When asked where she gets her samples, geologist Susan Kidwell says, “Dumpster diving,” with a laugh. Kidwell uses pieces of discarded shells of marine creatures such as clams, scallops, and mussels to learn about seafloor ecosystems of the past. She collaborates with biologists studying the seabed who are more than willing to hand over the shell fragments they come across—they call it “the grunge”—from their samples.

Identifying the various species that produced such shell fragments and dating those fragments allow researchers to compare present-day communities of clams and other bivalve mollusks with those of tens, hundreds, or thousands of years ago. For example, Kidwell’s group identified the collapse of a bivalve community from the 1800s off the coast of Southern California by documenting the downfall of species that thrive in clear water and the rise of species that tolerate a muddier habitat.

Kidwell is now shifting her sights northward to the Arctic, not only to delve into the paleoecology but also to further analyze the shell fragments to understand how they persist in the chemically and physically aggressive conditions on the seafloor there. Emma Hiolski spoke with Kidwell about her recent work on shell debris and its life after death at the bottom of the ocean.

What are shells made of, and what information can fragments provide?
Bivalves secrete a mixture of calcium carbonate and a very tough, protein-rich form of organic matter to create their shells. My focus is on the calcium carbonate, specifically the mineral form aragonite, which is the most common form used by mollusks. The other common form is calcite.

Mollusks have evolved a wide array of different mineral microstructures, even just of aragonite alone. Figuring out

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which organism produced a shell fragment can tell you something about water depth, temperature, or clarity at the time that the shell was produced, based on that species’ preferred environment. I’m trying to, among other things, get biological information out of these samples. But as a geologist, I’m mainly focused on those shells as sedimentary particles. They’re extremely interesting because they carry elemental and isotopic proxy information from when they were first precipitated by an organism. And these fragments can bear witness—by physical or chemical transformation—to the surrounding environmental conditions post-mortem.

What are those post-mortem conditions like?
The upper layer of the seafloor can be very thick and mixed. It’s actively churned by worms, crabs, bivalves, fish, and larger animals—like walrus in the Arctic—and of course gobs of microbes because there’s plenty of dead organic matter for them to eat. It’s geochemically very active because it’s biologically very active. Aerobic decomposition of the dead organic matter produces carbon dioxide, which produces carbonic acid and reduces the pH within small pores in the sediment. Oxidation of hydrogen sulfide, a by-product of anaerobic decomposition, lowers the pH even more. Aragonite and calcite are both reactive, but aragonite especially so. You can visualize it disintegrating like mad in pockets of low pH.

Your current work focuses on how a shell transforms right after the clam dies until it becomes part of the geologic record. What is that process, and why does it matter?
We want to know the percentage of a cohort of shells that will survive into the permanent, long-term geologic record. At any given site, we date a large number of shell fragments to learn the age of the oldest and youngest shells and the median shell age. The age distribution gives us information on how rapidly shells are destroyed and whether there’s any change in loss rates over time.

We know shells everywhere have very high initial loss rates, but at a certain point post-mortem, the shells stop being so reactive. So there’s some kind of stabilization that occurs. We’re using scanning electron microscopy to zero in on visual changes in the mineral microstructure of shells as they age.

One such change we’re observing in the Arctic—and also in the tropics—is formation of a surface layer on shell fragments that seals off the original microstructure within. This nanoscale layer appears to be a microbial precipitate. Thus, microbial activity puts aragonite at peril post-mortem, but for a small subset of shells, it promotes a kind of case hardening.

What comes next?
We’re hoping to start some experimental geochemistry experiments to understand how aragonitic shells persist in the face of aggressive chemical conditions. The biologists we’re collaborating with in the Arctic have been very interested in what we learn about this process. They are now seeing accelerating rates of shell dissolution from ocean acidification. They have observations from the 1970s onward, but the Industrial Revolution was cranking well along by the late 19th century, so they’re very curious whether we see evidence of ocean acidification in older shells.

It’s been great having so many biologists to talk with who are so deeply interested in the bottom fauna, including the clams. And they’ve been absolutely great about handing over and saving their trash for us.

Emma Hiolski is a freelance contributor to Chemical & Engineering News, the weekly newsmagazine of the American Chemical Society. Center Stage interviews are edited for length and clarity.