Archaeocyathans are a group of calcareous fossils of world-wide distribution, but stratigraphically limited to deposits of Early Cambrian age. Archaeocyathans were sedentary benthic organisms, which often formed dense clumps of small reefs in shallow warm seas covering extensive cratonic areas after the Early Cambrian transgression. Despite more than one and half centuries of research the systematic position of archaeocyaths is still enigmatic. They were interpreted variously as the remains of protozoa, coelenterates (corals), algae and sponges. The latter view of archaeocyaths affiliation has gained the most acceptance in recent decades, and is reflected in their placement in the poriferan part E of the newly published revision of the Treatise on Invertebrate Paleontology. The revival of the idea of the sponge affinity of archaeocyaths was advanced beginning in the 1970s after discovery in underwater caves of deeper zones of the Mediterranean littoral of unusual spicules devoid calcareous sponges and resembling in some anatomical details the skeletons of archaeocyaths. The aim of our project is to conduct a critical test of the sponge affinities of archaeocyaths, and will be based on samples from Siberia and Mongolia already at our disposal, and on samples to be collected during a field trip to the well-known Lower Cambrian archaeocyathan deposits of Sardinia. Our preliminary study of the Siberian material showed that there are grounds to question the sponge model of archaeocyaths origin. We will acquire new evidence to evaluate their algal affinity, previously suggested, without any in depth studies, by 19th and 20th century paleontologists.
Proving, with the support of grant funds, an algal affiliation of archaeocyaths will be of great importance for understanding the nature of the marine environment near the border of the Precambrian and Cambrian, which was a time of great transformation of Earth's biosphere. The most expressed aspect of this transformation was, among others, the advent in many groups of organisms of mineral (calcium and phosphate) skeletal structures, which made possible the preservation of the fossil record of life. Archaeocyathans, due to their massive presence and considerable taxonomic diversity, are the best witnesses to that time of great biotic change called the Cambrian “explosion". The heuristic value of the proposed project goes therefore far beyond the mere question of solving the conundrum of the systematic position of archaeocyaths. The results of the project can help explain the causes of the abrupt increase of mineral skeletons in the history of life and offer the opportunity to test the hypothesis of calcium detoxification as the cause for the beginning of calcification processes in living systems. This hypothesis, promoted since the mid-1980s by the project leader, in cooperation with German geochemists, explains the emergence of biocalcification processes on the border of the Precambrian and Cambrian as a response of the marine biota to an increased concentration of Ca^{2+} in oceanic water to levels subtoxic for many organisms. This hypothesis, unlike the difficult-to-test alternative hypotheses relating the Early Cambrian skeletonization wave to increasing concentration of atmospheric oxygen or increasing activities of predators, has already received geochemical support by results of analyses of liquid inclusions in marine halite crystals from that age. The inclusion data indicate that between 543 and 510 million years ago (i.e. a time span of about 25 million years) the concentration of Ca^{2+} in the oceanic water increased by a factor of three.
Since the first archaeocyathans appeared and rapidly differentiated at the beginning of the Tommotian stage of the Early Cambrian (approximately 530 million years ago), there is a clear time coincidence between the origin of these intensively calcified organisms and chemical changes of sea water. We hope that some components of this puzzle will be deciphered with help of geochemical methods we plan to apply in this project directly to archaeocyaths skeletons and/or from sediments embedding or filling them. For this purpose we are planning application of a whole range of geochemical analytical techniques, such as SEM/EDS, ToF-SIMS, SHRIMP, EMPA, Raman and stable isotopes of carbon, oxygen, boron and calcium, techniques whose usefulness for such studies has many times been proven.