Recoil induced intermediate age maximum: Revealed by diffusion of Ne and Ar in diocahedral mica

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Gradients observed in $^{40}Ar/^{39}Ar$ age spectra assume a uniform distribution of $^{39}Ar_k$ and a concentration of $^{40}Ar^*$ that increases from the surface to the core of the crystal that develops due to thermally activated diffusion. However, white mica $^{40}Ar/^{39}Ar$ age spectra commonly exhibit an intermediate age maxima (IAM) that cannot be explained by single domain volume diffusion. Previous authors have suggested additional causes for IAM: (1) dehydroxylation and delamination during in-vacuo step heating or (2) loss and/or remobilization of $^{39}Ar_k$ during nuclear recoil. To test the two hypotheses for IAM, we measured the neon (Ne) and argon (Ar) diffusivities in cogenetic phengite and paragonite. Both phases produce Ne and Ar isotopes during neutron irradiation [$^{24}Mg(n,\alpha)^{21}Ne$ and $^{39}K(n,p)^{3}9Ar$]. Since Ne diffuses more rapidly than Ar, it is released at lower temperatures than those at which dehydroxylation begins. Progressive dehydroxylation was monitored by FTIR spectroscopy of micas recovered from heating schedules that were terminated at progressively higher temperatures.

Each of the mica $^{40}Ar/^{39}Ar$ age spectra are characterized by an initial age gradient that reaches a maximum age during the intermediate heating steps (950-1100 ^{o}C), followed by a decrease in age at higher temperatures. Arrhenius plots of ^{21}Ne and $^{39}Ar^{++}$ both display an initial linear rise in $\log(D/r^2)$ with increasing temperature before rolling over. The break in linearity occurs ~600 ^{o}C for ^{21}Ne and 950-1000 ^{o}C for $^{39}Ar^{++}$ in both phases. Similar average values of Arrhenius parameters [Ea and $\log(Do/r^2)$] for ^{21}Ne and $^{39}Ar^{++}$ for both white mica phases indicate no major difference in retentivity between phengite and paragonite. FTIR results indicate ~25% water loss by 800 ^{o}C and almost complete water loss by 950 ^{o}C for both phases.

Nearly complete water loss prior to the development of the IAM and similar patterns displayed by ^{21}Ne and $^{39}Ar^{++}$ in the Arrhenius suggest that the kinetics of Ar loss are not controlled by dehydroxylation in dioctahedral micas. Arrhenius plots for ^{21}Ne and $^{39}Ar^{++}$ indicate a domainal character for Ne and Ar within paragonite and phengite. New coupled Ar and Ne results demonstrate the importance of reactor-induced recoil in the development of $^{40}Ar/^{39}Ar$ age spectra.