Adirondacks - Grenville Orogen

Combination and Comparison of Thermochronological Methods

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Introduction

Zr-in-rutile thermometry is a robust method to determine peak temperatures in high-grade metamorphic rocks. This makes rutile suitable for recording peak metamorphic temperatures on a regional scale (Ewing et al. 2013). In high-grade metamorphic rocks rutile can incorporate sufficient U for precise U-Pb dating. However, the interpretation in a geodynamic context is hampered by uncertainties related to the closure temperature of the chronometer. Estimates range from 600 °C (Vry et al. 2006) to 400 °C (Mezger et al. 1989).

This study combines and compares various thermochronological methods to unravel the orogenic history of the Adirondack Mountains.

Geological Background

The Adirondack Mountains in northern New York State are part of Grenville Province. The province has a complex tectonic history. So far at least 4 orogenic events with ages of c. 1300 to c. 1050 Ma have been identified (Lancaster et al. 2009).

The region is divided into granulite facies Highlands and amphibolite facies Lowlands in the NE. The Highlands, subject to this study, extend from Lakes Champlain, George and Great Sacandaga in the east to Harrisville, Carthage and Boonville in the W. The core of the Highlands is formed by the Proterozoic anorthosite intrusions in the northeast, the Marcy Massif.

Methods

- SEM analysis of rutile growth structures and rutile zircon relations
- Electron Probe Microanalysis of Zr in rutile
- TIMS: Sr-concentrations in biotite
- ICP-MS: Rb-concentrations in biotite

First Results

- Zr-in rutile temperatures and biotite ^{87}Rb-^{87}Sr ages (figure 1)
- SEM analysis in combination with Zr-in-rutile temperatures (figure 2)

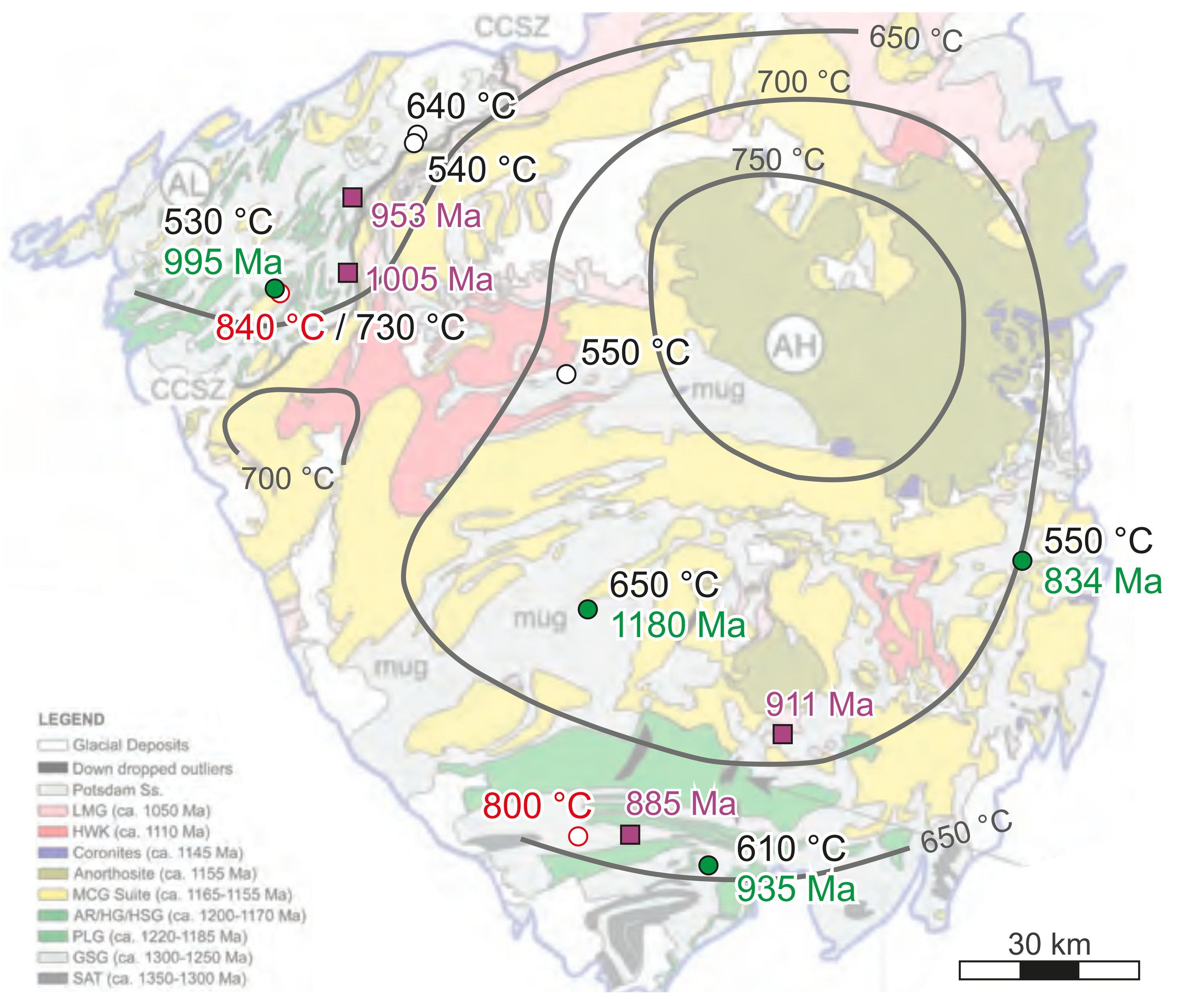

Fig. 1: Geological Map of the Adirondack Mountain Highlands (Chiarenzelli and Selleck, 2016) and sample localities. Temperature countours are based on oxide and two-feldspar thermometers (Bohlen 1979). Zr-in-rutile temperatures for rutile grown during prograde metamorphism (peak temperature), and in black for the rutile grown during retrograde metamorphism (cooling temperature). Rb-Sr ages in green from Hafner (2020). U-Pb rutile ages in purple from Mezger et al (1991).

