U-Pb zircon ages correlate the Columbia River flood basalt with the Mid-Miocene Climate Optimum

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The Columbia River Basalt Group (CRBG) is the youngest and best-preserved continental flood basalt province, but its environmental effects remain disputed. Based on current geochronological (K-Ar and $^{40}Ar/^{39}Ar$) estimates for the age of the CRBG, there appears to be a very broad temporal coincidence between the main eruptive phase of the CRBG and the Mid-Miocene Climate Optimum (MMCO), a period of elevated global temperatures 4-6° above background and atmospheric CO_2 >400 ppm. However, a causative relationship between volcanism and global warming remains speculative as high-precision geochronology precisely linking the two events are lacking. Current age models suffer from large (>1 Myr) analytical uncertainties, inconsistencies with the geomagnetic polarity timescale, and dates that violate stratigraphic order.

Here, we use CA-ID-TIMS U-Pb geochronology on zircon-bearing volcanic ash beds to build a high-resolution (10 kyr) eruption record for the Columbia River Basalt Group, and to calculate effusion rates that permit comparison with Mid-Miocene climate change. While basalt does not typically saturate zircon, interflow sediments, paleosols, and volcaniclastic layers in the CRB stratigraphy contain felsic ash sourced from regional silicic volcanism. More than 95% of the CRBG erupted between 16.7 and 15.9 Ma, over twice as fast as previous estimates, with an average eruption rate of 0.33 km^3/yr. By suggesting a recalibration of the geomagnetic polarity timescale, these data support that the onset of flood volcanism was contemporaneous with the onset of Mid-Miocene warming, and that the warmest intervals may have been concurrent with the eruption of the largest CRBG formation. We also show that >20% of the total volume erupted in thousands of years near the peak warming, suggesting the tempo of eruptions is an important factor of flood basalt impact on global climate throughout Earth history. Further high-precision geochronology in this and other LIPs will be crucial for understanding why some flood basalts apparently result in mass extinctions and others do not.