About four and a half billion years ago as our solar system was beginning to come together in a quiet little corner of the milky way galaxy two large clumps of coalescing rock were developing relatively close to each other and at more or less the same rate. One of them was a planet we now call Venus and the other one became the place we humans call home. Earth and Venus have similar size and mass and both planets are volcanically active which means from time to time vast quantities of subterranean carbon dioxide gets spewed out into the atmosphere. Over geological time scales that CO2 built up and today it makes up 96% of the atmosphere on Venus keeping that planet at a nice toasty temperature of 475 degrees Celsius. We're not 475 degrees Celsius here on earth though are we, so apart from being a bit further away from the sun, what lucky break did we get that Venus didn't. Well photosynthesis was pretty handy for a start. Nature's own miracle combination of sunlight and carbon dioxide provided the energy for the astonishing explosion of life on earth that we enjoy today. But while all that lovely stuff was going on there was a much less visible process taking place as well. Atmospheric carbon dioxide was reacting with minerals on land and on the seabed in a process known as Chemical Weathering to form carbonate-rich rocks like limestone which over hundreds of millions of years locked up the vast majority of the warming gas, bringing our planet back down to what was a nice survivable average temperature of about 15 degrees Celsius, until about 200 years ago when we humans started burning fossil fuels and belching massive quantities of CO2 back out into the atmosphere again. So now we've got a climate crisis on our hands and scientists all over the world are frantically trying to find ways to drag our species out of the smelly brown stuff and back onto a path towards a more sustainable existence. And it turns out one of the potential solutions may be a super accelerated version of nature's own chemical weathering process. So how are we going to do that then?

Hello and welcome to Just Have a Think. We really do use an awful lot of stuff to keep our modern world going. Probably way more than most of us realize, as this very enlightening new book by Bill Gates's favourite author Vaclav Smil has been reminding me. Quite a lot of that stuff comes from blowing up large chunks of mountains and countryside to liberate rocks from which we can extract the metals and minerals we all rely on in our daily lives. The by-product of that process is an awful lot of rock dust that has to be carefully managed at great expense to the mine operators. Some of the more enterprising of those operators have been quite cleverly marketing their waste product to keen gardeners around the world for several years now, hailing it as some kind of miracle nutrient additive that can immediately make soils more fertile and productive. It's an extremely expensive way to improve your vegetable patch though! While it certainly won't do you any harm you'd probably be better off spending your money on a trailer full of well-rotted cow manure from your local farm. But there is a growing body of evidence suggesting that employing very large scale use of rock dust on agricultural land could make a huge contribution to the carbon dioxide removal or CDR challenge that we face in the 21st century. This research paper published in July 2020 by a team from the Leberhulme Centre for Climate Mitigation at Sheffield University outlines the size of the task. It points out that even the most ambitious greenhouse gas emissions phase-out plans of our global leaders failed to achieve the targets set out in the 2015 Paris agreement for limiting global warming unless a whole bunch of atmospheric CDR happens as well. And the numbers are eye watering. We're talking about removing 10 billion metric tons of CO2 from the air every single year based on current emission reduction policies. Now we might get serious and actually start reducing our emissions in a more meaningful way in the coming years, although there's absolutely no sign whatsoever of that happening anytime soon, and even if we did employ every technological and social measure to radically cut down our greenhouse gas emissions immediately, we'd still need to be removing about 2.5 billion metric tons a year every year through most of the rest of this century. The best we can manage at the moment with current technologies like direct air capture or DACCS is about 10,000 tons a year according to this very recent analysis. And here's another interesting little stat from an Australian number crunching consultancy called Keynumbers. They calculated that in 2020 the world used 462 exajoules of energy from fossil fuels which resulted in 32 billion tons of carbon dioxide emissions. Capturing all that CO2 using DACCS, say Keynumbers, would require 448 exajoules of energy. You see the problem there? So barring a miracle we're going to need something else to get us out of the doodoo and that's where chemical weathering might just play a very important role. Nature's version works like this. Atmospheric CO2 gets dissolved in rain to make a dilute solution of carbonic acid which is the same stuff we drink in fizzy soda. As the rain falls onto rocks like basalt which have a high content of silicate minerals those minerals react with the carbonic acid to form water-soluble ions like calcium and bicarbonate. Those ions get into waterways via groundwater runoff and eventually travel out to the oceans where marine animals use them to build their shells. As those animals die they fall to the ocean floor and their shells eventually turn into limestone and other carbonate rocks and over geological time scales