We are exploring aqueous phase coexistence as a primitive means of compartmentalization to form protocells. Compartmentalization through introducing aqueous two-phase systems enables concentration of the genetic and catalytic materials that are presumed to have been present at low concentration on the early earth.

Particle-stabilized emulsions, known as Pickering emulsions, are formed from fluid droplets of dispersed phase in a continuous phase of liquid in the presence of solid particles. Particle assembly at liquid/liquid interfaces is well known for oil/water systems and has been observed in aqueous biphasic systems. We explored the assembly of clay mineral particles as surfactants in PEG/dextran aqueous two-phase system (ATPS). We decided to use three different main types of clay that are classified depend on their crystal structure for our experiments: kaolinite, montmorillonite and illite. Clay particles differ in their particle size, crystal structures, layering and their swelling properties. In order to understand where clay particles assemble in the ATPS, confocal microscopy images (Figure1) and zeta potential measurements were obtained. Different types of assemblies were observed for the different clay types (Figure 1). Kaolinite (KGa-2) interacts with labeled dextran, which labels the clay and pronounces the jammed structures in Figure 1-A. The jammed structures suggest that KGa-2 is not in equilibrium phase. Both types of the montmorillonite, Swy-2 and STx-1b, appear to be encapsulated in dextran-rich droplets or dispersed over the PEG-rich phase (Figure 1-B and C). Encapsulation of montmorillonite differed in %15-%15 w/w PEG-Dext ATPS suggesting that surface tension plays role in this behavior.

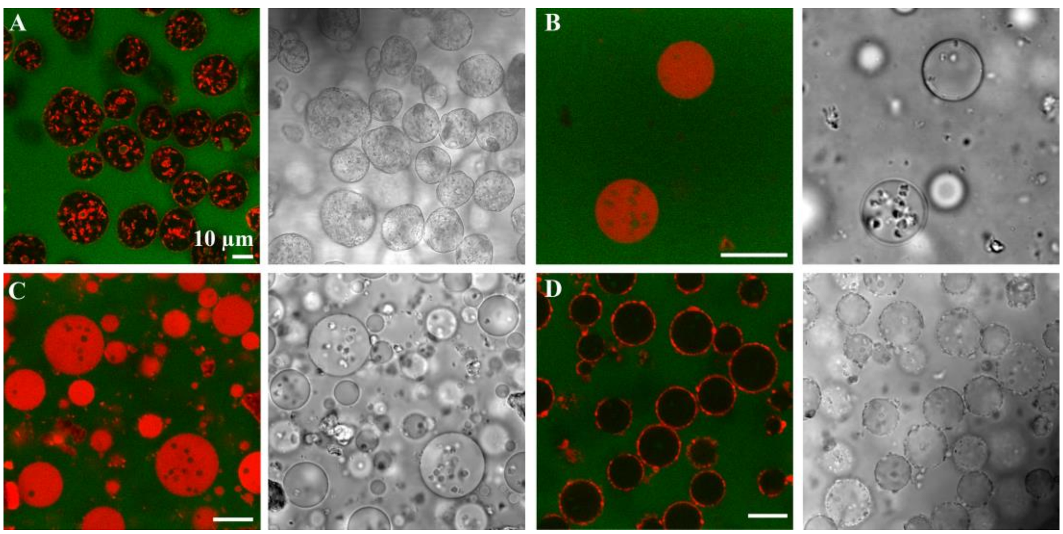

Figure 1. Microscope images showing clay particles in PEG/dextran ATPS. Left images show overlay of fluorescence channels and right images show transmitted light for samples containing: (A) Kaolinite (KGa-2), (B) Na-rich montmorillonite (Swy-2), (C) Ca-rich montmorillonite (STx-1b) and (D) NX-illite in 20%/20% w/w PEG-Dext ATPS. Fluorescent-labeled dextran (red) and PEG (green) has been included to aid visualization of the dextran-rich phase droplets and PEG-rich continuous phase.

We have results of surface tension for different percentage of ATPS by using pendant and spinning drop methods. NX-illite is at the interface of the dextran-rich droplet and interacts with the labeled dextran (Figure 1-D). Droplets sizes for NX-illite are smaller and more uniform compared to others, suggesting that droplets are stabilized by clay particles forming monolayers at the interface.

Understanding how these particle types interact with the ATPS will lead to improved understanding of Pickering type emulsions in all-aqueous systems and may have relevance to compartmentalization of catalytic activity for protocell. We also proposed a reaction that is catalyzed by clay in ATPs for proof of principle.