

[Paebbl and Maia]

Carbon dioxide removal prepurchase application Summer 2023

General Application

(The General Application applies to everyone; all applicants should complete this)

Public section

The content in this section (answers to questions 1(a) - (d)) will be made public on the [Frontier GitHub repository](#) after the conclusion of the 2023 summer purchase cycle. Include as much detail as possible but omit sensitive proprietary information.

Company or organization name

Maia & Paebbl

Company or organization location (we welcome applicants from anywhere in the world)

UK/France & Netherlands

Name(s) of primary point(s) of contact for this application

Aur lie Gonzalez, Andreas Saari

Brief company or organization description <20 words

Maia and Paebbl are DAC and mineralisation companies, working together to capture and store CO₂ in minerals.

1. Public summary of proposed project¹ to Frontier

- a. **Description of the CDR approach:** Describe how the proposed technology removes CO₂ from the atmosphere, including how the carbon is stored for > 1,000 years. Tell us why your system is best-in-class, and how you're differentiated from any other organization working on a similar approach. If

¹ We use "project" throughout this template, but note that term is not intended to denote a single facility. The "project" being proposed to Frontier could include multiple facilities/locations or potentially all the CDR activities of your company.

your project addresses any of the priority innovation areas identified in the RFP, tell us how. Please include figures and system schematics and be specific, but concise. Aim for 1000-1500 words.

[public answer]

SOLUTION OVERVIEW

Maia:

Maia has been created to overcome the main hurdles preventing DAC from reaching gigatonne scale CO₂ capture: energy, land, water, and materials requirements.

Scaling carbon removal solutions that strain ecological and economic systems is counterproductive. Energy-intensive DAC processes, for instance, could demand over 60% of the USA's electricity supply ([source 1](#))([source 2](#)) to reach gigatonne scale, utilizing 1% of global fresh water supply ([source 1](#)) ([source 2](#)) and up to 10% of Japan's land ([source 1](#))([source 2](#)) if powered by solar farms. On the other hand, Maia at scale would require 10% (energy), 0.5% (water), and 2% (land).

Liquid sorbent DAC technologies with forced flow contactors often lose several tonnes of water per tonne of CO₂ captured. However, Maia's heat delivery system doubles as a water recovery system, reducing water loss by at least 50%. A novel contactor design could further reduce water consumption.

Certain DAC approaches consume thousands of kilowatt hours of energy per tonne due to steam generation or high-temperature desorption ([source](#)). This high energy consumption poses economic constraints and requires substantial land use for solar and wind power generation.

Thermal CO₂ desorption is energy-intensive due to high desorption temperatures (over 100 °C). Heat is lost as sensible heat input and latent heat from water evaporation absorbed with CO₂ during capture. Vacuum desorption reduces temperature but still requires energy and vacuum pumps. Some processes use high surface area materials like metal organic frameworks to reduce heat demand, but their supply chains are limited and scalability is uncertain.

A different approach involves using water instead of heat for desorption: moisture swing desorption. It requires less energy but its performance varies with humidity, wind speed, and temperature, making it semi-passive ([source](#)). This method is most effective in dry air but requires orders of magnitude more water compared to liquid sorbent DAC, limiting its geographical deployability. An alternative is to use captured air moisture for the moisture swing. This broadens the technology's deployability, however the moisture capture requires additional energy and materials demand for two sorbents.

The remaining class of DAC approaches utilises electrochemical cells to drive desorption of CO₂ at ambient temperature without the need for vacuum pumps. However, the kinetics of CO₂ desorption are slow at ambient temperature, so large overpotentials must be applied to ensure fast capture rates ([source](#)). Furthermore, thermodynamically speaking, the full enthalpy of desorption must be supplied, and electrochemical cells can efficiently supply the free energy (i.e. work) component of the enthalpy, but are not the most efficient systems for supplying the heat component of the enthalpy.

Maia's hybrid electrochemical-thermal desorption allows CO₂ to be desorbed at an elevated temperature, yet still below 100 °C, and at atmospheric pressure, thereby reducing latent and sensible heat loss without requiring vacuum pumps or exotic materials. Energy demands on the electrochemical cell are significantly reduced because the heat component of the desorption enthalpy is supplied thermally and because the overpotential required to drive desorption is

significantly decreased due to faster desorption kinetics at the elevated desorption temperature. Heat is supplied efficiently via a combination of novel process integrations, while a separate process integration reduces the energy and water consumption of the air contactor.

Maia removes CO₂ from the atmosphere by first contacting a commercially available liquid sorbent with air in a forced flow contactor. The sorbent is then regenerated, and the CO₂ desorbed, in a hybrid electrochemical-thermal process. The CO₂ is then compressed and pumped into Paebbl's mineralisation reactor where it is transformed into a carbonate mineral.

