Energy analyst proposes injecting carbon dioxide into deep sea ravines for permanent storage

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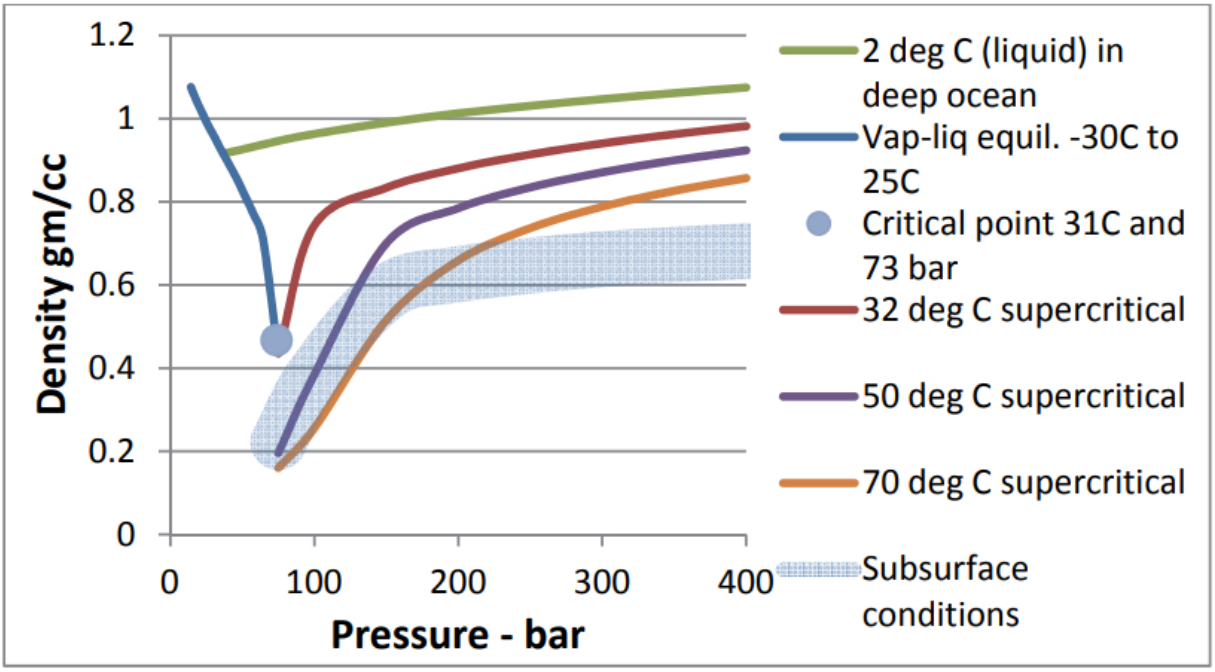

Density vs. pressure for CO2 at subcritical and supercritical conditions. Credit: *Energy Procedia* (2017). DOI: 10.1016/j.egypro.2017.03.1686

(Phys.org)—New Zealand energy analyst Steve Goldthorpe has published a paper in the journal *Energy Procedia* suggesting that carbon dioxide pulled from the atmosphere (or scrubbed from coal plant smoke

stacks) could be stored permanently in deep ocean trenches. Once there, he notes, the gas would become a liquid denser than ocean water, which would cause it to fall naturally to the ocean floor, creating an underwater lake.

In order to prevent serious changes to our planet, most scientists agree that we need to stop pumping greenhouse gases, particularly carbon dioxide, into the atmosphere—and we should probably start trying to remove at least some of what we have already put there. But where would put it? We cannot just dump it somewhere, because it is a gas and would simply make its way back into the atmosphere. Some have suggested injecting it into spent natural gas wells or other underground vacancies. Goldthorpe suggests that perhaps the ocean would be a better option, noting that at depths of 3000 meters, the density of carbon dioxide is greater than that of ocean water, which means it would sink. Ideally, it would sink into a hole of some sort so that it would not spread across the ocean floor. Ocean trenches, he notes, could serve that purpose. They would fill like an empty bucket with water here on land, creating a lake of carbon dioxide. He adds that it is possible that over a long time period, the carbon dioxide would solidify.

