Can mine waste help tackling climate change? Diamond mine waste as a resource for ocean alkalinity enhancement.

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To prevent average global temperatures from exceeding 2 °C, conventional mitigation alone will not be sufficient. Strong greenhouse gas emission reductions will need to be accompanied by large scale implementation of Carbon Dioxide Removal (CDR) technologies. The ocean is essential for regulating Earth's climate and has absorbed about 25% of the anthropogenic CO_2 emissions since 1850. The CO_2 storage capacity of the ocean in determined by its total alkalinity (A_T). One of the most promising CDR technologies - Ocean Alkalinity Enhancement (OAE) - aims to increase the natural CO_2 uptake capacity by increasing the oceans A_T content. OAE has the potential to sequester gigatons of CO_2 while at the same time alleviating ocean acidification. So far, however, most research has focused on adding A_T through enhanced dissolution of olivine.

Olivine has been of interest for application in OAE due to its abundance and relatively fast dissolution rate. However, large scale applications of olivine in the coastal environment also has several drawbacks. To achieve the required amounts of olivine needed for large scale OAE applications, significant up-scaling of the mining operations would be required which results in negative environmental and energy consequences. Furthermore, the mined olivine needs to be ground to the appropriate grain size which adds an additional energy penalty. Next, upon dissolution of olivine, trace elements, such as Ni, are released which can cause damaging effects to marine life. Therefore, I propose kimberlite, a waste product from diamond mining, as a possible alternative resource for application in OAE. Large amounts finely ground kimberlite are available in historic stockpiles from the diamond mining industry with an addition ~175 million tons of kimberlite produced every year[1].

To investigate the potential of kimberlite compared to olivine for OAE in the coastal zone, I conducted an experiment where a mixture of kimberlite or olivine was continuously rotated at three different rotation speeds on bottle/tube rollers. This simulated weathering under bedload transport conditions in the coastal ocean. To assess the weathering rate, I measured A_T, dissolved inorganic carbon (DIC) and trace elements over the course of 10 weekly accumulation sessions. I found that weathering was enhanced by bedload transport in both kimberlite and olivine, which is in line with previous research[2]. My results show that the A_T generation per gram of kimberlite rock is comparable to that of olivine, while the release of potential toxic trace elements, such as Ni, is much lower. Overall kimberlite is a viable and more environmentally safe alternative feedstock to olivine for OAE applications in the coastal zone with the potential for up to megaton scale CO_2 drawdown per year if all currently generated kimberlite mine waste would be used.

[1] Bullock, L. A., Nkosi, Z., Vele, M., & Amponsah-Dacosta, M. (2023). Catalogue of South African mine tailings for geochemical carbon dioxide removal purposes. International Journal of Greenhouse Gas Control, 124, 103844. https://doi.org/10.1016/j.ijggc.2023.103844

[2] Flipkens, G., Fuhr, M., Fiers, G., Meysman, F. J. R., Town, R. M., & Blust, R. (2023). Enhanced olivine dissolution in seawater through continuous grain collisions. 44 Geochimica et Cosmochimica Acta, 359, 84–99. https://doi.org/10.1016/j.gca.2023.09.002

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