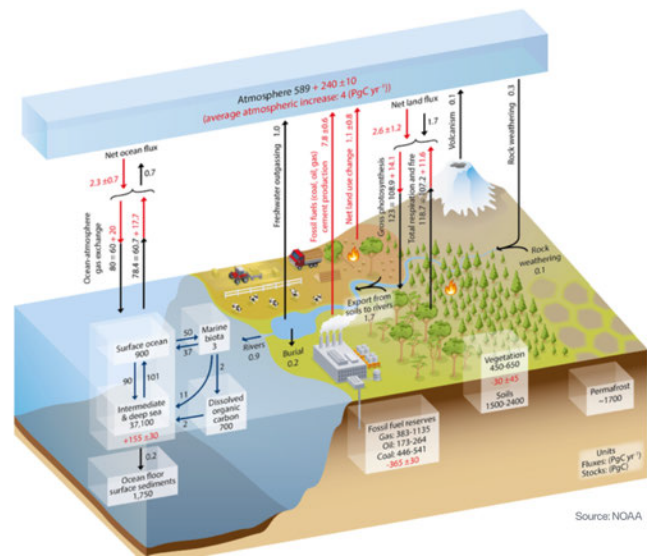
The table below shows our energy consumption estimates for three existing electrochemical DAC approaches and Maia, all optimised at scale:

- Electrochemical 1: 787 kWh/t (integrated contactor and electrochemical cell)
- Electrochemical 2: 803 kWh/t (non-thermal electrodialysis)
- Electrochemical 3: 1232 kWh/t (electrolysis)
- Maia: 461 kWh/t

Paebbl takes captured CO₂ and mineralizes it efficiently in a continuous industrial process, using ground silicate minerals on-site, producing a CO₂-negative cementitiously active blend of a carbonate mineral and amorphous silica. Paebbl's on-site mineralisation technology removes the need for a geologic injection well or pipeline to achieve permanent sequestration of CO₂; the end-use of the produced mineral product is in construction materials, which is where a secondary CO₂ benefit is afforded by Paebbl's solution: the substitution of cement and limestone in concrete, where each ton of Paebbl's material has the potential to generate 0,3 - 1 tons of avoided emissions. This use of the mineralized CO₂ allows for a second significant revenue stream which has a realistic potential of rendering the effective cost of running a DAC + mineralisation plant extremely low or negative.

The permanent storage achieved by turning CO₂ into a carbonate mineral is driven by the stability of a carbonate mineral (Lackner 2002) and its use in long-lasting applications, like concrete (storage permanence at End of Life addressed below in application).

Accelerated CO₂ mineralisation is based on a natural process, rock weathering, which is a thermodynamically driven geological process of CO₂ turning into a carbonate mineral, and it is part of the Earth's carbon cycle. Every year, this process naturally removes around 1,1 GtCO₂ from the atmosphere.



Exposing more reactive mineral surface by grinding and introducing the ground minerals into a chemical reactor with elevated temperature and pressure makes this process that usually takes hundreds or thousands of years proceed in minutes, providing an industrially viable process for CO2 sequestration and utilisation.

[Bardow et al \(2020\)](#) describe several versions of a similar kind of CO2 mineralisation technology as ours and highlight its potential for further CO2 savings by acting as a substitute material for cement and other fillers in concrete. Below an optimal future scenario:

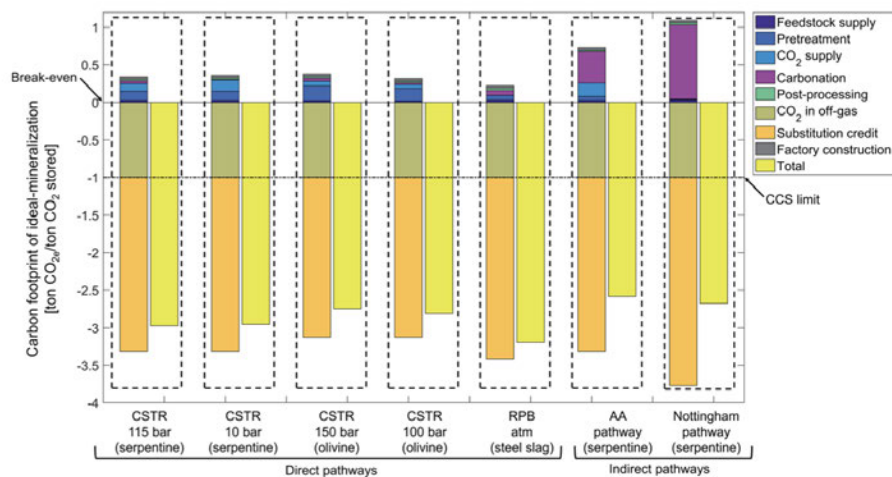


Fig. 10 Carbon footprint of the 7 CCU by mineralization pathways for the ideal-mineralization scenario. For each pathway, the left bar shows the contribution of each life cycle stage, and the right bar shows the total carbon footprint. Break-even is where the avoided CO_{2e} emissions are equal to CO_{2e} emissions caused throughout the life-cycle such that the total carbon footprint is zero. CCS limit is the maximum potential of CCS technologies. RPB – rotary packed bed, AA – Abo Academy.