Goldthorpe takes his idea even further by offering some possible sites—he used Google Earth to check for suitable candidates. He notes that Sunda trench, which is 6 kilometers below the surface in an area south of the Indonesian archipelago would be a good choice. He's calculated that it could hold 19 trillion tonnes of liquified carbon dioxide, which, he notes, is more than all of the carbon dioxide that humans have injected into the atmosphere to date. He notes also that the idea is not out of the blue—natural carbon dioxide lakes already exist on the ocean floor. Other possibilities might include the Japanese Ryuky trench or the Puerto Rico trench.

Goldthorpe concludes by acknowledging that much more study would

have to be done before serious consideration, particularly to prevent the top portions from spreading or causing an increase in ocean acidity.

More information: Steve Goldthorpe. Potential for Very Deep Ocean Storage of CO 2 Without Ocean Acidification: A Discussion Paper, *Energy Procedia* (2017). DOI: 10.1016/j.egypro.2017.03.1686

Abstract
Carbon Capture and Storage (CCS) is an essential contributor to the mitigation of climate change. CCS will require vast CO2 storage capacity. At present only geological storage is being considered. This paper revisits an alternative CO2 storage possibility in enclosed basins on the deep and very deep ocean floor. For example, the Indonesian Sunda trench, the Japanese Ryukyu trench and the Puerto Rico trench are more than 6 km deep. If liquid CO2 were to be placed in such a trench, it would be 7% more dense than seawater and could remain permanently as a lake of liquid CO2 on the ocean floor, possibly becoming a solid hydrate over time which could inhibit mixing between the stored CO2 and ocean currents. At depths greater than about 4 to 5 km metres, seawater is under-saturated in calcium carbonate, so ocean ecosystems are significantly different. Any impact on deep marine fauna would need to be investigated. The London Dumping Convention has provisions for disposal of material into the ocean provided the absence of adverse effects can be proven. Deep ocean CO2 entrapment is more certain than geological CO2 storage in deep aquifers. A CO2 delivery concept by ship and vertical pipe is suggested for exploratory trials, with subsea pipelines for permanent installations, which might be much cheaper than geological CO2 storage. There is vast capacity for storage of CO2 in the world's very deep ocean trenches. The Sunda trench below 6 km has the capacity to accommodate 19,000 gigatonnes of liquid CO2, which is greater than the CO2 yield from all currently known global fossil fuel reserves. The Puerto Rico trench has capacity for 24,000 Gt of liquid CO2 deeper than 7 km. Enclosed basins of limited area could

easily accommodate captured CO2. China has the largest potential demand for CO2 storage from power generation and industrial sources, which could be 3 Gt per year by 2050. The Ryukyu trench, which is 700 km from the Chinese coast and is in Japanese water, has two sections deeper than 7 km. Those sections of the Ryukyu trench would have the capacity to accommodate all the CO2 captured in China at 3 Gt per year for over 200 years. In the event that very deep ocean storage of CO2 is found to be practicable and acceptable, the minimum practical depth would need to be determined as a criterions for acceptable additional storage locations. For consideration, there is an enclosed basin on the floor of the Mediterranean Sea 60 km off Southern Greece, with capacity for 84 Gt of CO2 deeper than 4.5 km. Also, there is an enclosed basin in the Arabian Sea, 320 km south west of Karachi, with capacity for 86 Gt of CO2 deeper than 3.5 km. The potential storage of CO2 in such locations would be temperature dependent. The global CCS community has previously considered ocean storage of CO2 on the basis of ultimate dissolution and dispersion of CO2 in ocean water. Those studies have dismissed ocean storage as environmentally unacceptable due to ocean acidification. This paper postulates that very deep ocean trenches (>6 km) and deep ocean floor depressions (>4 km) are environments for CO2 storage, where permanent storage without dissolution, acidification or adverse effects on fauna may be possible. The purpose of this paper is to pose the question "Why not?" to the CCS community and to suggest that active research is timely.