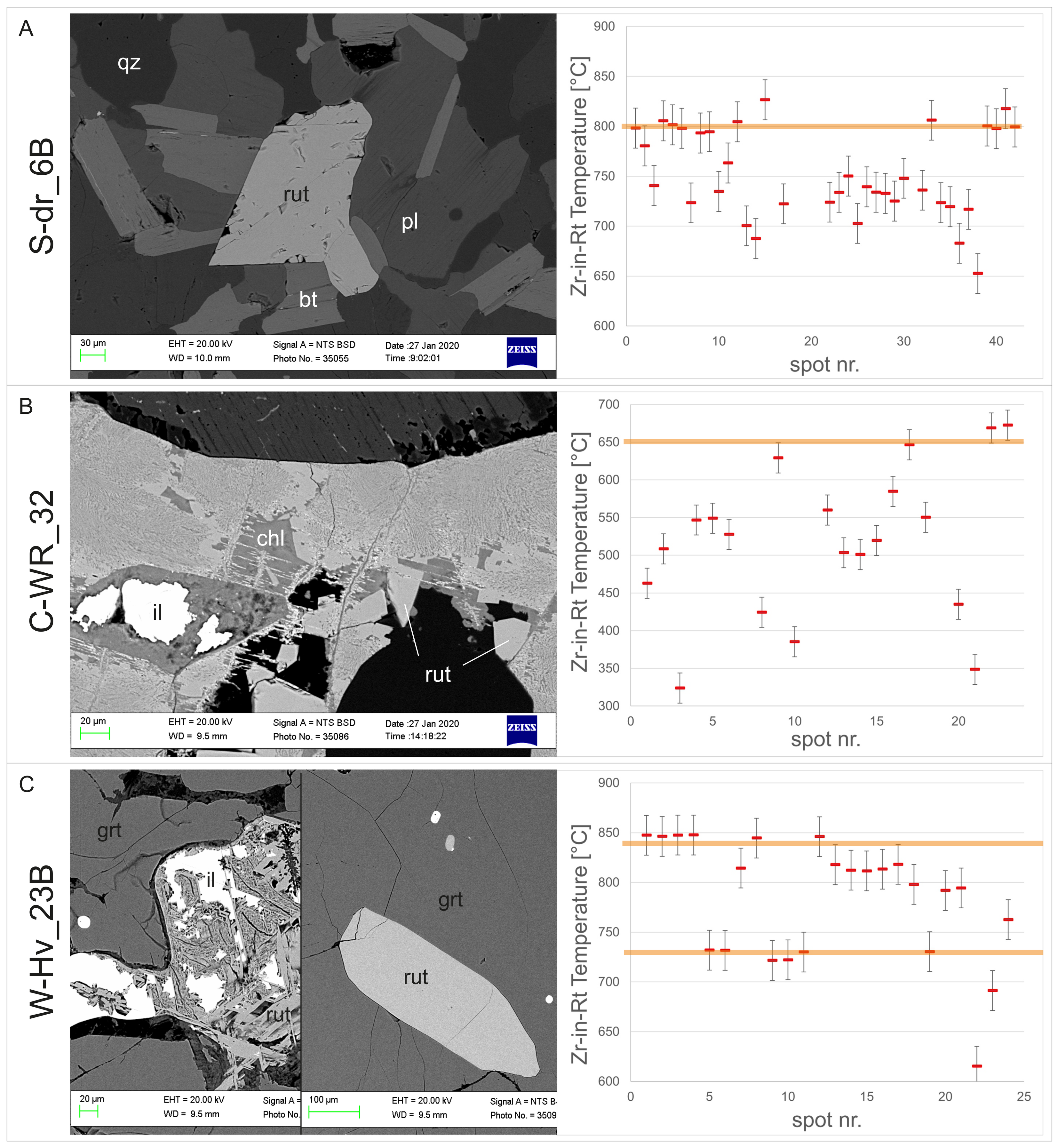

Fig. 2: SEM images of rutile grains and the corresponding Zr-in-rutile thermometry calculated after Watson et al. (2006). The orange lines represent the interpreted minimum metamorphic temperatures. rut: rutile, il: ilmenite, chl: chlorite, grt: garnet, pl: plagioclase, qz: quartz

A) Sample S-dr_6B: euhedral rutile grains and a minimum temperature of 800 °C

B) Sample C-WR_32: strong intergrowth of rutile and chlorite and a minimum temperature of 650 °C

C) Sample W-Hv_23B: two generations of rutile; diffuse intergrowth of rutile and ilmenite (left) and garnet shielded rutile grains (right) and two sets of temperatures with minima of 840 °C and 730 °C.

Conclusions

- At least 2 generations of rutile; prograde vs. retrograde rutile growth
- Prograde rutile have experienced at least 800-830 °C
- Previous peak metamorphose temperature estimates by Bohlen (1979) might be record of cooling temperatures

Outlook / Future Work

- Biotite ^{87}Rb-^{87}Sr ages of more locations
- Zr-in-rutile ages of more locations
- U-Pb zircon ages
- LA-ICP-MS of rutile to determine U-Pb rutile ages
- Compare U-Pb ages with thermal history and estimate relative closure T

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