Source: Bardow et al (2020)

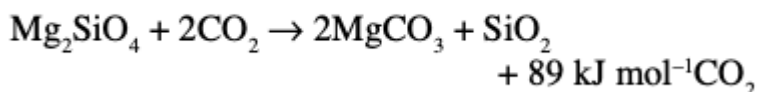
Paebbl's proprietary technology is a single-step, aqueous, high-pressure continuous process. The inputs are CO₂ (currently >80% purity), ground silicate minerals like olivine, water and a mix of affordable, non-toxic additives.

The inputs are fed into a high-pressure system (>50bar) with an elevated temperature (<200°C) where first the ground (≤100µm) input silicate minerals are mixed with water and a proprietary recipe of additives. The resulting slurry is pressurized to the operating pressure, after which the pressurized CO₂ is added. The CO₂ dissolves in the water, forming carbonic acid. In the slightly acidic conditions, the silicate minerals start dissolving, releasing metal cations into solution, which in turn combine with the carbonic acid, forming a solid carbonate mineral. The silicate matrix that is depleted of metal cations forms amorphous silica. The slurry is subsequently de-pressurized and cooled down, with further carbonate precipitation. The output is an aqueous solution of carbonate minerals (e.g. MgCO₃) and amorphous silica (SiO₂) with residues of unreacted input silicates and small quantities of secondary compounds, like iron carbonate. The output slurry is then de-watered and dried, and an overwhelming majority of the water and additives will be recycled. An additional separation step allows for the possibility to recirculate unreacted input silicates and incrementally lowering the need for mineral supply.

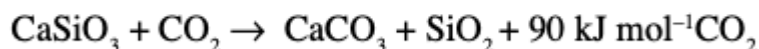
As the reaction is exothermic, the need for heating energy can be significantly reduced or entirely removed by controlling the solids loading of the process, leaving input material pressurization and product drying as the main drivers of energy input.

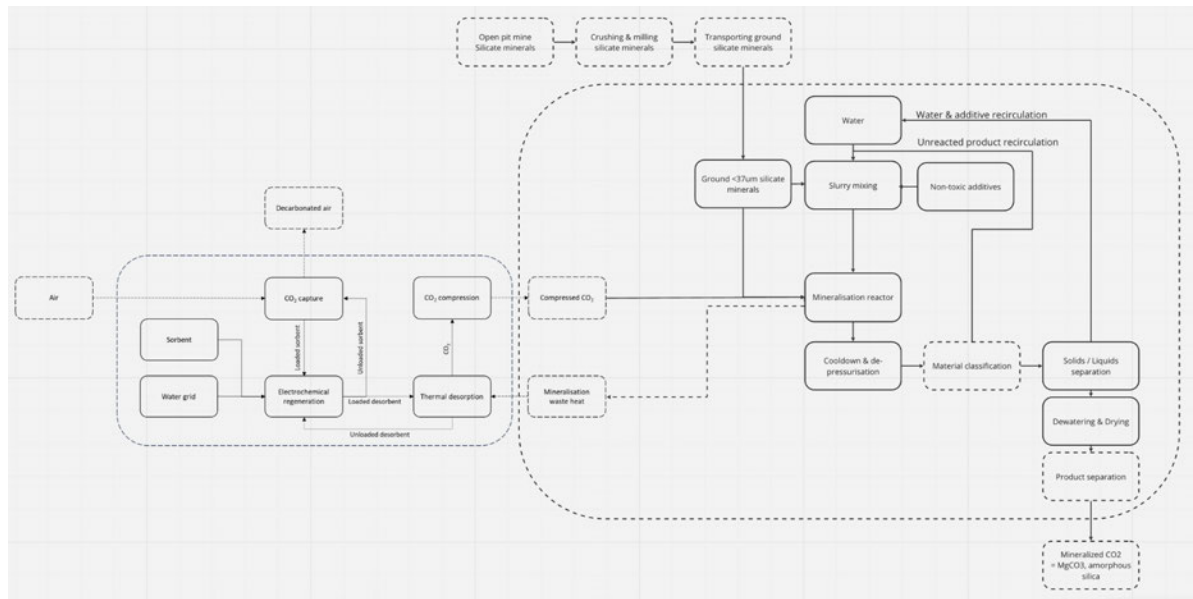
The simplified chemical reaction the process is based on is illustrated with two silicates, olivine (reactive, abundant) and wollastonite (more rare but very reactive).

