Numerical simulation of in-situ production of cosmogenic nuclides

J. MASARIK

Department of Nuclear Physics, Komensky University, Mlynska dolina F/1, Sk-842 48 Bratislava, Slovakia [masarik@fmph.uniba.sk]

The application of in situ cosmogenic nuclide method in earth sciences is based on the continuous production of nuclides in exposed surfaces. The production rates of nuclides depend on many parameters. Reliable interpretation of the measured in-situ-produced cosmogenic nuclides requires a good understanding of involved nuclear processes. We present a pure physical model [*Masarik and Beer, 1999*] for the simulation of the relevant processes enabling an investigation of nuclide production dependence on composition, geomagnetic latitude, altitude, geomagnetic field intensity and depth under the surface.

LCS and GEANT codes are used in our simulations for the calculation of spectra of particles inducing reactions that produce cosmogenic nuclides. Having calculated neutron fluxes with these codes, the production rates of nuclides are determined by integrating over energy the product of these fluxes with experimental and evaluated cross sections for the reaction producing particular nuclide. Technical details of these codes and their application to the cosmogenic nuclide production rate calculations are given in [Masarik and Beer, 1999; Masarik and Reedy, 1995].

Using these codes, theoretical dependencies of production rates at depth, on the size of the sampled object being exposed on the flat Earth surface were obtained. We present also new elemental production rates calculated from our new particle fluxes and updated excitation functions. The total production rates [in atoms / g-element / year] only by neutrons and high latitudes and sea level are given by

^{3}He=128.7[O] + 110.8[Mg] + 102[Al] + 106[Si] + 57.7[Ca] +38.5[Fe]

^{10}Be=9.82[O]+ 1.74[Mg] + 1.03[Al] + 0.89[Si] + 0.35[Fe]

^{14}C=34.36[O] + 1.78[Mg] + 1.34[Al] + 0.9[Si]+ 0.26[Fe]

^{21}Ne=102[Na] + 175.1[Mg] + 62.4[Al] + 41.7[Si] + 1.8[Ca] + 0.187[Fe]

^{26}Al= 0.20[Mg] + 195.52[Al] + 73.52[Si] + 0.26[Fe]

^{36}Cl=122[K] + 68[Ca] + 13.5[Ti] + 6.75[Fe] + 2.03[Ni]

in which the target-element concentrations, such as [O], are given in weight fractions.

Muon fluxes in the atmosphere and on the earth surface were also obtained and will be presented. The obtained theoretical values are compared with experimental data and other theoretical estimates.

References

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Possible "soft" natures of S-containing fluids

T. MASUDA[1], S. NAKASHIMA[2], V. FAMIN[3] AND H. KANEDA[1]

[1] Department of Geosystem Engineering, The University of Tokyo, Tokyo, Japan (t.masuda@mx2.ttcn.ne.jp)

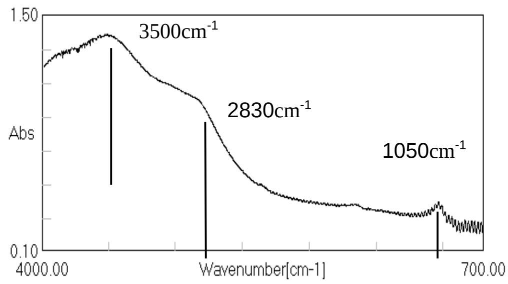
[2] Interactive Research Center of Science Tokyo Institute of Technology, Tokyo, Japan (satoru@geo.titech.ac.jp)

[3] Laboratoire de Tectonique, University of Paris á✷

IR spectra of fluid inclusions in Toyoha mine

Infrared (IR) spectra of fluid inclusions in sphalerite (ZnS) from polymetallic hydrothermal Zn-Pb Toyoha mine, Hokkaido, Japan were measured under an IR microscope. The IR spectra (Fig.1) show a broad absorption shoulder around 2600cm^{-1}-2850cm^{-1} and the band position varies with Fe contents. This band together with the small band at 1050 cm^{-1} might be attributed to sulphur-containing dissolved species in fluid inclusions. It should be noted that the OH stretching band position (3500 cm^{-1}) is much higher than those of pure liquid water (3400 cm^{-1}) and NaCl solutions (3450 cm^{-1}). This might imply that the sulphur-containing fluids can be far more "softer" than pure water and NaCl solutions.

Figure 1: A microscopic infrared spectrum on fluid inclusions



in ZnS from Toyoha mine, Japan.

"Softness" of fluids and geodynamics

The above "soft" character of sulphur-containing fluids might have significant effects on geodynamics such as rock deformation. In fact, pyrite is very often found in the most deformed shear zones in cycladic metamorphic rocks in Greece. In order to verify this hypothesis, IR spectra on fluid inclusions from most deformed rocks from Tinos Island, Greece will be measured. Attenuated Total Reflection (ATR) IR spectra will also be measured on synthetic sulphur containing solutions.