Constraints on Enhanced Weathering and related carbon sequestration – a cropland mesocosm approach
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S1. Soil and rock characterization

The soil was provided by the Bodemkundige Dienst van België in 2013. Initial soil pH was reported as 7.8. The bulk density was 1.15 g cm$^{-3}$ (dry mass) at a soil moisture of 16%.

Basic granulometric data for the soil amended with rock powder and the rock powder alone can be found in Figs. S1 and S2, respectively.

![Granulometric analyses of the topsoil with and without amended dunite material of fine and coarse grain size.](image)

*Fig. S1. Granulometric analyses of the topsoil with and without amended dunite material of fine and coarse grain size.*
Fig. S2. Granulometric analyses of the dunite material used. (a) shows the class weight distribution and (b) the cumulative class weight.
S2. DIC concentrations

Fig. S3. Development of DIC concentrations over one year where available, differentiated by olivine and crop treatment. Error bars indicate ±1SD.
S3. pH

**Fig. S4.** Development of pH over the experiment time, differentiated by olivine and crop treatment. Error bars indicate ±1SD.
S4. Mg concentrations

**Fig. S5.** Development of Mg concentrations over the experiment time, differentiated by olivine and crop treatment. Error bars indicate ±1SD.
Fig. S6. Development of DSi concentrations over the experiment time, differentiated by olivine and crop treatment. Error bars indicate ±1SD.
S6. Mg/Si ratios

Fig. S7. Development of Mg/Si ratios over the experiment time, differentiated by olivine and crop treatment. Error bars indicate ±1SD.
S7. Cr concentrations

Fig. S8. Development of Cr concentrations over the experiment time, differentiated by olivine and crop treatment. Error bars indicate ±1SD.
S8. Ni concentrations

Fig. S9. Development of Ni concentrations over the experiment time, differentiated by olivine and crop treatment. Error bars indicate ±1SD.
S9. Trace element accumulation in the topsoil

Fig. S10. Trace metal concentrations in the topsoil. Part 1
**Fig. S11.** Trace metal concentrations in the topsoil. Part 2
S10. Mg fluxes from the outlet

Fig. S12. Fluxes of Mg from the outlet, corrected for background Mg release (no treatment values). Values refer to the daily-normalised flux of the interval preceding the sampling day.
S11. Partial pressure of CO$_2$ in the soils

**Fig. S13.** Partial pressure of CO$_2$ (pCO$_2$) measured in selected mesocosms at different depth in winter (a) and spring (b). Bars indicate ±1 SD.
S12. pH development over time

Fig. S14. Mean pH anomaly in the soil pore water of olivine treated mesocosms (with increasing depths) throughout the experiment time, relative to the control (pore water w/o olivine treatment, and irrigation water, dashed line: blank). Differences in pH were calculated with pH values and do thereby not directly represent proton concentration differences.
S13. Ni and Cr concentrations corrected for blank values

Fig. S15. Average concentrations of Cr (a) and Ni (b) relative to the control (pore water w/o olivine treatment) in the soil pore water of olivine treated mesocosms over the first 5 months, relative to the control (pore water w/o olivine treatment).
S14. Calculation of weathering and CO$_2$ sequestration rates

The average flux of Mg from dunite amended soils at the outlet can be calculated by

\[
\text{Flux}_{Mg^{2+}} = ([Mg^{2+}]_{\text{treated}} - [Mg^{2+}]_{\text{untreated}}) \times q
\]

Eq. S1

With \( q \) as water volume discharged at the outlet per sampled time interval. The sequestration rate can subsequently be calculated by

\[
\text{CO}_2 \text{ sequestration} = \left( \frac{\text{Flux}_{Mg^{2+}} \times \text{molweight}_{Mg}}{\text{fraction of Mg in Forsterite}} \times RCO_2 \right)
\]

Eq. S2

with a RCO2 of 1.1 as claimed by Hartmann et al. (2013).

The global CO$_2$ sequestration potential was then calculated by multiplying with the available arable land in an optimistic and a pessimistic scenario (Moosdorf et al., 2014).

The weathering rate can be estimated by

\[
\text{Weathering rate } R \left[ \frac{\text{mol Olivine}}{m^2 s} \right] = \frac{\text{Flux}_{Mg^{2+}}}{2} \times \frac{\text{applied mass}_{\text{olivine}} \times \text{specific surface area}}{t}
\]

Eq. S3

The numerator converts the molar flux of Mg to molar flux of olivine (2 mol Mg per 1 mol olivine). Time factor \( t \) is used to convert the flux measured in 340 days to seconds.
S15. Calculation of the amorphous Si layer

The Mg depleted and Si enriched layer that forms during the dissolution process (Daval et al., 2011) was roughly estimated using the release of Mg in conjunction with the Mg/Si ratio and the available surface area of the forsterite:

The mass of SiO$_2$ that precipitated per year as amorphous Si can be estimated by

$$ m_{SiO_2, amorph} \left[ \frac{g \ SiO_2}{a} \right] = \left( \frac{R_{Mg}}{Mg/Si_{theoretical}} - R_{Si} \right) \times M_{SiO_2} \times t \quad \text{Eq. S4} $$

with the dissolution (weathering) rates $R_{Mg}$, $R_{Si}$, calculated from experimental data, the theoretical Mg/Si ratio (1.7), $M_{SiO_2}$ as the molar mass of SiO$_2$, and time factor $t$ to convert seconds to years.

The depletion layer thickness can then be calculated as

$$ \text{growth rate of } SiO_2 \text{ layer} \left[ \frac{nm}{a} \right] = \frac{m_{SiO_2, amorph}}{\rho_{SiO_2, amorph} \times \left( 1 - \varphi_{SiO_2, amorph} \right)} \times 10^9 \quad \text{Eq. S5} $$

with the density $\rho_{SiO_2, amorph}$ as $2.23 \times 10^6$ g m$^{-3}$ (Iler, 1979) with the porosity $\varphi_{SiO_2, amorph}$ as 0.3 (20-40 %; Maher et al., 2016).
S16. References


