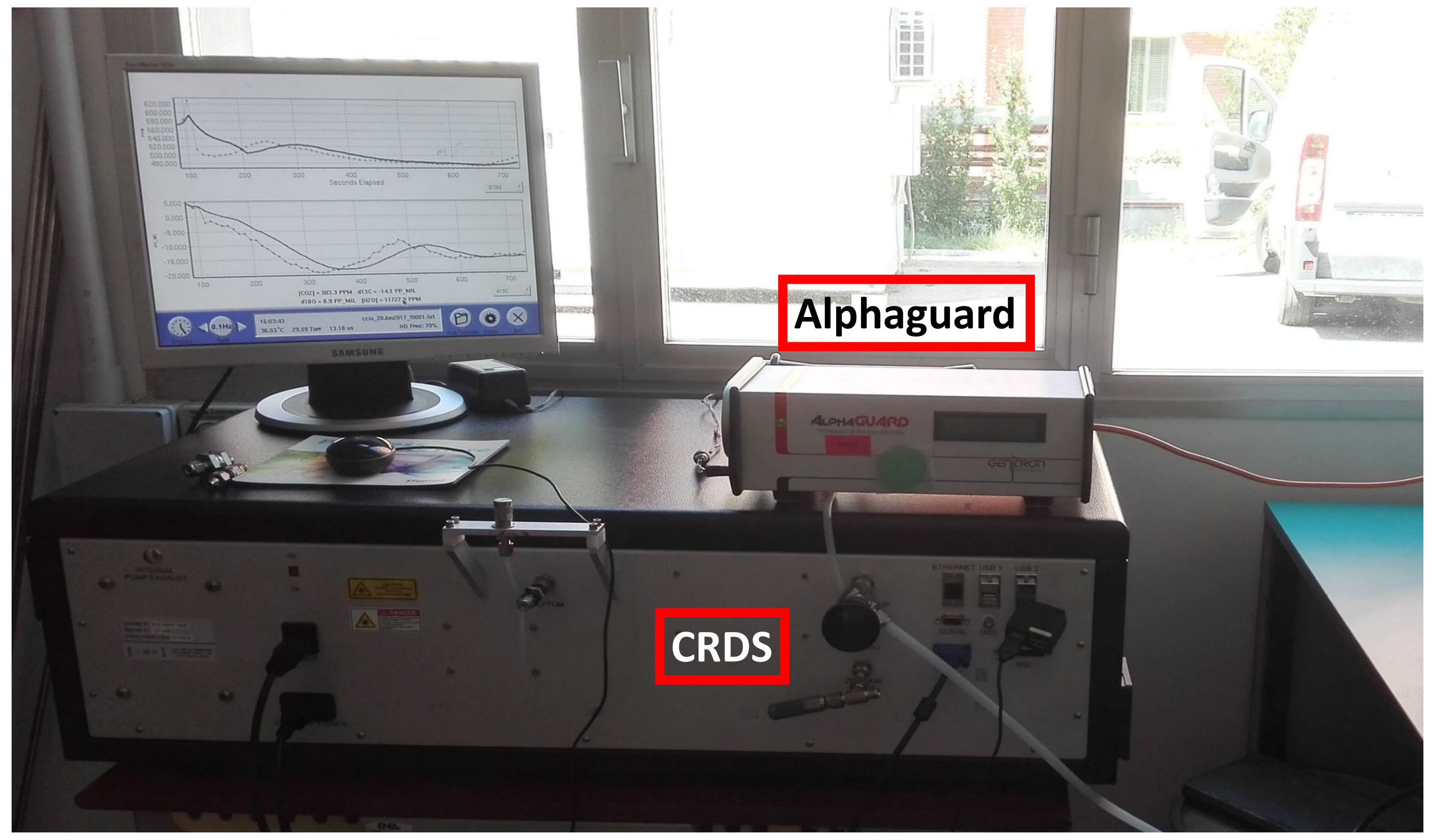
(Ref. Burnard P, 2012. The Noble Gases as Geochemical Tracers. Advances in Isotope Geochemistry, Springer)

<u>PROPOSED METHODOLOGIES for OSI</u>:
A portable isotopic analyzer measuring d13C and CO2 could be used to localize faults and fractures that could lead to a seeping of the subsurface gases.
Therefore, this technique could be proposed as an **auxiliary equipment** for:
search logic screening during an OSI ;
monitoring tool during subsurface gas sampling.



