Using Deuteron-Deuteron Fusion Generated Neutrons for $^{40}Ar/^{39}Ar$ Geochronology – Proof of Concept

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We present progress on the development and the proof of concept of a deuteron-deuteron fusion based neutron generator for $^{40}Ar/^{39}Ar$ sample irradiation. It is based on ionization of deuterium, acceleration towards and implantation into a self-loading Ti target where deuterons fuse with already implanted deuterium to produce neutrons; $^2H + ^2H \rightarrow ^3He + n$. The target acts as a ~2.8 MeV neutron source for adjacent geochronology samples.

In a series of experiments we irradiated K-feldspar and K-rich glass shards ranging in age from ~2 ka to 1.2 Ma, natural fluorite, synthetic K-glass and KBr, and metallic neutron fluence monitors (In and Ni). (i) We determined maximum neutron fluxes of 1.6×10^7 $cm^{-2}s^{-1}$ and a cross section of $^{39}K(n,p)^{39}Ar$ at 2.8 MeV of 121 mb, equivalent to 5.5×10^{-10} *J*/h in the center of the sample holder and decreasing radially outward to about 80% at 5 mm distance, and to about 50% at 10 mm away from the center. (ii) We tested the reproducibility of relative variation in $^{40}Ar_{rad.}/^{39}Ar_K$ ratios of three samples of different and well established geologic age. (iii) We provide a first quantification of the loss of ^{39}Ar by recoil based on irradiation and analysis of variable grain size sanidine of the Campanian Ignimbrite and glass shards and crystals from an East African tuff and compare it to ^{39}Ar recoil loss resulting from irradiation with a fission neutron spectrum. (iv) We present first experimental results on production rates for interfering Ar isotope from K and Ca.

Currently the ^{39}Ar production rate is about 5 orders of magnitude smaller compared to fission reactors. For reasonable irradiation times of several weaks, high-K samples with mass of several mg are required to produce quantifiable amounts of ^{39}Ar. Resulting large $^{40}Ar/^{39}Ar$ ratios pose analytical challenges and require analysis in a low-memory, high resolution instrument.

The next technical development will focus on elevating the neutron flux by improving deuterium plasma density and quality in the ion source, deuteron beam optics and heat transfer in the self-loading deuteron target.