

Electron probe (Ultrachron) microchronometry of metamorphic monazite: Unraveling the timing of polyphase thermotectonism in the easternmost Wyoming Craton (Black Hills, South Dakota)

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ABSTRACT

A metapelite from the easternmost Wyoming craton (Black Hills, South Dakota) has been analyzed by microstructural methods to unravel polyphase deformational history associated with 1800–1700 Ma assembly of southern Laurentia. Three deformational fabrics are recognized in oriented thin sections: an ENE-trending S_1 fabric, preserved as oblique inclusion trails in garnet porphyroblasts; a NNW-trending S_2 fabric, preserved as microlithons in the rock matrix; and a flattening fabric, S_3 , which transposed S_1 - S_2 and dominates the matrix. A complex monazite porphyroblast has been analyzed in situ with the electron microprobe (Ultrachron) to constrain the timing of S_1 - S_3 fabric formation associated with monazite growth. The core of this grain uniquely preserves the S_1 - S_2 fabrics as sigmoidal inclusion trails. The mean total-Pb age of this domain is 1750 ± 10 Ma (all dates reported at 95% confidence; $n = 39$ spots), which is equivalent to the published $^{207}\text{Pb}/^{206}\text{Pb}$ age for the same domain. These results validate the total-Pb dating method in general and the Ultrachron in particular, for reliable age determination in low-Th monazite, and are interpreted as 1750 Ma minimum ages for the S_1 - S_2 fabrics and sequential, D_1 - D_2 collisional events that imposed them (\sim N-directed arc accretion and \sim E-W continental collision, respectively). A higher-Th, Y rim of this same “Rosetta” grain truncates the S_1 - S_2 sigmoid, and is associated with resorption textures in garnet porphyroblasts, coupled release of Y, and an S_3 fabric that pervasively overprinted S_1 - S_2 in the rock matrix. The mean Ultrachron date of this domain is 1692 ± 5 Ma ($n = 17$ spots), which is slightly younger than the published isotopic age for all monazite rims combined. These results support a \sim 1715–1690 Ma timeframe for localized doming (D_3) related to granite magmatism, the onset of which has been dated independently at 1715 ± 3 Ma. The timing of post- D_3 cooling through 350 and 300 °C is constrained by $^{40}\text{Ar}/^{39}\text{Ar}$ dates of \sim 1610 and \sim 1480 Ma obtained for separates of D_3 matrix muscovite and biotite, respectively, which are interpreted as closure ages.

This study shows that fabrics in poly-deformed rocks can be dated by linking monazite spot ages to key microtextures. Further, the results of this micrometer-scale study enhance previous knowledge of local thermotectonism (Black Hills) and regional terrane assembly (Laurentia).