Olivine:



Wollastonite:





Process flow diagram of Maia's and Paebbl's processes integrated

The total estimated electrical energy input for our process at scale (TRL-9 NOAK) would be 0,6GJ/tCO₂, with no additional thermal energy used. The upstream value chain fuel energy input is heavily dependent on plant location and required mineral sourcing logistics, but can be reasonably lower than 0,25GJ/tCO₂.

Paebbl and Maia's processes will work together to transform atmospheric CO₂ into carbon-negative cement and filler substitute for the construction industry. The carbonate-bound CO₂ is chemically stable and achieves a 1000+ year storage permanence (even if a concrete structure is demolished, the particle size of set concrete decreases but the chemical bonds in the contained carbonate mineral are not broken). Cement is currently produced on a global scale of ~4GTPY, being the key component in concrete, which has a global annual production volume of 30 GTPY (Source).

Paebbl and Maia benefit from each other thanks to:

high pressure, high temperature, high purity CO₂ supplied to Paebbl by Maia's process, which reduces Paebbl's electricity consumption by more than 50%.

the integration of waste heat generated by Paebbl's process into Maia's process which reduces Maia's electricity demand by 27 %

To our knowledge, this mutually energy saving process integration is unique.

The total effective costs for running an integrated NOAK plant based on Maia's DAC and Paebbl's mineralisation technology are estimated to be between USD 15 - 60/tCO₂ in a conservative co-product revenue scenario. In a moderately optimistic scenario, the effective costs can be negative, unlocking a new paradigm for DAC deployment.

- b. **Project objectives:** What are you trying to build? Discuss location(s) and scale. What is the current cost breakdown, and what needs to happen for your CDR solution to approach Frontier’s \$100/t and 0.5Gt targets? What is your approach to quantifying the carbon removed? Please include figures and system schematics and be specific, but concise. Aim for 1000-1500 words.

[public answer]

What are you trying to build? Discuss location(s) and scale.

The integrated pilot plant of Maia’s DAC technology and Paebbl’s sequestration capability, both having a capacity of 1 ton CO₂/day.

The joint pilot deployment will be built at Paebbl’s Rotterdam facilities (where permitting is already underway). According to current design specs, the pilot plant is expected to have an annual gross capacity of up to 365 tCO₂ and be completed by 10/2024. The pilot plant will likely need to be finetuned and primarily serves to generate maximum process learnings; it will not run at full capacity for very long stretches. As a result, we would like to define our project as the first 36 months where we can feasibly reach more continuous operation, starting 12/2024. Assuming a conservative 30% uptime, we are asking Frontier to purchase 100% of this project, which would amount to 170 tonnes over 3 years, however we are prepared to discuss alternative amounts and pricing. A higher uptime will likely be reached after the first year of operation.

What is the current cost breakdown, and what needs to happen for your CDR solution to approach Frontier’s \$100/t and 0.5Gt targets?

The total effective costs (including co-product sales) for running an integrated NOAK plant based on Maia’s DAC and Paebbl’s mineralisation technology are estimated to be between USD 15-60/tCO₂. In a moderately optimistic scenario, the effective costs can be negative. This takes into account an at-scale cost estimate of USD 85/tCO₂ for DAC by Maia, and at-scale cost estimate of mineralising the captured CO₂ with olivine for USD 66/tCO₂ by Paebbl. When using olivine as feedstock in an optimised process that achieves 90% conversion, each ton of CO₂ turns into 3,2 tons of valuable output product for cement and limestone replacement. If the average output material sales price exceeds USD 46 per ton, the effective “unit” costs of direct air capturing and permanently mineralising CO₂ turn negative.

Below is a breakdown of estimated costs for running the integrated pilot scale installation, an integrated TRL-9 FOAK plant and an integrated NOAK plant.

1st plant	Paebbl	Maia	Total
Levelised capex (\$/t)	3,043	1,796	4,839
Levelised fixed opex (\$/t)	1,696	1,110	2,806
Levelised energy cost (\$/t)	25	112	137
Levelised other variable opex (\$/t)	102	27	129
Total levelised cost (\$/t)	4,866	3,018	7,884

