Goldschmidt 2021 Abstract
https://doi.org/10.7185/gold2021.5550

An influx of bioavailable elements to the Earth 0.8 billion years ago suggested by the size-frequency distribution of the lunar craters

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We investigate the formation ages of 59 lunar craters with fresh morphologies and diameters greater than approximately 20 km and first find that 8 of 59 craters were formed simultaneously. Considering the radiometric ages of ejecta from Copernicus crater and impact glass spherules from various Apollo landing sites, we conclude that sporadic meteoroid bombardment occurred across the whole Moon at approximately 0.8 Ga. Based on crater scaling laws and collision probabilities with the Earth and Moon, we suggest that at least (4–5) × 10^16 kg of meteoroids, approximately 30–60 times more than the Chicxulub impact, must have plunged into the Earth-Moon system immediately before the Cryogenian. If we assume the chemical composition like CI or CM chondrites, around ~10^15 kg of carbon must have been supplied to the Earth. It is also noted that our new finding also suggests that ~10^14 kg of extra-terrestrial P should have accreted across the Earth, which is one order of magnitude higher than the total P amount of the modern sea. In general, large-scale changes in marine biogeochemical cycles are undoubtedly forced by tectonic and magmatic processes and chemical weathering of the continental crust, but our new finding suggests that the flux of extra-terrestrial bioavailable elements might also have influenced marine biogeochemical cycles.