Field detection of ureolytic metabolism and its potential application to understanding the biogenicity of carbonate tufas

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Microbially-induced carbonate precipitation (MICP) can drive microbialite formation, yet it is difficult to determine the specific mechanisms involved in carbonate authigenesis, particularly in structures of untested biogenicity, such as many tufa towers. Among the different microbial mechanisms promoting MICP, ureolysis—the lysis of urea into ammonia and carbon dioxide by urease (Eq. 1)—could be evaluated *in situ* by measuring the activity of urease:

$$(NH_2)_2CO_{(aq)} + H_2O_{(l)} \rightarrow CO_{2(g)} + 2NH_{3(g)} \quad (1)$$

We designed a simple, rapid, and economical test to detect urease activity in the field. The assay contains a pH-sensitive strip detector and the enzyme substrate inside a microcentrifuge tube, which allows testing of biomass directly in the field to obtain a qualitative result in minutes. We evaluated the field test using biofilms from a series of calcareous fens, iron springs, and saline lakes, finding urease-positive biofilms in lake samples and some fen samples. We also found active urease in surficial biofilms from carbonate tufa towers of alkaline (pH ~9.2–9.8) Big Soda Lake, Nevada, USA. Big Soda Lake tufas show signs of rapid growth, active groundwater upwelling in tufa deposition sites, and abundant microbial biofilms, but the role of microbes in tufa formation is poorly constrained. A combination of photosynthesis, extracellular polymeric substances, and microbial urease activity in tufa surficial mats may further increase the pH at the biofilm microenvironment, particularly where groundwater mixes with lake water, promoting carbonate precipitation and accelerating the growth rate of Big Soda Lake tufas. This *in situ* activity detection complements molecular approaches for determining MICP mechanisms, expanding our knowledge of environmental protein expression and its effects on carbonate precipitation.