

A semi-quantitative approach to identify optimal ocean regions and sedimentary rocks for the efficient micrometeorite collection

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Micrometeorites (MMs), remnants of cosmic dust, constantly bombard Earth, with thousands of tonnes reaching the surface annually [1,2]. This study investigates the distribution and collection of MMs, focusing on samples retrieved from the Central Indian Ocean Basin. Analyzing approximately three tonnes of wet sediments and ~5,000 MMs, we employed a machine learning approach. This algorithm, incorporating terrestrial sedimentation rates (TSR) and MM abundance, facilitated the identification of optimal collection zones [3,4]. Our research reveals a significant concentration of MMs in deep-sea sediments characterized by low TSR (<0.01 cm/kyr), despite these regions remaining relatively unexplored. These sediments average ~50 MMs/kg of dry sediment. Moderately deep-sea sediments ($0.01 < \text{TSR} < 0.1$ cm/kyr), such as those examined in this study, contain fewer MMs, averaging ~15/kg. Shallow-sea sediments yield even lower concentrations. Modelling suggests that oceanic regions between 45° N and 45° S latitude are particularly favourable for MM accumulation, with the eastern Pacific ($10\text{--}40^\circ$ N and $10\text{--}30^\circ$ S) and the Central Indian Ocean ($0\text{--}45^\circ$ S) identified as prime targets. Beyond deep-sea collection, ancient sedimentary rocks formed in quiescent environments with minimal TSR (e.g., shale, claystone, mudstone, chert, and limestone) are promising repositories of fossil MMs. This research aims to refine MM collection strategies, leading to more accurate flux estimations and investigate extraterrestrial activity and its influence on Earth's systems. Specifically, this study offers valuable guidance to researchers working on marine environments, enabling targeted sampling in specific global ocean locations for efficient MM collection. Moreover, it provides alternative avenues for researchers lacking the resources or access to collect MMs from remote locations like the deep ocean or Antarctica, regions traditionally dominating MM collection efforts. Identifying suitable rock formations for fossil MM extraction significantly broadens participation in this field and allows for studying the long-term relationship between extraterrestrial events and Earth's processes.

References

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