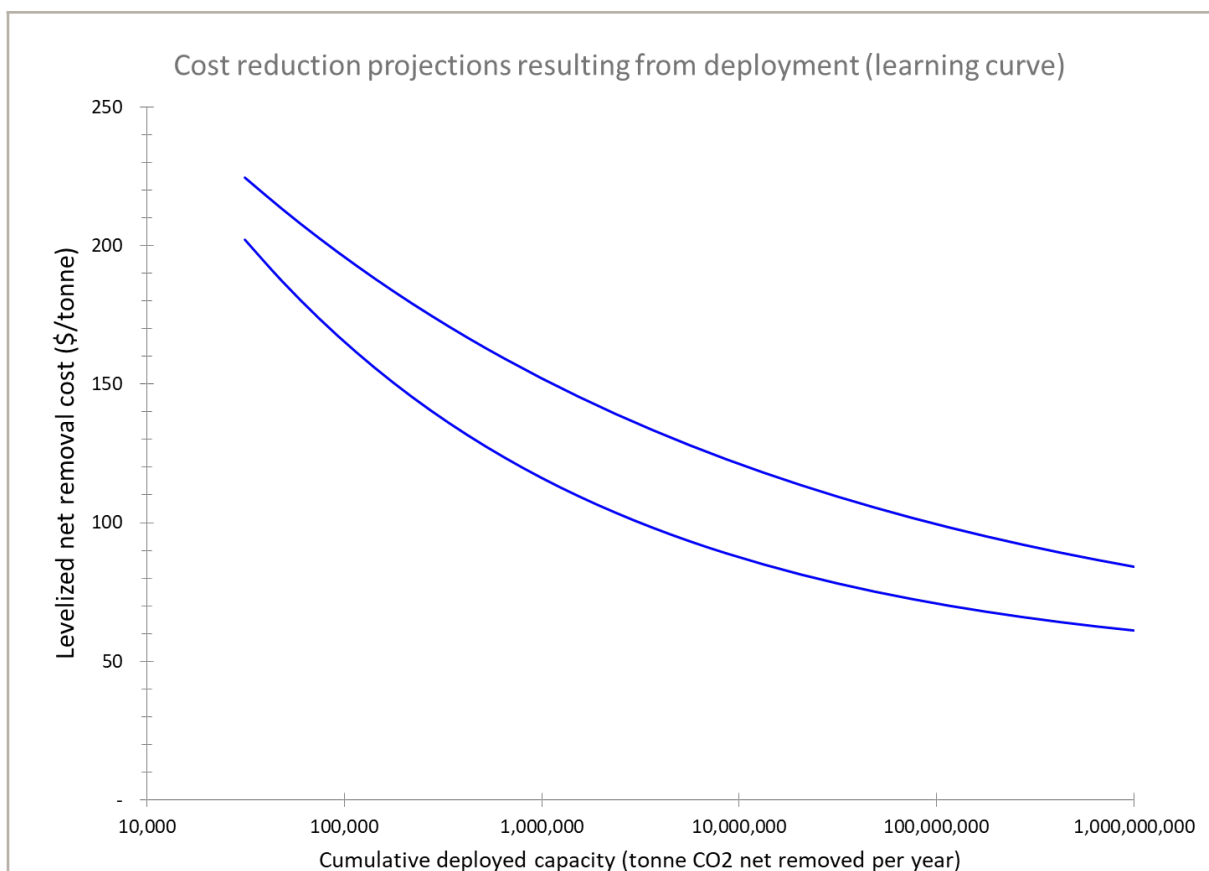
FOAK TRL-9	Paebbl	Maia	Total
Levelised capex (\$/t)	62	156	218
Levelised fixed opex (\$/t)	22	10	32
Levelised energy cost (\$/t)	16	37	53
Levelised other variable opex (\$/t)	31	11	42
Total levelised cost (\$/t)	131	213	344

NOAK	Paebbl	Maia	Total
Levelised capex (\$/t)	14	35	49
Levelised fixed opex (\$/t)	5	2	7
Levelised energy cost (\$/t)	16	37	53
Levelised other variable opex (\$/t)	31	11	42
Total levelised cost (\$/t)	66	85 (nominal 72, low 61)	138

Scalability

To reach a cost of <\$100/tCO₂ removed and sequestered, the following optimisations need to occur:

Maia:



As the technology scales, it is expected that some of the less mature supply chains (particularly those supplying components for the electrochemical system) will grow and benefit from learning and economies of scale themselves. This is expected to drive down the capex over time. Maia's first system will use off the shelf components and materials as far as possible. However, in subsequent iterations of the process, a bespoke sorbent will be developed with properties optimised specifically for Maia's process (144 kWh/t saving). For example, the heat capacity, CO₂ capacity (in terms of mol CO₂ captured per mol of sorbent moiety) electrical conductivity and boiling temperature of the sorbent will be optimised to bring the significant of the energy efficiency gains required to reach below 100 USD/t. Further energy efficiency gains will be made by optimisation of the design of the electrochemical cell itself (302 kWh/t saving) and minor energy savings will be achieved through optimisation of the contactor design (20 kWh/t saving).

As a primarily electrochemical and modular system, the scalability of Maia's process is relatively predictable. We plan to reach 0.5 Gt/yr captured via the operation of approximately between 10,000 and 15,000 DAC modules globally. We expect that the construction and running of the first demonstrator and subsequent plants will allow us to determine the optimum scale for a single DAC module. The scale of the module will be determined by the lowest levelised cost CO₂ removal, and specifically by the optimum between energy efficiency and ease & cost of manufacture. Today, we are estimating this scale to be 100 t/d per module.

