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INVITED CENTENNIAL ARTICLE

Metamorphic chronology—a tool for all ages: Past achievements and future prospects

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Abstract

Metamorphic chronology or petrochronology has steadily evolved over several decades through ever improving analytical techniques and more complete understanding of the geochemical and petrologic evolution of metamorphosing rocks. Here, the principal methods by which we link metamorphic temperatures (*T*) and ages (*t*) are reviewed, focusing primarily on accessory minerals. Methods discussed include textural correlation, inversion of diffusion profiles, chemical correlation, and combined chronologic and thermometric microanalysis. Each method demonstrates remarkable power in elucidating petrologic and tectonic processes, as examples from several orogens illustrate, but limitations must also be acknowledged and help define future research directions. Correlation methods are conceptually simple, but can be relatively non-specific regarding pressure-temperature conditions of formation. A new consideration of errors indicates that modeling of chronologic diffusion gradients provides relatively precise constraints on cooling rates, whereas models of chemical diffusion gradients can lead to large (factor of 2 or more) cooling rate uncertainties. Although arguably the best method currently in use, simultaneous *T*-*t* measurements are currently limited to zircon, titanite, and rutile. Directions for future improvement include investigation of diffusion profiles for numerous trace element-mineral systems using now-routine depth profiling. New trace element models will help improve chemical correlation methods. The determination of inclusion entrapment *P*-*T* conditions based on Raman spectroscopic measurement of inclusion pressures (“thermoba-Raman-try”) may well revolutionize textural correlation methods.

Keywords: Geochronology, monazite, titanite, zircon, trace elements and REE, Zr, zircon, titanite, rutile, metamorphic petrology, UHP, Invited Centennial article