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Closure of the Rheic Ocean and post-orogenic uplift of the Western Tatra Mountains, Western Carpathians (Poland/Slovakia)

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The Variscan Orogeny records the closure of the Rheic Ocean and resulted in the formation of a significant mountain belt in central-western Europe. The eastern prolongation of that belt is represented by mountain ranges in the Alpine belts of the Carpathians and Alps. The Tatra Mountains are the northernmost crystalline massif in the Carpathian Belt, and have only a weak Alpine overprint, giving the opportunity to reconstruct pre-Alpine processes. Granitoid magmatism, associated with collisional processes in the Tatra Mountains developed from 370 Ma to 340 Ma [1].

Apatite and titanite are common accessory minerals in magmatic and metamorphic rocks, and can be used for high-temperature thermochronological studies. The closure temperature of the U-Pb system in apatite is 350-550ºC [2] while that in titanite is 660-700ºC [3], making both minerals useful for constraining the high temperature cooling history of crystalline basement rocks.

Apatite and titanite crystals were separated from Western Tatra amphibolites, sampled both from the southern and northern metamorphic cover around the granitoid intrusion. The titanite sample yields a LA-ICP-MS U-Pb lower intercept Tera-Wasserburg age of 345.3 ± 4.5 Ma. LA-ICP-MS U-Pb apatite ages from the northern metamorphic cover yield ages of 351.8 ± 4.4 Ma, 346.7 ± 5.9 Ma and 342.6 ± 7.1 Ma. U-Pb apatite ages from the southern metamorphic cover yield an age of 344 ± 11 Ma.

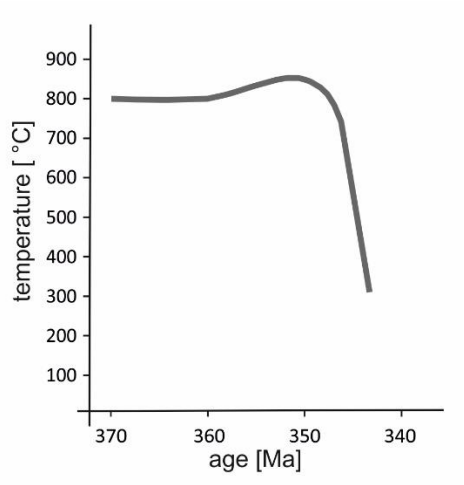

Figure 1. Temperature versus time showing rapid exhumation of the Variscan Tatra Massif.

Obtained titanite and apatite cooling ages are in agreement (within uncertainty) with the youngest U-Pb zircon age of granitoid magmatism in the Tatra Mountains (345-340 Ma). Assuming substantially different closure temperatures for the dated minerals (zircon – titanite – apatite) the only explanation for the age similarities is a relatively rapid post-peak inversion and uplift of the Tatra Massif, with cooling rates differing in different parts of the massif, and higher than previously suggested 30^{o}/myr [4]. Such high uplift and cooling rates could be comparable with the exhumation of the Sikkim Himalayas during Alpine orogeny as well as the classical Barrovian scheme in Scotland [5].

In this described case of the Tatra Mountains, the quantification of orogenic processes is crucial for understanding formation of the Variscan Belt.

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