A multi-system geochronology of Cenozoic tuffs in the western Pannonian Basin with implications for interpretation of (U-Th)/He data

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We applied a range of geo-/thermochronological methods (i.e., zircon U-Pb, apatite fission track and apatite (U-Th)/He) and thermal modelling approaches (i.e., thermal maturity and thermochronological data) to Upper Eocene-Lower Oligocene tuff layers from a biostratigraphically exceptionally well-controlled borehole (Alcsútdoboz Ad-3) in order to test the efficacy of the methods for dating volcanic rocks and to constrain the age of Cenozoic geodynamic events in the western Pannonian Basin. Apatite fission track and zircon U-Pb data document two volcanic phases of Middle Eocene (43.4-39.0 Ma) and Early Oligocene (32.72±0.15 Ma) age, respectively. Apatite (U-Th)/He ages (23.8-14.8 Ma), and independent thermal and subsidence history models revealed a brief period of heating to 55-70°C at ~17 Ma caused by increased heat-flow related to crustal thinning and mantle upwelling. These results demonstrate that, contrary to common perception, the apatite (U-Th)/He method is likely to record 'apparent' or 'mixed' ages resulting from subsequent thermal events rather than 'cooling' or 'eruption' ages directly related to distinct geological events. It follows that a commonly used, yet naïve conversion of 'apparent' or 'mixed' (U-Th)/He ages into cooling, exhumation or erosion rates is incorrect. Thus, we recommend applying a multi-methodological approach involving other thermo-/geochronometers, thermal maturity data, and/or stratigraphy, to reconstruct a robust thermal history from (U-Th)/He data.