Description for the general public

Perhaps, it will not be a great exaggeration to paraphrase, in relation to corals, the famous expression by Winston Churchill that "so much (was) owed by so many to so few" (or ... to so delicate). The delicate bodies of coral polyps, that precipitate a fraction of a millimeter of skeleton each day, have contributed through thousands/millions of years to the formation of the largest carbonate structures in the world - the coral reefs. Reefs, that are are centers of marine biodiversity, are considered critically endangered by current climate change (e.g., rising surface temperatures), but there is also a hope that some groups of them will survive and, as happened many times in the geological history, will give rise to new branches of the phylogenetic tree. evolutionary clades. The key to understanding the history of coral adaptations to climate change are their calcium carbonate ($CaCO_3$) skeletons. Various geochemical and isotopic signatures recorded in their skeletons allow to interpret e.g., environmental records of sea surface temperature, water salinity, pH, ocean chemistry, and various anthropogenic inputs to the coral environment. A prerequisite for such studies is that the biogenic carbonates of the skeleton retain the original (bio)geochemical composition. But various natural processes affect the primary structure and composition of calcium carbonate phases, that may undergo secondary alterations, often following the phase transformations (changes of unstable/metastable into stable phases). For example, the aragonite (which is the main, but metastable calcium carbonate phase of the coral skeleton) transforms into stable calcite (unless the skeleton is entirely sealed off from the environment). During such processes, the structure and various environment- and biologically-related signatures are typically altered, rendering the skeletons unsuitable for geochemical interpretations. In contrast to abiotically precipitated calcium carbonates, the minerals formed by organisms (corals), called biominerals, show highly heterogeneous distribution of biogeochemical components. This influences fine-scale phase transformation processes differently in comparison with abiotic calcium carbonates (this is supported by our preliminary studies).

To date, these fine-scale processes remained nearly completely unexplored. The central hypothesis of this project is thus that the biologically-related geochemical heterogeneities in the biogenic carbonates are the key factors influencing dynamics and the course of phase transformations and secondary redistribution of various physiological and environmental signatures. Understanding of these processes is therefore crucial for any precise (paleo)environmental interpretations in which these signatures are used. To test this hypothesis, we will investigate various structural (reaching the atomic-scale level) and compositional details of the coral skeleton during its whole "life cycle": in this truly detective work we will examine the skeleton from the first moments after formation (so called precursor phases) to the post-mortem alteration in natural and experimental conditions. Experiments will be conducted in specially designed computer-controlled reactor system, where different water compositions, temperatures and pressures will be applied to coral samples. By labelling of the experimental liquids with isotopic/elemental dyes we will be able to visualize the successive steps of the resulting changes in skeleton structure/composition by microscopic and modern mass spectrometry analyses. Next, we will also compare our observations with real fossils where such changes could occur through millions of years. Our preliminary experiments give us reason to believe that we will find inconsistencies in previous interpretations of so called "excellently preserved" fossils. Such "corrections" will be very useful for geologists, geochemists, and paleontologists who use for their work such fossils.

There is another famous saying "those who do not learn history are doomed to repeat it". To learn the evolutionary history of corals (and maybe learn how to protect the modern coral reefs) we need to base our knowledge on good sources. Better understanding of such geological sources - information recorded in the coral skeleton - is the goal of our project.