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Cosmic dust fertilization of glacial prebiotic chemistry on early Earth

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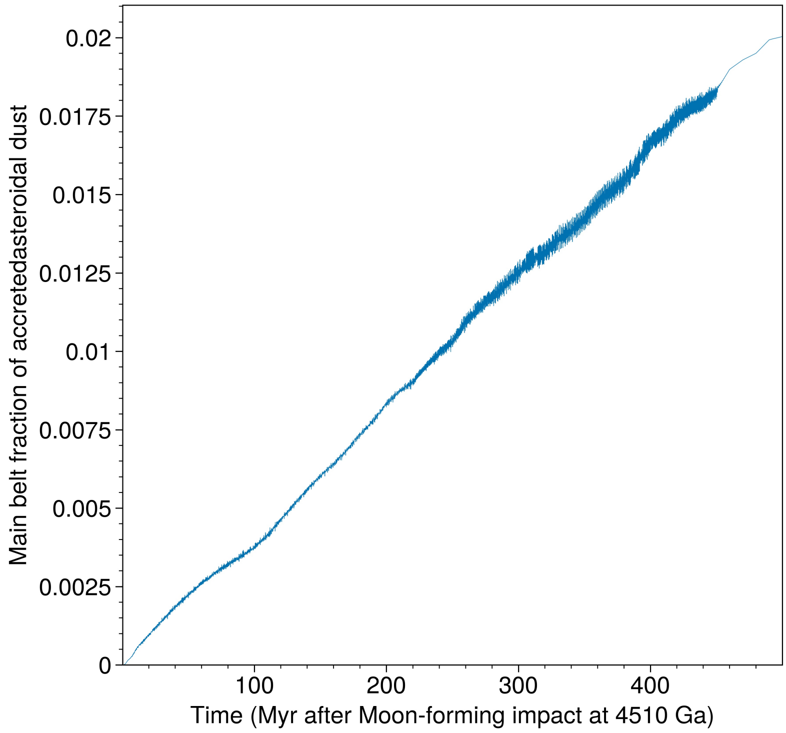
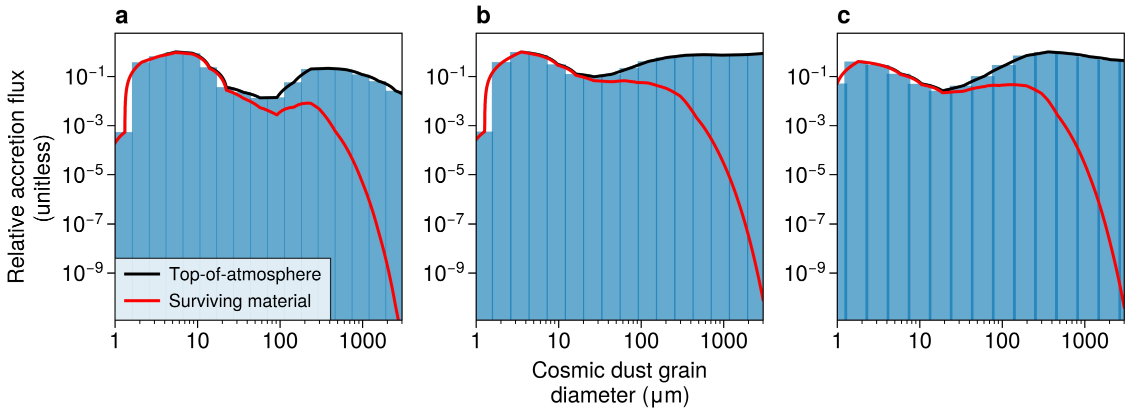


