Mode of life and habitat of scaphitid ammonites as a key for understanding their evolution near the end of Cretaceous

Scaphitids (family Scaphitidae) are a spectacular group of ammonites that depart from the typical ammonoid „Bauplan“ in having partially uncoiled shells. They belonged to predominant marine invertebrates during the last 45 million years of the Cretaceous, particularly in Europe and North America, and became extinct as a result of the ecological catastrophe at the Cretaceous-Paleogene boundary, 66 million years ago. Recently, significant progress in scaphitid taxonomy has been made. However, several aspects of their palaeoecology are still poorly known, especially where European forms are concerned. This has a negative impact on our understanding of selection pressures that these cephalopods were subjected to, and, as a consequence, on our knowledge of the environmental drivers behind their evolution in the Cretaceous seas.

The aim of the planned project is to reconstruct the habitat and mode of life of scaphitid ammonites, based on their fossils from the higher levels of the Upper Cretaceous in Europe, as well as on a study of scaphitid-bearing strata and co-occurring biota. On that basis, an environmental interpretation of scaphitid evolution will be proposed, and its significance discussed in terms of current views on ammonite palaeobiology and evolution. An attempt will be also made to explain the gradual extinction of some scaphitid lineages prior to the end of Cretaceous, a kind of prelude to their final demise during the mass extinction across the Cretaceous-Paleogene boundary.

The upper Campanian-Maastrichtian interval has been selected as stratigraphic target for this study, corresponding to the last 10 million years of scaphitid evolution. This choice can be explained by an abundance of scaphitid fossils in deposits of that age across Europe. Moreover, these strata cover a wide spectrum of facies, which allows to test hypotheses on relationships between scaphitids and environments. For comparison, selected materials of North American scaphitids will be studied; these represent evolutionary lineages that were largely independent of the European ones in the time interval indicated.

The project will be based on material already in the possession of the applicant, on museum collections and on supplementary material acquired during fieldwork in key upper Campanian-Maastrichtian successions across Europe, supplemented by North American material. The planned study is of an interdisciplinary nature, encompassing various aspects of functional analysis of scaphitid shells (with focus on their hydrodynamic and predator-protective characters), facies analysis of scaphitid-bearing deposits, palaeoecological considerations on associated biota, and documentation of traces left by durophagous predators on scaphitid shells. Post-mortem drift of empty shells will be considered as a factor that potentially influenced the geographic distribution of scaphitid fossils. The data collected will be arranged in terms of stratigraphy and geography, which would allow for the detection of spatio-temporal trends in the material studied.

Of special importance for the project are geochemical (isotopic) signals gained from scaphitid aptychi (calcareous coverings of the lower jaws, which are much better preserved in Europe than the shells are). Such analyses have not yet been conducted on scaphitid aptychi. Oxygen isotope signals from scaphitid aptychi will be used to estimate palaeotemperatures recorded during scaphitid life (which, in turn, would allow for an assessment of their bathymetry and, perhaps, migrations through the water column). Carbon isotopic signals would be used to obtain data on the trophic position of scaphitids in Cretaceous ecosystems. These data will be assessed against isotopic data obtained from skeletons of co-occurring organisms of known depth habitats (benthic *vs* planktonic foraminifera) and from data on skeletal geochemistry and life activity of Recent cephalopods and other molluscs. Isotopic studies will be preceded by rigorous tests in order to avoid consideration of diagenetically altered samples.

The expected outcome of the project will be to reconstruct the mode of life and habitat of scaphitid ammonites in order to determine environmental drivers of their evolution at the close of the Cretaceous. From a wider point of view, the expected results may be potentially insightful for our understanding of the palaeoecology of other ammonites, especially those with „abnormal“ shells (so-called heteromorphs). From a still wider perspective, this study may provide new arguments to the discussion whether evolution is driven mainly by biotic interactions between species (the Red Queen, Escalation hypotheses) or by random fluctuations of abiotic environments, such as changes of sea level or climate (the Court Jester hypotheses).

The expected impact on society is linked to science popularisation: ammonites belong to the best-known and most easily recognised fossils, and the role of the fossil record for testing evolutionary hypotheses is always worthy of popularisation amongst a wide audience.