Zircon Raman thermochronometry

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Zircon ($ZrSiO_4$) is a mineral that incorporates radioactive U and Th in its crystal structure and is therefore widely used for geochronology. Its chemical and mechanical durability and occurrence in a variety of rocks make it a robust archive for geochemical and geochronological applications. The diverse effects of radioactive disintegration processes taking place in zircon are exploited by several geo-/thermochronological methods, such as U-Pb, (U-Th-Sm)/He, and fission-track dating. Zircon Raman dating, on the other hand, is a method still in development. It is based on the effect of α-disintegration of ^{238}U, ^{235}U, ^{232}Th, and their daughters on the crystal lattice. The emitted α-particles and the recoil of the mother nuclei disrupt the zircon lattice leading to amorphization (metamictization) at high α-doses. The radiation damage affects the Raman spectrum: Raman bands broaden and shift towards lower wavenumbers. The Raman bandwidth provides a quantitative estimate of the radiation damage. A Raman date is determined from the damage and the effective uranium concentration, measured in the same spot. Radiation damage anneals upon heating. The interpretation of the Raman date thus depends on the thermal history of the zircon. The Raman age represents the formation age, if the zircon cooled rapidly after formation. If the zircon cooled slowly, it is a cooling age, corresponding to cooling through a specific closure temperature (T_c). For more complicated thermal histories, the Raman date is either a reset age or a meaningless mixed age. This contribution presents the radiation-damage calibration based on several Raman bands, a kinetic model to determine T_c, and a measurement protocol for zircon Raman dating.