Surviving impact winters and reconquering the oceans: Tales from ancient coccolithophores

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Calcareous nannoplankton provide stratigraphically continuous fossil records that reveal the evolutionary roller-coaster of the last 220 million years and the links between ocean ecosystems and changing environments. We have endeavored to expand the reach of these records in recent years, by tapping into a rich archive of intact cell-wall coverings – coccospheres – from sedimentary successions that provide exquisite microfossil preservation. These coccospheres convey invaluable information about the original living cell including its size, levels of particulate organic carbon and inorganic carbon, ontogeny, and growth phase and ecology, and allow for direct comparison with their modern counterparts. I will illustrate the application of fossil 'cell' records to understanding the life and times of calcareous nannoplankton communities across the Cretaceous/Paleogene (K/Pg) boundary mass extinction event (66 Ma) – arguably, the most important mass extinction in Earth's history. Calcareous nannoplankton were nearly eliminated during the event but the surviving and recolonising coccospheres from this time reveal extraordinary ecological strategies. Combining unique high-resolution assemblage and morphometric records with novel eco-evolutionary modelling, we have found that calcareous nannoplankton survived the K/Pg boundary by turning to phagotrophy (prey capture and ingestion): a trophic strategy buried in the diversity of shelf species. Furthermore, the striking post-extinction record of global, high-abundance, 'acme' nannoplankton populations show that this mixotrophic (photosynthesis and phagotrophic) ecological strategy persisted as coccolithophores reconquered the oceans, a strategy predicted by ecosystem modelling of a recovering ocean, stripped of diversity, with plankton communities dominated by small cells and little top-down grazing pressure. Coccolithophores were therefore not just lucky survivors that clung on against the odds in the face of global darkness, but rather a highly adaptable group, able to draw from a diverse ecological toolkit that enabled survival of an exceptional extinction-level event and then exploitation of the recovering ocean ecosystem. When is a plant-like plankton not a plant-like plankton? At the K/Pg.