Effects of microstructure on ^{222}Rn diffusion from zircon

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Zircon is one of the most widely used minerals for geochronology because of its persistence in harsh geological environments and its afinity for uranium. ^{238}U and ^{235}U both go through a number of intermediate daughters before arriving at the stable daughter products of ^{206}Pb and ^{207}Pb. Loss of intermediate daughters results in loss of the final daughter, and a younger than expected U/Pb age. Radon, a noble gas, is an intermediate daughter in both ^{238}U and ^{235}U decay chains, however, the half-life of ^{219}Rn in the ^{235}U series is only ~4 s, leaving very little time for the ^{219}Rn to be transported out of the system before decaying. ^{222}Rn has a much longer half-life of 3.82 days, which increases the potential for ^{222}Rn to escape from the system, meaning that ^{238}U/^{206}Pb ages are more likely to be affected by Rn loss than ^{235}U/^{207}Pb ages. This study investigates high temperature loss of ^{222}Rn from zircon.

We measured initial activity of ^{226}Ra (vis ^{214}Bi and ^{214}Pb) in crushed aliquots of a large (>100 mg) zircon crystal from Bancroft, Ontario using gamma spectroscopy. The aliquots were then heated at temperatures ranging from 200–975 ˚C for durations of 4–48 hours. After heating, samples were returned to the gamma spectrometer and ^{222}Rn activity was measured via ^{214}Bi and ^{214}Pb every 3-5 days until equilibrium between ^{226}Ra and ^{222}Rn was reestablished (~30 days). A ^{222}Rn ingrowth curve was fit to the data in order to calculate the amount of ^{222}Rn that was lost during heating. The maximum ^{222}Rn loss achieved was ~36%, and occurred at a temperature of 975 ˚C. Preliminary data from different temperature steps form a linear array in Arrhenius space, suggesting loss by diffusion. However, repeated heating steps resulted in dramatically lower ^{222}Rn loss values of ~10%. We interpret this as a result of microstructural change within the crystal during heating, e.g. annealing of fission tracks or radiation damage. We will relate rates of ^{222}Rn diffusion to microstructure using TEM observation of these samples and measurements of ^{222}Rn loss from two additional zircons with lower U concentrations and thus different initial microstructure.

Preliminary results suggest that high temperature ^{222}Rn diffusion may contribute to discordant U/Pb ages, and that microstructure is likely to play an important role in ^{222}Rn diffusion kinetics in zircon.