

# NANOSCALE ANISOTROPIC PLASTIC DEFORMATION IN SINGLE CRYSTAL ARAGONITE

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Aragonite, the orthorhombic form of  $\text{CaCO}_3$ , is ubiquitous in natural systems, including both living organisms and geological structures. In living organisms, aragonite is found to take on a variety of micron and sub-micron structures such as platelets, fibers, and needle-like spicules. The outstanding material properties resulting from the ultrastructural architectures found in natural systems consisting of aragonite are dependent on its ability to resist yield. Some studies have investigated the nanoscale response of several of these biocomposites but in order to fully understand the nanoscale material behavior it is necessary to isolate the material in its pure form. In this study, we use the technique of nanoindentation combined with in-situ tapping mode atomic force microscopy (TMAFM) imaging to show, for the first time, the anisotropic nanoscale plastic behavior of single crystal aragonite. Individual force vs. indentation depth curves for nanoindentation on the (001) plane exhibited distinct load plateaus (ranging between 400-500 $\mu\text{N}$  for a cono-spherical indenter and 275-375 $\mu\text{N}$  for a Berkovich indenter), suggestive of dislocation nucleation events. Residual impressions made by the cono-spherical indenter showed four pileup lobes around the central indent and residual impressions made by the Berkovich indenter showed protruding slip bands in pileups occurring adjacent to only one or two of the residual indent's sides. Numerical simulations based on a crystal plasticity model were used to both interrogate and identify the kinematic mechanisms leading to the experimentally observed plastic anisotropy. In particular, the governing roles of the  $\{110\}\langle 001\rangle$  family, as well as the (100)[010] (100)[001], (010)[100] (010)[001] and (001)[100] (001)[010] systems were revealed.