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Applications of SURF Geobiology to Ending Fugitive Emissions from Abandoned Wells

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The United States contains an estimated three million oil and gas wells that were abandoned after they stopped producing economical quantities of hydrocarbons. State regulations require these to be sealed, but the proper plugging and abandoning (P&A) procedure for a well can cost about $100,000. It is often cheaper to maintain the annual lease payment and shut in the well. Over time, ownership becomes obscure as companies buy and sell leases, operators retire, and old-timers with legacy knowledge disappear. Orphan wells no longer have an identified owner, and their P&A becomes the responsibility of state agencies. Steel casings and wellbore cement deteriorate over time, and many old wells emit methane gas, volatile organic compounds (VOCs), and even hazardous substances like hydrogen sulfide into the atmosphere. Conventional P&A on millions of abandoned wells is an expensive undertaking.

We propose a cheaper solution using carbon dioxide captured from the air, injected into depleted oil and gas reservoirs, and converted into solid carbonate minerals. This durably sequesters the carbon dioxide and stops fluid migration through the pores, halting fugitive emissions. Because the carbonate in the pore space blocks fugitive emissions at the source, it will plug any orphaned wells that tap into the reservoir, including those with no visible presence at the surface.

The conversion of carbon dioxide into carbonates like calcite and magnesite occurs inorganically when carbon dioxide in seawater reacts with unstable minerals, and organically as sea creatures from clams to corals create it on a regular basis. We are investigating the potential for microbes to carry this out at the temperature, pressure, salinity, and pH conditions typical of an oil reservoir rock at depths of 2,500 to 10,000 feet. Horizontal drill cores collected for the COLLAB program from the 4100-foot level of the SURF were sampled for indigenous microbes. Species of Geobacillus were obtained from the cores that showed potential to survive at oilfield depths. Persephonella marina, a species of bacteria found at deep sea hydrothermal vents is also being studied. An enzyme called carbonic anhydrase can be used by both Geobacillus and P. marina to convert CO2 into carbonate. Laboratory assessments are currently underway to assess the viability of the microbes under a variety of pressure and temperature conditions and on a variety of different substrates.

Extremophile microbes and carbon dioxide injected into the residual saltwater brines in depleted oilfields could use cations in the brine to convert CO2 into carbonates in the subsurface pore space. This would permanently sequester the greenhouse gas and halt fugitive emissions from abandoned wells.

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