that rock gets buried in the earth's crust locking the carbon content up for millions of years. The trouble is the naturally occurring version of the process takes centuries to work so it's not going to help us in the next 30 years. But by crushing silica mineral rocks like basalt into a fine powder the surface area available to react with the carbonic acid is massively increased which in turn accelerates the speed of the reaction. It's a process the science bods call enhanced silicate rock weathering or ERW and it was initially conceived as an effective way to draw down carbon into the soils of tropical rainforests because the process works particularly well in warmer more humid environments. But as the team at the Leverhulme Centre for Climate Mitigation continued their studies they realized there was a really significant opportunity to combine ERW with existing cropland soil management processes in major agricultural economies where farmers already use industrial scale machinery to spread fertilisers and other chemicals on the land. Those spreaders could easily be utilized for the distribution of crushed basalt at virtually zero extra cost of the farmer. There'd be some extra side benefits as well. When crushed basalt is added to soil it gradually reacts to produce magnesium, calcium and small amounts of zinc and copper, all of which are essential nutrients that plants need for healthy growth. So over time the farmers would get healthier soil and the world would get a much needed drawdown of atmospheric carbon dioxide. And as those carbon rich rocks eventually seeped back into the ocean they'd help reduce the acidity of the ocean water creating a healthier environment for sea shells and corals to grow. The research team calculated that if the process was implemented to its full potential it could be removing as much as 2 billion metric tonnes of carbon dioxide every year by 2050. That's equivalent to the combined annual emissions of Germany and Japan. Most of that would need to come from the world's largest agricultural producers and highest greenhouse gas emitters, China and the USA, but there's so much of this crushed rock building up as a waste product all over the world that many other countries could easily get involved as well. A more recent paper by the same Leverhulme team focused on the potential of ERW here in the United Kingdom. That paper found that the process could be delivering as much as 30 million metric tons of carbon dioxide removal per year in the UK by 2050 which equates to about 45% of the overall carbon removal required for this country to meet its net zero emissions target. What's not to like then? Let's crack on immediately eh? Well, as usual it's not quite that simple. There are a couple of slightly wrinkly caveats that our governments will need to consider before flying headlong into this kind of globally ambitious initiative. First of all it'll obviously require a great deal of energy to transport vast quantities of crushed basalt from mines to agricultural areas where it will be applied and today that energy mostly comes from fossil fuels so we need to be sure that the atmospheric carbon dioxide removed by the process wasn't getting cancelled out by the CO2 emitted from production and transportation. Secondly, although adding crushed rock to agricultural land would gradually enhance the quality of the soil it wouldn't happen overnight and even though the spreading equipment already exists handling the product and managing the supply chain would be an additional logistical cost to individual farmers who are already struggling to survive on razor thin margins so convincing them to add an extra process to their operation just so they could feel like they were contributing to climate mitigation might be a tough ask. There will most likely need to be some pretty robust government-funded carbon credit incentive schemes in place to make it worthwhile for farmers to adopt these new practices. The Leverhulme team did crunch the numbers though for different countries around the world and they reckon that China, the USA, India and Brazil have the greatest potential. After all the mining and transport costs are factored in the study found that enhanced rock weathering in those countries would come in at between $80 and $180 per tonne of CO2 removed. That's certainly very competitive with direct air carbon capture which is currently costing as much as six hundred dollars per ton. And the team argues that a major benefit of using crushed basalt in this way is the very fact that it can be used on the same land as agriculture rather than competing with it for space as many other climate mitigation projects do. Just like most other climate mitigation technologies currently in development the big question is whether enhanced rock weathering can genuinely be scaled up in a real world scenario. If it can though then the benefits in soil health, reduced ocean acidification, and carbon dioxide removal could be massive. Let me know what you think in the comments section below but that's it for this week. A massive thank you, as always, to our fantastic Patreon supporters who keep these videos completely independent and ad free. If you feel like you could support the channel for about the price of a coffee each month then you can find out how to do just that by visiting www.patreon.com/justhaveathink and of course the best and easiest way you can support the channel via YouTube is by clicking that subscribe button and hitting the notification bell. It's completely free and dead easy to do. You just need to click on the little icon in the corner or on that icon there. As always, thanks very much for watching, have a great week and remember to just have a think. See you next week.