Study of $^{40}Ar/^{39}Ar$ Geochronology with a New Neutron Activation Method

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Abstract: $^{40}Ar/^{39}Ar$ dating method is widely applied to measure geologic time, from the formation of the Earth, which is 4.6 Ga, to the eruption of Vesuvius in 79 AD (Renne et al., 1997).^{39}K (n, p) ^{39}Ar is an important reaction for $^{40}Ar/^{39}Ar$ geochronology,which is usually carried on in ^{235}U fission reactor.However, the neutron energy of a ^{235}U fission reactor ranges widely from less than 0.1MeV to higher than 10MeV.Besides ^{39}Ar is produced via ^{39}K (n, p) $^{39}Arreaction$, other Argon isotopes can also be produced by reaction between lower energy neutrons and K, Ca, Cl isotopes such as $^{40}K(n,p)$ ^{40}Ar and $^{40}Ca(n,n\alpha)^{36}Ar$. These unwanted interfering reactionsare the main factor controlling the precision of dating results (McDougal and Harrison 1999), especially for the young samples with high Ca/K ratio.In addition,^{39}Ar produced by high energy neutrons can recoil from their original crystal chemical site. Mean recoil distance for silicates is 0.08 μm for neutrons in a fission spectrum (Villa et al., 1997, Renne et al., 2005). Therefore, ^{39}Ar maybe lost during irradiation if grain size is small, and recoiling of produced ^{39}Ar may cause fractionation between ^{39}Ar and ^{40}Ar which will influence apparent ages. Thus, based on the neutron energy, recoiling of ^{39}Ar, and corrections for data processing, the ideal neutron energy for $^{40}Ar/^{39}Ar$ geochronology is 2-3 MeV (Renne et al., 2005). Renne et al. (2005) proposed to apply a Deuteron-Deuteron neutron generator to $^{40}Ar/^{39}Ar$ geochronology. Neutron flux of Deuteron-Deuteron neutron generator is much lower than that of ^{235}U fission reactor, thus low production of ^{39}Ar after irradiation by Deuteron-Deuteron neutron generator cause the Ar isotope measurement difficult. Either developing high flux neutron generator or optimizing low amount Ar measurement can overcome this difficulty. In our study, we make $^{40}Ar/^{39}Ar$ dating with Deuteron-Deuteron neutron generator come true by improving mass spectrometric $^{40}Ar/^{39}Ar$ measurements.

Key words: $^{40}Ar/^{39}Ar$ geochronology, neutron activation, Deuteron-Deuteron neutron generator

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