Paebbl: the biggest significant long-term barrier for reaching a 0,5GtpaCO₂ scale for Paebbl's CCUS technology is scaling up the availability of olivine and preparing the market for the adoption of 0,5 - 2 Gtpa material.

Olivine is currently mined at ~10Mtpa but the accessible reserves count in trillions of tonnes (example: the Semail ophiolite in Oman and the Red Hills Ultramafic Complex in New Zealand conservatively

contain 1.4×10^5 and 871 billion tonnes of olivine, respectively (Scott et al 2021).

A likely parallel method to create resilience for technology scaleup is the extension of the reactor design to efficiently accommodate other Mg- and Ca-bearing silicate minerals. Each of these comes with a different CO₂ uptake factor (see table below) and would effect process economics as well as the composition of the output product.

Table 1. Mineral chemistry, carbonation potential, and reactivity.¹

Rock/mineral group	Mineral	Formula	Concentration, wt pct				R _{CO2} ²	ε _A ³ , %	R _x ⁴ , %
			Feed			Prod.			
			Ca	Fe ²⁺	Mg	CO ₂			
Feldspar	Anorthite (An)	CaAl ₂ Si ₂ O ₈	10.3	3.1	4.8	1.9	4.4	23	9
Serpentine	Antigorite (Ant)	Mg ₃ Si ₂ O ₅ (OH) ₄	<0.1	2.4	24.6	24.2	2.1	47	92
Pyroxene	Augite (Aug)	CaMgSi ₂ O ₆ + (Fe,Al)	15.6	9.6	6.9	11.1	2.7	37	33
Basalt	An, Aug, Mt, Ol		6.7	6.7	4.3	2.9	4.9	37	15
Olivine (Ol)	Fayalite (Fa)	Fe ₂ SiO ₄	0.6	44.3	0.3	19.2	2.8	36	66
Olivine (Ol)	Forsterite (Fo)	Mg ₂ SiO ₄	0.1	6.1	27.9	29.7	1.8	56	81
Serpentine	Lizardite (Liz)	Mg ₃ Si ₂ O ₅ (OH) ₄	0.3	1.5	20.7	16.0	2.5	39	40
Oxide	Magnetite (Mt)	Fe ₃ O ₄	0.6	21.9	0.3	1.5	5.5	18	08
Ultramafic	Talc	Mg ₃ Si ₄ O ₁₀ (OH) ₂	2.2	9.2	15.7	5.2	2.8	36	15
Ultramafic	Wollastonite (Wo)	CaSiO ₃	31.6	0.5	0.3	22.9	2.8	36	82

(Penner, 2004)

To illustrate the feasibility of annually introducing 1,5 billion tonnes of carbonates and amorphous silica to the market, global cement production currently sits just above 4 billion tonnes annually (and expected to grow towards 5Gtpa with the globally growing population and increasing urbanisation). The global demand for sand is around 50 billion tonnes per year (UNEP 2022), which is increasingly causing environmental damage through its extraction methods. It would only require introducing a minority fraction of carbon-storing “synthetic (very fine) sand” to these industries where logistically feasible, and helping them decarbonise and deal with increasing social and financial pressure originating from their environmental footprint. The largest opportunity would be at the intersection of suitable geology and the fastest-growing urban areas, where an integrated negative emissions materials plant would also contribute to local wealth generation.

