

## **A new approach for constraining the magnitude of initial disequilibrium in Quaternary zircons by coupled U and Th decay series dating**

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To obtain reliable ages for Quaternary zircons, corrections for initial disequilibrium associated with deficits and excesses of both  $^{230}\text{Th}$  and  $^{231}\text{Pa}$  relative to secular equilibrium resulting from differential partitioning during zircon crystallization or source melting must be made. In contrast, the  $^{232}\text{Th}$ – $^{208}\text{Pb}$  decay system is clearly advantageous for samples affected by disequilibrium because the  $^{232}\text{Th}$  decay system lacks long-lived intermediate daughter isotopes. Conventionally, the initial disequilibrium for the  $^{238}\text{U}$  and  $^{235}\text{U}$  decay series has been determined by the distribution ratio between the melt and zircon (i.e.,  $f_{\text{Th/U}} = (\text{Th/U})_{\text{Zircon}}/(\text{Th/U})_{\text{Melt}}$  and  $f_{\text{Pa/U}} = (\text{Pa/U})_{\text{Zircon}}/(\text{Pa/U})_{\text{Melt}}$ ).

In our study, these correction factors were determined from comparison of the measured  $^{238}\text{U}$ – $^{206}\text{Pb}$  and  $^{235}\text{U}$ – $^{207}\text{Pb}$  ages with  $^{232}\text{Th}$ – $^{208}\text{Pb}$  ages obtained for three zircons of known eruption and, in some cases, zircon crystallization ages (Kirigamine Rhyolite, Bishop Tuff, and Toga Pumice). The resulting correction factors are  $f_{\text{Th/U}} = 0.19 \pm 0.14$  and  $f_{\text{Pa/U}} = 3.66 \pm 0.89$  (Kirigamine Rhyolite),  $f_{\text{Th/U}} = 0.24 \pm 0.20$  and  $f_{\text{Pa/U}} = 3.1 \pm 1.2$  (Bishop Tuff), and  $f_{\text{Th/U}} = 0.28 \pm 0.17$  and  $f_{\text{Pa/U}} = 3.04 \pm 0.99$  (Toga Pumice). Although the uncertainties of these  $f$  values are relatively large, our results support the adequacy of the conventional approach for correction of initial disequilibrium. A recent study published results that apparently show zircon crystallization ages are younger than the eruption age of Bishop Tuff. It seems to be difficult to eliminate these discrepancies, even if the Th/U partitioning and disequilibrium generated during partial melting are taken into account for recalculation of its zircon age. However, magma chamber process and history of Bishop Tuff are too complex to obtain accurate zircon ages by U–Pb method. To overcome this, therefore, the Th–Pb zircon dating method is a key technique for understanding complex, pre-eruptive magma processes, and further efforts to improve its precision and accuracy are desirable.