CO$_2$ concentration in soil air affects recrystallisation rate of primary CaCO$_3$

M. Gocke (1), K. Pustovoytov (2), Y. Kuzyakov (1)

(1) Dep. of Agroecosystem Research, University of Bayreuth, 95440 Bayreuth, Germany, (2) Institute of Soil Science and Land Evaluation (310), University of Hohenheim, 70593 Stuttgart, Germany (martina.gocke@uni-bayreuth.de / Phone: +49-921-552336)

Pedogenic (secondary) carbonates originate from dissolution and recrystallisation of lithogenic (primary) carbonates with CO$_2$ from soil air, leading to a complete exchange of the lithogenic with the atmospheric carbon (C) during time. Therefore, isotopic signature of pedogenic carbonates ($\delta^{13}C$ and $\delta^{18}O$) will be used as important information for reconstruction of paleoclimatic conditions. Therefore, the interest in pedogenic carbonates increased over the last years. However, the recrystallisation rate of primary CaCO$_3$ by pedogenic carbonate formation and the dependence of the rate on environmental factors (i.e. CO$_2$ concentration in soil air) are not known. To ascertain this correlation was the main intention of this study.

Loess from Nussloch (SW-Germany) was chosen instead of soil because it contains solely primary CaCO$_3$, has high carbonate content (30%) and nearly no organic carbon. Within metallic tubes, air containing increasing CO$_2$ concentrations (400, 5000 and 50000 ppm) labeled with $^{14}$CO$_2$ was applied to the loess. After increasing time periods (3 days, 2 weeks, 2 months), the $^{14}$C activity in loess carbonate, dissolved inorganic carbon (DIC), and CO$_2$ were measured by liquid scintillation counting.

The maximal $^{14}$C activity was recovered in loess CaCO$_3$, followed by $^{14}$C activity in DIC, and the minimal $^{14}$C activity was in CO$_2$. $^{14}$C activity in loess CaCO$_3$ and $^{14}$C specific activity of input CO$_2$-C were used to calculate the amount of recrystallised loess carbonate. The amount of recrystallised CaCO$_3$ increased with increasing CO$_2$ concentration. After 3 days, the amount of recrystallised carbonate was 0.0002%,
0.0003% and 0.0006% of original CaCO$_3$ for 400, 5000 and 50000 ppm, respectively. Under 5000 and 50000 ppm CO$_2$ concentrations, an equilibrium between $^{14}$C in DIC and CaCO$_3$ was not reached even after 2 months, and the increase of the $^{14}$C activity in the loess carbonate was stronger at 50000 than at 5000 ppm.

CO$_2$ concentration in soil air, ranging from atmospheric values in the upper horizons up to 70000 ppm in deeper horizons, plays an important role for the soil CaCO$_3$ re-crystallisation.