(Ref. Jenden PD, Hilton DR, Kaplan IR, Craig H, 1993. Abiogenic hydrocarbons in and mantle helium in oil and gas fields. In: Howell DG (ed) The future of energy gases, U.S. Geological Survey Professional Paper 1570. U.S. Geological Survey, pp 31–56)

Lithologies can perform filtration and chromatographic separation of underground gases. Cavity enhanced laser absorption technology, providing an absolute accurate measurements of 13C/12C in methane (δ13CH4) and carbon dioxide (δ13CO2), that could be used to identify geochemical anomalies in endogenous gas emissions due to the presence of specific lithologies.



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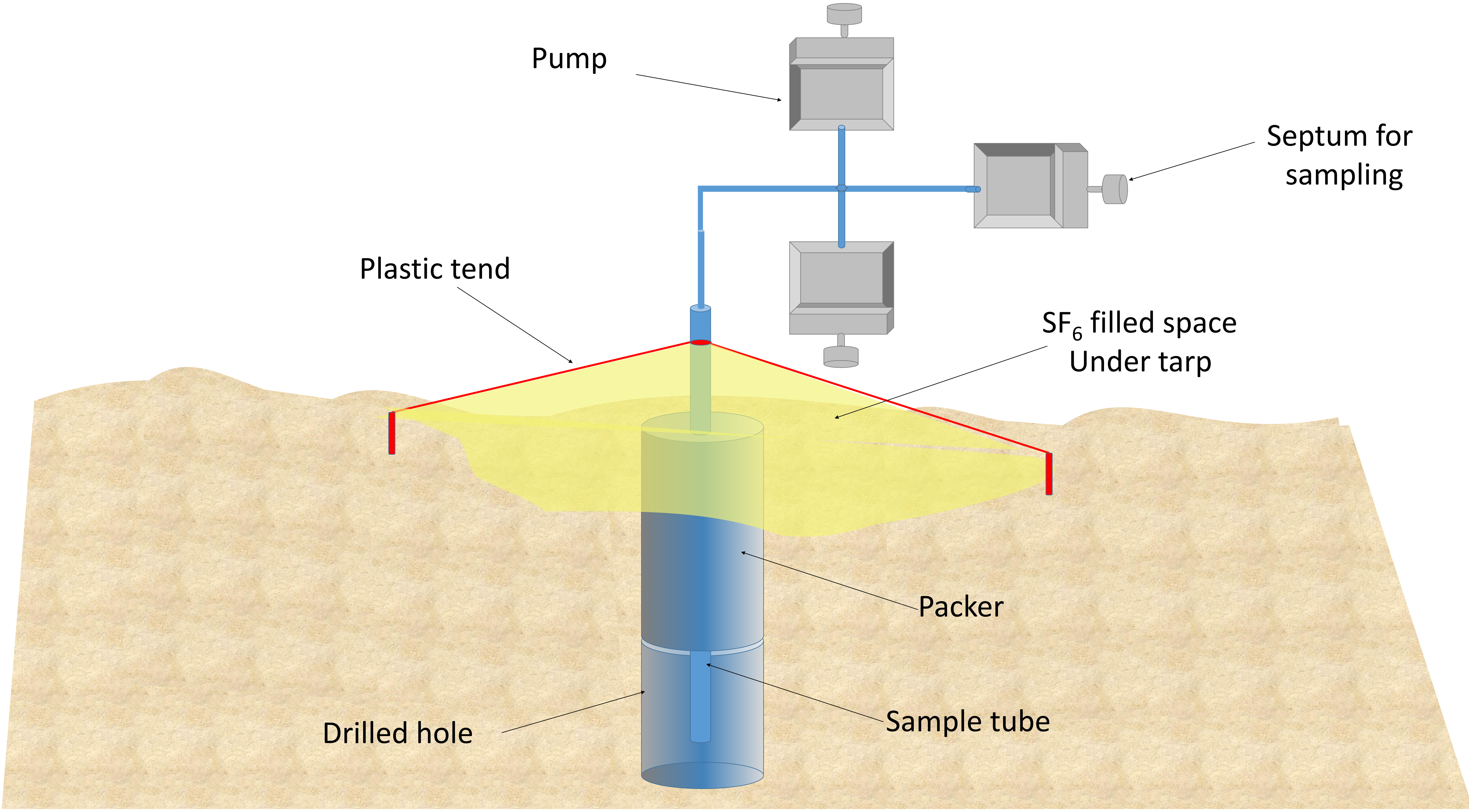
Sample station arrangement: proposed more sampling lines



(Ref. Carrigan C.R., Sun Y. 2011. Issues Involving The OSI Concept of Operation For Noble Gas Radionuclide Detection. LLNL-TR-467731)