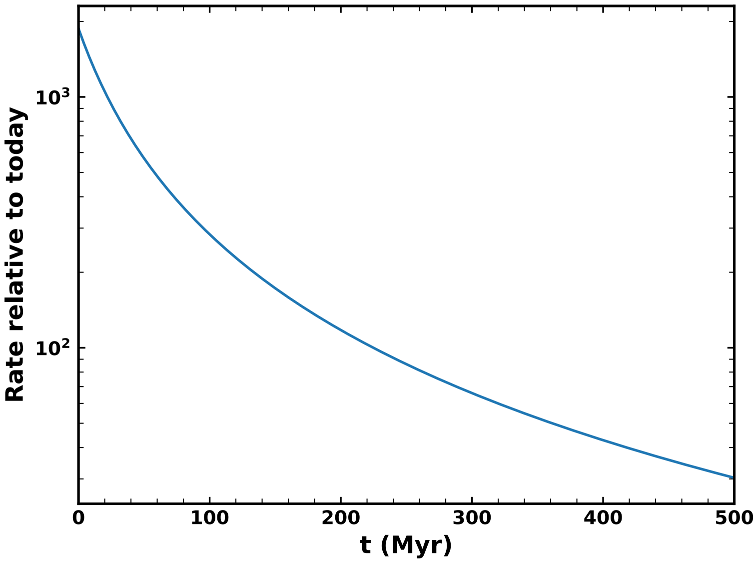
Supplementary Figure 1: Main belt fraction of asteroidal dust accreted to early Earth. Results from our simulations are plotted for the first 500 Myr of Solar System history.



Supplementary Figure 2: Grain size distribution for the mean accretion flux of cosmic dust per type, before and after atmospheric entry. Simulations predict the mean mass accreted for a given size bin, plotted as a histogram, and normalised in the case of each dust source to the maximum accretion flux among all bins. Smoothed distributions plot an interpolation between the centre-point of each bin. The bimodal distribution predicted by our numerical model for a) main belt asteroid, b) comet, and c) rapidly depleted asteroid sourced dust arriving at Earth's atmosphere undergoes a process of ablation that destroys larger grains with progressively greater efficiency. Results are unitless, being normalised to the highest accretion flux as a function of a grain size for each class of dust.

Parameter	Symbol	Value (units)	Reference
Nitrogen in cometary dust	$--$	2500 (ppm)	[38]
Carbon in cometary dust	$--$	50,000 (ppm)	[38]
Sulfur in cometary dust	$--$	90,400 (ppm)	[88]
Phosphorus in cometary dust	$--$	1000 (ppm)	[89]
Nitrogen in asteroidal dust	$--$	1500 (ppm)	[89]
Carbon in asteroidal dust	$--$	30,000 (ppm)	[89]
Sulfur in asteroidal dust	$--$	60,000 (ppm)	[89]
Phosphorus in asteroidal dust	$--$	1000 (ppm)	[49]
Nitrogen in upper continental crust	$--$	83 (ppm)	[33]
Carbon in upper continental crust	$--$	500 (ppm)	[90]
Sulfur in upper continental crust	$--$	600 (ppm)	[33]
Phosphorus in upper continental crust	$--$	600 (ppm)	[33]
Cosmic dust fraction in glacial trap	δ_{modern}	$1.52E-03$	[13]
Cosmic dust fraction in deep sea sediments	δ_{modern}	$7.00E-07$	[87]
Cosmic dust fraction in arid aeolian sediments	δ_{modern}	$8.00E-04$	[25]
Melted dust fraction in glacial trap	f_m	0.57	[13]
Vaporised dust fraction	f_v	0.9	[13]
Volatile loss fraction (N), unmelted	f_{loss}	0.9	[15, 62]
Volatile loss fraction (N), melted	f_{loss}	0.99	[15, 62]

Supplementary Table 1: Parameters used in estimating cosmic dust deposit compositions. All compositional values for meteoritic components are model values, i.e., chosen to be representative of a group, rather than fully quantitative average compositions. Such an assessment would require compiling lines of evidence from different techniques, classes of meteoritic material, and forms of samples. Determining unbiased average compositions is an ongoing challenge in cosmochemistry and is beyond the scope of the present study. Noting this, we have chosen indicative and conservative values for parameters, on the basis of published literature.



Supplementary Figure 3: The rate at which comets are input into the inner Solar system throughout the simulations. Data is plotted relative to the rate at which JFCs are scattered inward in the present Solar system. Results from our simulations are plotted for the first 500 Myr of Solar System history.