Calcium carbonate is one of the most common materials used by marine invertebrates to form their skeletons. Calcitic and aragonitic (polymorphs of $CaCO_3$) fossils are also used as an archive for paleoenvironmental and paleoclimatic reconstructions. Trace element concentrations and isotope data of fossil skeletons are commonly used as proxies of paleotemperatures and seawater chemistry.

The primary information preserved in fossil can be blurred by the processes that influence the skeleton since the death of animal to the moment when it is discovered as a fossil. Some specimens can be dissolved and disappear from the fossil record. The mineral that formed the original shell can be replaced by other, which only mimics primary microstructure of a skeleton. The $CaCO_3$ polymorph that composed primary skeleton can transformed into more thermodynamically stable form and preserved only the shape of original skeleton. The taphonomy is the science which investigate all those processes.

In this project we will attempt to identify mechanism that cause differences in preservation of fossils. Thanks to over 200 years of geological studies, the general factors that favours preservation of fossils are known, e.g. rapid burial, anoxic conditions that inhibit bioerosion, surrounding by impermeable deposits or incrustation by microorganisms. When some exceptional conditions occurs, the acummulations of diverse and well preserved fauna or flora can be formed.

The complex rules governing the preservation of fossils may led to selective preservation of only specific group of organism. This bias is particularly important when using fossil material to assess ancient biodiversity. Among calcium carbonate skeletons, different primary mineralogy (aragonite vs calcite (both low and high magnesium varieties)) is responsible for preservation bias between skeletons of various marine organisms. Aragonite or high-Mg calcite skeletons are either transformed into more stable low-Mg calcite or are entirely dissolved, whereas the co-occurring primary low-Mg calcitic shells typically remain well preserved. This explains why the preservation potential of aragonite decreases with geological age. It was assumed that the aragonite fossils are either excellently preserved or they can be found only as ghost – casts or recrystallized, calcitic specimens. Surprisingly, it appeared that sometimes, the one specific group or aragonite forming organisms can survive, whereas other primarily aragonitic fossils can be recognized only as voids left after dissolution. The difference in preservation pattern are observed even within single specimen, between different parts or layers of the shell. moreover, the microscale relicts of primary aragonite were found in “entirely” calcitized specimens. These observations provided inspiration for deeper investigations of microscale processes that may cause different preservation of fossils, sometimes regardless of mineralogy. As a part of this project we will test the impact of factors such as skeletal microstructure different $CaCO_3$ polymorphs, crystallographic orientation, the amount of intraskeletal organic matter or trace element concentration. We will compared also the material properties of skeletons of various group of organisms and we will investigate how elasticy and hardness can influence on the survival in the fossil record (e.g. for the pace of disarticulation during post-mortem transport or under sediment load).

The project are planned to tackle taphonomy of carbonate skeletons from two perspectives. The experiments will give opportunity to test the research hypotheses under controlled and adjusted conditions (pH, alkalinity, temperature, salinity, aragonite and calcite saturation). The effects of experiments will by documented by comparison of the proportional weight loss, density and porosity of skeleton in different groups of marine calcifiers. We will analyse micromorphology and microstructure of altered samples. We will also test the hypothesis about preferential leaching of certain elements during skeleton dissolution, what can be crucial for proper interpretation of geochemical analysis of fossil material. The dissolution experiments will provide a new data to predict the effects of increasing carbon dioxide in the atmosphere and ocean acidification on calcifing taxa.

The second task of the project is to investigate fossil specimens of various mineralogy, taxonomic affinity and geological age. Fossils will be used as an archive of the effect of long-term processes that are impossible to perform in the laboratory. The goal of the experiments and observations of fossils representing successive stages of preservation is to propose models of alterations for different types of skeletal microstructures. The models will serve to interpret the primary mineralogy or/and microstructures of diagenetically altered organisms and to identify skeletal fragments that can became a reliable source of geochemical data.

Identification of aragonite relicts in specimens previously considered as entirely altered may extend the range of data used for reconstructions and allow comparison of data from aragonite fossils with those based on calcitic species. The recognition of mechanisms that influence on the ultimate state of fossil, can be used also to identify the primary mineralogy of organisms known only from diagenetically altered skeletons.