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# The Noble Gas Facility for Isotope Hydrology at IAEA, Vienna: Goals, technical Principles and first Results

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Since 2007 the International Atomic Energy Agency (IAEA) operates a noble gas facility, presently producing measurements of $^{3}$He, $^{4}$He, $^{20}$Ne and $^{22}$Ne on groundwater samples (both classical copper tubes and passive samplers). Since noble gases have proven to be an important tool in modern isotope hydrology, installation of such a facility at IAEA aims primarily to strengthen the use of the T/$^{3}$He dating method in groundwater studies. Besides, we want to further develop methods using helium as a tracer in groundwater beyond the time scale of the application of tritium, to use noble-gas derived recharge temperatures as constraining parameter both to derive the origin of groundwater and to better correct for excess air in T/$^{3}$He dating and finally to improve the detection limit of tritium by the $^{3}$He ingrowth technique.

Our facility measures the $^{3}$He/$^{4}$He isotopic ratio with a MM5400 sector field mass spectrometer and has two quadrupole mass spectrometers (QMS), one dedicated to measure $^{20}$Ne and $^{22}$Ne, the second planned to measure argon, krypton and xenon. The system has a very consequent all-metal design, runs fully automated and enables high throughput by an eight-sample multiport plus off-line extraction system for ten parallel samples in one run. In He/Ne measurement mode, gas purification is done by cryo techniques only, with a final charcoal trap operated between 10 K and 150 K to separate helium and neon. For the measurement of Ar, Kr and Xe additional traps and getters and two charcoal traps operated between 90 K and 450 K will separate first the He/Ne fraction and then the heavy noble gases. A precise spinning rotor gauge (SRG) together with a system of split volumes allows us to determine the absolute helium concentration and to automatically partition large helium amounts. This keeps the signal range for the $^{3}$He/$^{4}$He determination in the MM5400 sector field mass spec-

trometer within less than a factor of five for $^4$He. Tests have shown that this splitting influences the Neon measurement by less than a percent, even if the helium amount varies by more than four orders of magnitude between 1e6 ccSTP (a typical sample) and 2e2 ccSTP.

The measurement is controlled by our own software "NobleControl", written in LabView. Very flexible process control is possible with a script language having the typical syntax features of present day high-level programming languages. This includes Variables, Repeat and While loops, nested blocks and the parallel processing of several command queues plus storage of all system state parameters like pressures, valve states, temperatures etc. at user-defined intervals. Post-processing of the typical 20 MByte ANSI text files that NobleControl produces, is achieved using a noble gas dedicated sub-system of the "LabData" laboratory management and database system. LabData imports the raw data, computes extrapolated signals at inlet time for the mass specs and evaluates those measurements performed during preparation, like the absolute gas amounts from the SRG signals. To compute absolute gas amounts, it evaluates efficiency, background and linearity for each of the noble gas species in question ($^3$He, $^4$He, $^{20}$Ne, $^{22}$Ne...). Post-processing further includes algorithms to convert measured concentrations into T/$^3$He ages, into mean residence times using lumped parameter models and to deconvolute heavy noble gas concentrations to infiltration temperatures and to correct for excess air. Both NobleControl and LabData are open source codes and the entire software is available free of charge for other groups.

A typical gas inlet (reference air split or unknown) is processed through the whole system within 40 minutes. A typical 24 hour measurement sequence consists of 7 blanks, 20 efficiency and linearity standards plus 8 unknowns. This results in the possibility to measure up to 40 unknowns per week. We define our internal isotope ratio reproducibility as the standard deviation of the isotope ratio of air aliquots. Our internal amount reproducibility we define as the standard deviation of the relative differences of known amounts of gas from aliquot inlets of an air standard from the computed amounts. Both these kinds of reproducibility are computed over the whole measurement process and for a time period of at least six months. For this reproducibility we obtain values of better than 1.2% and 0.2% for the $^3$He/$^4$He and $^{20}$Ne/$^{22}$Ne isotope ratios and better than 1% for the $^3$He, $^4$He, $^{20}$Ne, $^{22}$Ne gas amounts.

The talk will give a short overview over the measurement facility. Besides it will present the first results obtained in the Marchfeld aquifer near Vienna. Here we studied different methods to obtain depth-resolved samples from groundwater. It turns out that the common sampling method in Austria, where a mixed sample is drawn from a continuously screened well or where packer systems are used to constrain the water depth, are both far from ideal to give a depth resolution of transport time within the

aquifer.