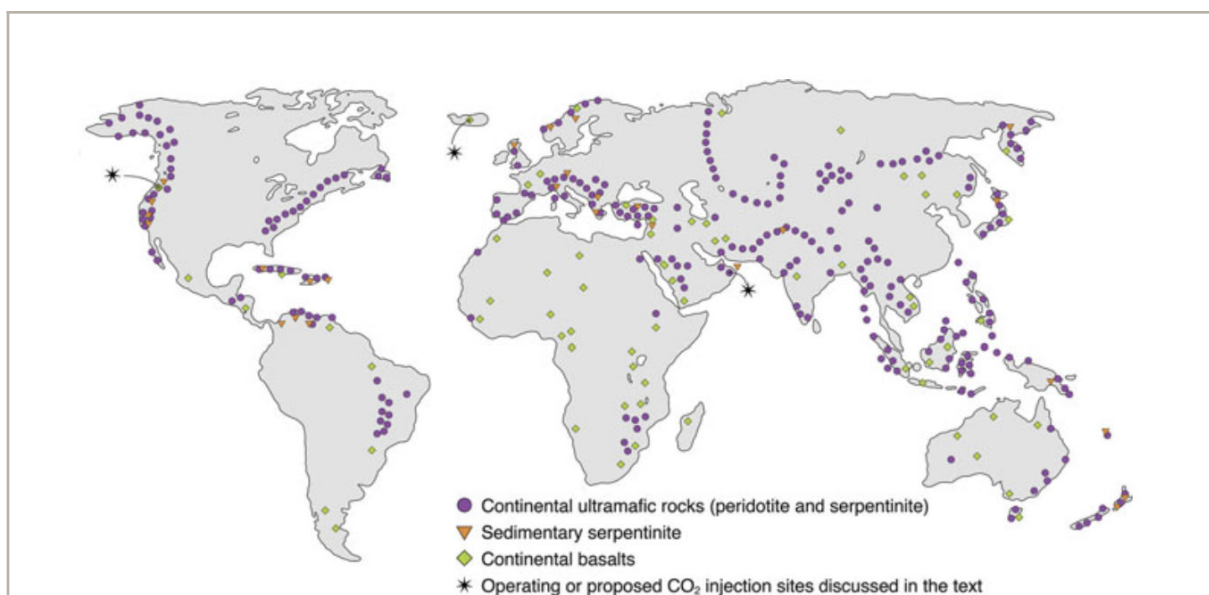


Fig. 2 World map distribution of (a) continental crystalline ultramafic rocks (peridotite and serpentinite), (b) sedimentary serpentinite, and (c) basaltic rocks. Also shown is where injection of CO₂ has occurred in the past, continues to this day, or is projected in the near future. Data points display general location of lithologies and are not representative of the size or extent of the rock exposures. Ultramafic rocks location data from Oze et al. [19], sedimentary serpentinite from Lockwood [22], and basalts from Oelkers et al. [14]

With an increased scale of mining, the price of suitable silicate rocks can be expected to reach a reasonable level. To reach an “unsubsidised” CO₂ mineralisation cost of <@100/tCO₂ excluding co-product sales, olivine should be mined and ground to a particle size of d₉₀ 100µm at a cost of ≤\$9/ton (estimates from Hangx & Spiers 2009 and Strefler 2018) and delivered a reasonable distance of ≤300km for a price of \$3/ton (Bremen 2022).

The second most important lever to get to <\$100 of processing cost within OPEX is efficient but industry-standard level heat integration with a 90% efficiency to recover heat from the reactor output at cooldown.

Finally, a mineralisation plant will have to be built for a cost to reach a NOAK levelized capital cost of ≤\$44/tCO₂. This is reasonable by combining already developed equipment from the oil & gas and mineral processing industries, by building modular plants, by optimising plant design and by centralising procurement.

Quantifying the CDR

Maia: The outflow rate of CO₂ can be measured using mass flow meters calibrated for the pressure and temperature of the delivered compressed CO₂ gas. This will give the total mass of gas leaving Maia’s compressor train. However, the CO₂ purity must also be measured to give the actual rate of capture, and this will be measured by passing samples of the stream through a gas chromatograph or laser gas analyser at regular intervals (i.e. once per minute). In case this measurement system malfunctions, it will be possible to measure the CO₂ capture rate indirectly via measurements which will be taken for process control. For example, it is possible to calibrate the CO₂ loading of the sorbent against its electrical conductivity. Differences in conductivity before and after desorption along with mass flow rates of the sorbent can therefore be used to calculate the CO₂ capture rate

(source).

Paebbl will have mass flow controllers for the incoming CO₂ stream and run continuous sampling of the output product to determine the CO₂ content. The analytical methods employed are Loss on Ignition tests as well as mass spectrometry.

The verification and reporting of the CDR measurement will be conducted by a neutral third party.

- c. **Risks:** What are the biggest risks and how will you mitigate those? Include technical, project execution, measurement, reporting and verification (MRV), ecosystem, financial, and any other risks. Aim for 500-1000 words.

[public answer]

Maia:

Science & Engineering risks:

- Measurability of our proof of concept lab experiments which aim to demonstrate better energy efficiency to standalone electrochemical DAC.
- Supply chain lead time for main equipment; especially electrochemical cells and air contactors
- Specific equipment prices increases due to scarcity of suppliers and global supply chain constraints
- Engineering contractors and supplier management
- Unforeseen modifications to off-the-shelf components and the unforeseen need for bespoke components to be designed
- Patent being filed

Commercial and Financing risks:

- Even if MRV on DAC can be achieved with existing monitoring equipment, a bespoke methodology may need to be created.
- CO₂ credit market prices and demand for high quality product: actors and regulations evolution, depending on countries and applications, and adapt the compliance to every situation
- Seed fundraising

Paebbl:

Commercial, product, and financial risks:

- Business model risk: it takes longer for us to prove our business model than envisaged, making it difficult to fundraise, therefore slowing our R&D down considerably. To mitigate this, we have created a big enough pipeline, that we should be able to close first sales on our products in the coming months. We are actively working with early adopter customers to drive these processes forward.
- The product specs are significantly outside of our models in the the FOAK, and therefore we can only sell as a low grade mineral filler. This is where the dual business model becomes crucial, as inert mineral fillers do have a large market, but one that is defined by low prices and very low gross margin.

