Any geologist will say that rocks tell the earth's story. Sedimentary strata, fossils, lava flows, faults- all revealing something about a previous environment on Earth. But what about the biochemical archive of Earth's past environments? Do organic-rich layers in the rocks contain information unrecorded in the rocks alone? It's clear that Toby Maxwell, a PhD candidate in Agricultural and Environmental Chemistry at UC Davis, thinks so as he introduces the use of paleo-indicators in the Grand Canyon area to his peers on Wednesday.

"The geology is great and information in the rock record tells us a tremendous amount," Maxwell explains, "but adding in chemical and biological signals can tell us even more- and we can even use this information on a bunch of different time scales."

The famed Grand Canyon stratigraphy has hosted numerous geologic investigations over the years. The generalized story from these studies involves cyclical sea level change events. The Walcott member of the Kwagunt formation is a sequence of deep-marine sediments from ~740 million years ago- a time during which isotope signatures from rocks in the Walcott member suggest the water in this deep-ocean setting was extra salty.

Well, the biology has something to say, too. Long lipid (fat) molecules and other chemicals found in organic-rich layers of the Walcott member point to algae and archaea as primary residents of this deep ocean: specifically the protist Tetrahymena, which has been documented to thrive in super-salty conditions. "This is a great example of how the geology and biochemistry can be used together to reveal even more detail about paleo-environments," Maxwell continues.

Fast-forward ~739,990,000 years, marine strata of the Walcott member are now ~7,000 feet above sea level, and rodents are telling the story of ecological change after the end of the last ice age. Geologic data suggest the Laurentide Ice Sheet, one of North America's Pleistocene ice caps, melted rapidly between 16-13 thousand years ago. However, ecologists argue that plant communities didn't adjust to the warmer climate until 1000-3000 years later, an idea referred to as *biological inertia*. Packrat nests, or middens, may provide an answer to the dilemma. Living up to their name, Packrats of the past in the Grand Canyon area collected local organic detritus to make their nests. The dry climate characteristic of the Grand Canyon region has preserved middens from the Paleo-packrats and therefore a record of local ecology immediately following the ice age. A combination of ^{14}C dating, palynology, and DNA analysis on material from the middens gives evidence supporting biological inertia, and the persistence of Pleistocene plant communities for some time following recession of the Laurentide Ice Sheet.

In even more recent times, trees are recording the way humans have impacted forests on the north rim of the Grand Canyon. Wildfires are a natural and necessary component to many ecosystems. However, European immigrants have been suppressing wildfire since they settled the Grand Canyon area in the late 1800s. The change in fire frequency is recorded in a tree's growth rings as a burn mark and renewed rapid growth healing the burn. Major changes to understory vegetation and soil development accompany reduced fire frequency, which have resulted in a new type of forest structure in the Grand Canyon rim. The tree rings provide a valuable time component that may accompany other studies of forest succession and may be used to augment investigations of soil chemistry, understory ecology, and human history.

"It's great to see how the system works as a whole," Maxwell concludes, "…and it's even more interesting to see how a little bit of chemistry and biology can help us understand how environments on Earth have changed through time."