Assessing the role of the continental arc magmatic CO_2 flux on icehouse–greenhouse transitions: A ~720 Myr record

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Silicate weathering is commonly considered the primary regulator of atmospheric CO_2 on multimillion-year timescales. Spatiotemporal variability in the continental volcanic arc CO_2 flux, however, has recently been proposed to play a more dominant role in pCO_2 changes. Since the mineral zircon is abundantly produced in arc-related melts, we utilize a compilation of ~120,000 new and published single grain detrital zircon U-Pb age data from globally dispersed sedimentary rocks as a proxy to track continental magmatic arc systems through time. These data, which are derived from sedimentary rocks with depositional ages spanning the last ~720 Myr, are evaluated in a stratigraphic context to assess how global zircon production and inherently related volcanic CO_2 fluxes have changed in association with major icehouse–greenhouse transitions. These data demonstrate that zircon age distributions are skewed towards relatively young detrital zircon populations during periods of greenhouse climates (e.g., the Cambrian, Jurassic, and Cretaceous), whereas age distributions from periods with icehouse climates (the Cryogenian and Permian) contain relatively low concentrations of young grains. These shifts in the relative abundance of young zircon grains indicate that continental volcanic arcs were spatially extensive during greenhouse climates and spatially reduced during icehouse climates. Cryogenian deposits notably contain the lowest proportion of young zircon of any geologic period considered here, consistent with the hypothesis that a dramatic reduction in the volcanic CO_2 flux may have been a key parameter in driving severe "Snowball Earth" glaciations. Although silicate weathering is certainly a major component in the long-term carbon cycle, the data summarized here imply that major shifts in atmospheric pCO_2 and major icehouse-greenhouse transitions have been principally controlled by variation in the continental arc volcanic flux from the Cryogenian to present.