Biominerals, specifically nacre, or mother-of-pearl, attract a great deal of attention from a wide variety of fields (material science, mineralogy, biology, physics, etc.) because of their remarkable mechanical properties and the fact that despite being intensely studied, their formation mechanisms are still unclear.

Nacre is a composite material of alternating layers of organic matrix and aragonite, 30 nm and 400-500 nm thick, respectively. Each aragonite layer consists of irregularly shaped polygonal 5–10 µm wide tablets that completely fill the space between pre-formed organic matrix layers.

One possible growth mechanism for nacre in *Haliotis rufescens* (red abalone) based upon the observation of Schäffer et al. that the organic matrix layers have pores and that tablets have correspondingly sized and spaced mineral protrusions is that mineral bridges join subsequent nacre tablet layers. These mineral bridges were thought (though never observed) to be crystalline, leading to an epitaxial model in which there is no need for new nucleation events on every organic matrix layer.

However, recent data reported by Nassif et al. on *Haliotis Laevigata* show that each aragonite tablet is surrounded by a layer of amorphous calcium carbonate (ACC). This observation, along with other data by Rousseau et al., implies that mineral bridges do not provide a crystalline connection for epitaxial growth of tablets in subsequent layers. Additionally, recent data by Nudelman et al. indicate that there is a single organic nucleation site in the organic matrix for each nacre tablet.

All of these lines of evidence, along with our recent synchrotron spectromicroscopy data collected at the Synchrotron Radiation Center (SRC), led us to propose a new model for nacre formation. We tested the model with theoretical simulations of nacre growth in two and three dimensions and found results in agreement with the observed appearance of natural nacre. The spectromicroscopy data presented here demonstrate that X-ray absorption near-edge structure (XANES) spectroscopy can better than any other approach characterize the crystal orientation of individual nacre tablets in red abalone in 2 and 3 dimensions.