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300 million years of basin evolution – the thermotectonic history of the Ukrainian Donbas Foldbelt

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The Ukrainian-Russian Pripyat-Dniepr-Donets Basin is a large intracratonic rift structure formed during the Late Devonian. It is situated at the southern margin of the Precambrian East European Craton, adjacent to the Hercynian Tethyan belt in the Black Sea area and the Alpine Caucasus orogen. With a sediment thickness of more than 20 km, it is one of the deepest sedimentary basins on earth. The eastern part of the Pripyat-Dniepr-Donets Basin – called Donbas foldbelt – is strongly folded and inverted. Proposed models of basin evolution are often controversial and numerous issues are still a matter of speculation, particularly the erosion history and the timing of basin inversion. Basin inversion may have taken place during the Permian related to the Uralian orogeny, or in response to Alpine tectonics during the Late Cretaceous to Early Tertiary.

We investigated the low-temperature thermal history of the Donbas Foldbelt and the adjacent Ukrainian shield by a combination of zircon fission track, apatite fission track and apatite (U-Th)/He thermochronology. Although apatite fission track ages of all sedimentary samples were reset shortly after deposition during the Carboniferous, we took advantage of the fact that samples contained kinetically variable apatites, which are sensitive to different temperatures. By using statistic-based component analysis incorporating physical properties of individual grains we identified several distinct age population, ranging from late Permian (∼265 Ma) to the Late Cretaceous (70 Ma). We could thus constrain the thermal history of the Donbas Foldbelt and the adjacent basement during a ∼300 Myr long time period.

The Precambrian crystalline basement of the Ukrainian shield was affected by a Permo-Triassic thermal event associated with magmatic activity, which also strongly heated the sediments of the Donbas Foldbelt. The basement rocks cooled to near-surface conditions during the Early to Middle Triassic and since then was thermally stable. The basin margins started to cool during the Permo-Triassic whereas the central parts were residing or slowly cooling through the apatite partial annealing zone during the Jurassic and most of the Cretaceous and eventually cooled to near-surface conditions around the Cretaceous-Paleogene boundary. Our data show that Permian erosion was lower and Mesozoic erosion larger than generally assumed. Inversion and pop-up of the Donbas Foldbelt occurred in the Cretaceous and not in the Permian as previously thought. This is indicated by overall Cretaceous apatite fission track ages in the central parts of the basin.