

Bicarbonate-Rich Liquid Condensed Phase: a Fundamental Pathway to Biomineral Nucleation

M. A. BEWERNITZ^{1*} AND B. CONSTANTZ²

¹Blue Planet Ltd., Los Gatos CA 95032 USA

(correspondence: mark@blueplanet-ltd.com)

²Stanford University, Stanford, CA, 95034, USA

(brentc@stanford.edu)

Recent discoveries in the field of calcium carbonate (CaCO_3) biomineralization, such as prenucleation clusters, mesocrystalline biogenic mineral substructure, and a precursor bicarbonate-rich liquid condensed phase (LCP), have revolutionized our understanding of CaCO_3 mineralization and challenged the classical view of nucleation theory. The recent discovery of a bicarbonate-rich LCP prior to the solid nucleation of CaCO_3 is particularly important because it appears to be a potential non-classical means to nucleation for a myriad of carbonate and bicarbonate systems other than CaCO_3 and suggests that the principle governing its formation may be a fundamental nucleation mechanism in general. Using Nanoparticle Tracking Analysis (a light scattering technique) and other analytical techniques, we demonstrate that the LCP phase is present in many other solutions, even non- CaCO_3 systems as phase droplets between 40 nm and 150 nm in diameter. The size and amount of droplets depends on the system, type and amount of spectator ions present, and physical conditions such as pH and temperature. The common existence of the LCP phase suggests that the condensation mechanism of bicarbonate ion into LCP may be a ubiquitous, fundamental pathway to other nucleation systems and may require us to re-evaluate and re-interpret many fundamental assumptions regarding the behavior of electrolyte solutions, including empirically derived solubility coefficients, activity coefficients, and the interpretation of recent ocean acidification observations. In addition, bicarbonate-rich LCP may be a powerful, currently unutilized tool in the field of carbon sequestration and utilization.