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Accessing probable thermal histories through dispersed, partially-reset zircon (U-Th)/He ages

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We have applied the ZRDAAM model (Guenthner et al., 2013; Am. J. Sci. 313) to assess the thermal evolution of the Neoproterozoic stratigraphy of the Mackenzie Mountain fold-thrust belt (NWT, Canada), which witnessed protracted (100's m.y.) cooling through the uppermost crust. Single crystal ZHe dates from rocks in the cores of anticlines span 432 $\pm$ 35 Ma to 46 $\pm$ 4 Ma, with intrasample ZHe date dispersion as great as 350 m.y., indicating that the strata have not been heated sufficiently to fully reset the zircon (U-Th)/He system. The modeling has its most utility in samples where self-irradiation of zircon has occurred over long geologic timescales without significant annealing of damaged zones. Partially- to fully-reset detrital datasets can contain a tremendous amount of T-t information, due to the wide range in grain size, eU, and potential for variable pre-depositional histories and inherited radiation damage in the zircon population. These variables result in a broad spectrum of closure temperatures within a single sample, and in tectonic settings where strata are never buried to sufficiently high temperatures can potentially record more than the most recent thermal event. Additionally, modeling of these datasets has added value in strata where apatite is absent or too small for (U-Th)/He analysis, as highly damaged zircon can record similar parts of the cooling history as the apatite He system. However, several factors complicate interpretation of these datasets including the influences of pre-depositional history (e.g. inherited 4He and radiation damage, on ZHe dates and date-eU relationships). As a result of these variables, sampling from the same stratigraphic succession can yield substantially different ZHe date populations, despite having experienced the same T-t history, should the strata have different grain sizes or provenance. For these reasons, we believe that detailed thermal modeling is required to understand the probable geologic history exhibited by the datasets. We do not recommend selecting only the youngest dates from samples or averaging (U-Th)/He dates, as these methods do not acknowledge the complexity of the (U-Th)/He system and potentially exclude non-obvious, but equally probable, geologic scenarios. To this extent, using the vertical profile approach to assess exhumation rates from cooling age data may also provide an inaccurate result if the strata have not been buried to sufficient temperatures to completely reset any prior thermal history. As an alternative, we analyzed more grains from individual samples and combine data from similar structural regions to assess regional trends in thermal history. We believe that this approach does an appropriate job of acknowledging the errors and assumptions involved in the technique while providing meaningful information on thermal history of a region. Thermal modeling of the Mackenzie Mountains data reveals that (1) a substantial sedimentary package was deposited following the Devonian and removed during Permo-Triassic cooling, and (2) the Cordilleran deformation front propagated through the study area from the Albian to the Paleocene, with a moderate increase in cooling rates between 75-67 Ma in the southwest, and 60-55 Ma at the deformation front.