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Implications for the timing of gas release: Crush-degassing experiments (lab), continuous gas monitoring (near-field) and analysis of >1.5Ma old crustal fluids (regional), Wits Basin, South Africa

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Deep crustal fluids (0.8 to 3.3km) from the Witwatersrand Basin, South Africa, were investigated with methods of noble gas geochemistry, isotope hydrology and geomicrobiology to further specify the conditions (fluid dynamics and geochemistry) that enable life in the ultra-deep continental crust. Subsurface model ages of the ultra deep fissure water samples were quantified by means of dissolved radiogenic and fissiogenic noble gas concentrations 4He_rad, 40Ar_rad, 134Xe_fiss, and 136Xe_fiss. Minimum water ages were constrained based on 36Cl data: all individual fissure water samples are older than 1.5Ma; noble gas model ages range up to some 20Ma. Latest results reveal unusually high 21Ne/22Ne ratios in fissure water samples from some of the gold mines of the Witwatersrand Basin as well as in some vein quartz material. This quartz vein filling from ultra deep formations was crushed in a vacuum chamber and the released gases were analyzed for their noble gas contents and isotopic compositions. The gases set free by crushing in the lab might otherwise be released for example by diffusion, weathering or during seismic events. In nature, gases released by such processes get dissolved in pore or fissure water and accumulate therein with time. We understand the quartz vein filling as the precipitate of billion-year-old hydrothermal fluids (0.8 to 2.5Ga), and the fissure water as a mixture of paleometeoric water and such ancient hydrothermal fluids. A question arising from these studies is whether the unique Ne isotopic composition in some of the fissure waters is due to

pulsed gas release (e.g. caused by mining-induced seismic events) or to diffusive degassing and accumulation in fissure water during geologic time scales. Currently, we design an on-line, on-site long term gas monitoring and gas sampling system that is meant to employ this unusually high 21Ne/22Ne ratio (as well as other gas concentrations) as a tracer for the gas release from rocks during seismic events. This gas monitoring system will be installed in front of a 40m long borehole, 3.6km deep underground, that penetrates a fault system where a mining induced seismic event of up to magnitude 3 is expected to occur within the next couple of years. We will analyze the background gas composition prior to the event and determine a possible change in the gas composition during and after a seismic event. With this near-field experiment we intend to get constraints on the timing of gas release during and after seismic events as well as on the composition and quantity of gases released, and thus to better understand the fluid dynamics and geochemistry of gases in rock (source) and ultra deep ground water (sink).