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How reliable are maximum depositional age estimates based on detrital zircon? An example from Early Palaeozoic successions of the Trondheim Nappe Complex, Scandinavian Caledonides

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U-Pb age spectra of detrital zircons are widely used to estimate maximum depositional ages (MDA) for sedimentary successions of various age. Different methods have been proposed for calculating an MDA. The most common are based on calculated ages of either the youngest single grain (YSG), the youngest grain cluster composed of three or more grains that overlap at 2σ (YGC 2σ), or the youngest graphical peak (YPP). Many of these methods produce MDAs consistent with biostratigraphic age or the radiometric age of volcanic horizons within the same unit; however, several studies have shown that MDA estimates based on detrital zircon can be younger than the true depositional age, particularly in active tectonic settings, indicating that the methods should be applied with care for successions where independent depositional age control is lacking.

In this contribution we present a compilation of 27 detrital zircon samples from Ordovician to Silurian strata from a part of the Trondheim Nappe Complex of the central Scandinavian Caledonides. The samples belong to six stratigraphically distinct units with independent age control from fossils, dated volcanic horizons or bracketing units of known age. These successions represent various marginal basins filled during the closing stages of the Iapetus Ocean in an overall active tectonic setting with detritus from both continental landmasses and Cambro-Ordovician island arcs. Shortly after deposition, the successions were folded and metamorphosed at up to greenschist facies during Taconian accretionary events and/or the Scandian continent-continent collision.

We calculated MDAs by the three methods YSG, YGC 2σ and YPP for all samples based on $^{206}Pb/^{238}U$ ages, applying a rigorous discordance filter of 5% (most studies use 10%), in order to use the most reliable analyses possible. Our analysis shows that the YSG MDA is up to 36 m.y. younger than the known depositional age for 17 of the 27 samples, with up to six individual grains giving too young age estimates in some samples. Hence, YSG MDA obviously does not provide a reliable MDA estimate. Of the YGC 2σ (weighted mean age) estimates, six are still significantly younger than known depositional age; and an additional seven are younger but overlap with the known

depositional age when considering the maximum error on the YGC 2σ estimate. The only method which provides an MDA estimate within the age of known deposition or older for all samples is the YPP method.

Our results indicate that statistically robust estimates of MDA from detrital zircon data in such an active orogenic setting are provided only by the YPP method; both the YSG and the YGC 2σ methods provided unreliably young estimates even with a discordance filter of 5% (using a filter of only 10% makes the problem considerably worse). The spuriously young ages of up to six near-concordant grains in some samples is probably due to concealed lead loss, possibly caused by (fluid-assisted?) recrystallisation of zircon domains during regional greenschist-facies metamorphism shortly after deposition.