- Unit economics aren't good enough sub-scale: the COGS are high as we can't negotiate enough before we reach a certain scale. We are an early stage company, and as a result need to test our commercial hypotheses in the coming 12-24 months. The viability of our business model will be subject to our ability to negotiate COGS. One mitigation strategy is to increase supplier pool and ensure procurement focuses on driving down the core COGs. We may also choose to look at strategic relationships with our suppliers.
- We have about 50% of our equity round left, and will need to fundraise in the coming 6 months. The risk is that the macro-economic environment continues to be tough and it becomes more difficult to raise capital for early stage asset-heavy companies in general. This would be a huge limiting factor for us in a critical phase of R&D. To mitigate this, we need to show more commercial milestones already from early on, where a Frontier pre-purchase would be a significant validation to the market and therefore a catalyst for the development of the technology. In addition to securing demand for our CDR credits, we are also mitigating commercial risk by working with a strong pipeline of potential early adopter customers to secure first sales in 2023/2024.
- The regulatory approvals that unlock the ability to sell large amounts of material produced in our process take longer than anticipated to get through. To mitigate this, we have a two-fold strategy: (1) to work with regulators already from very early on to ensure that the products are technically and environmentally approved, and (2) we will need to have alternative markets to sell to. This is already built into our plans.
- Because mineralisation is still outside the scope of the ETS definitions (pending 2027 inclusions), it might be a challenge to get non-dilutive financing support from the EU for the FOAK before this regulation comes in place. However, this will be mitigated through offtake agreement based project financing, where today we know that this already exists for FOAK demo plants.

Supply chain risks:

- Given the macro-economic situation around the world, the price and availability of key components, most critically steel, becomes an even greater challenge than today. We are mitigating this by a "reverse sales" strategy, in which we build direct relationships with key suppliers through the lens of climate-tech needing to have a "priority lane". So far this strategy has worked well for us.
- The competition for olivine, the first mineral that we are working with, increases, making it not only more expensive, but also difficult to obtain appropriate amounts and qualities of the mineral. To mitigate this, we have already commenced building relationships directly with mines. Furthermore, as we know that we need to diversify feedstock source, we envisage to commence R&D on alternative feedstock, including mine tailings, in the coming 12 months.

Technical risks [Arnold Choi](#)

- The precise mass transfer rate of CO₂ into the fluid (water) is unknown. The risk is that if it is lower than expected, it will limit the overall olivine mineralization reaction rate, resulting in a lower than desired olivine conversion rate. The consequence of this risk are that more olivine will be required per ton of CO₂ (ie. feed cost), product performance may decline (ie product specs) or capex costs will increase to improve the residence-time to increase conversion rates (i.e. capex).
- The precise dissolution / mass transfer rate of Mg²⁺ ions into the liquid is unknown, but it is known to be the rate-limiting step in the formation of MgCO₃. If this rate is lower than expected, the consequences are the same as the above.
- The achieved conversion degree in our reactor turns out to be lower than modelled; it is a first-of-a-kind reactor. To be mitigated by using finer olivine and discounting the associated higher grinding-orienting emissions from the net delivered CDR.

- Equipment rate of erosion (including pump, piping, instrumentation, etc) is unknown. This could be caused by a number of different factors such as conversion rate, blockage of piping/tubing in some areas, material selection of the process design, etc. The risk is that if it is higher than expected, equipment will have to be replaced at a higher frequency than expected. The consequence of this is higher opex (i.e. fixed / maintenance costs).

Integration of Maia’s and Paebbl’s technologies:

- Solving the technical challenges relating to integrating the two technologies, including engineering of a buffer stage between the two core units for the FOAK
- Permitting to the integrated experimental system at Paebbl’s Rotterdam facilities

d. **Proposed offer to Frontier:** Please list proposed CDR volume, delivery timeline and price below. If you are selected for a Frontier prepurchase, this table will form the basis of contract discussions.

Proposed CDR over the project lifetime (tons) (should be net volume after taking into account the uncertainty discount proposed in 5c)	AS 170 tonnes
Delivery window (at what point should Frontier consider your contract complete? Should match 2f)	Dec 2027 (from Dec 2024)
Levelized Price (\$/ton CO ₂)* (This is the price per ton of your offer to us for the tonnage described above)	1900\$/ton CO2

* This does not need to exactly match the cost calculated for “This Project” in the TEA spreadsheet (e.g., it’s expected to include a margin and reflect reductions from co-product revenue if applicable).

[Redacted]

[Redacted]

[Redacted]