IMPACT OF SEEPING CO_2 ON SOIL ORGANIC MATTER IN THE HARTOUŠOV MOFETTE SYSTEM IN NW BOHEMIA

M. Noah[1], M. Alawi[1], K. Mangelsdorf[1], Q. Liu[1], R. Bussert[2], B. Plessen[1], B. Horsfield[1]

[1] Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences, Germany
[2] TU Berlin – Technical University Berlin, Germany

Introduction

Mofettes are cold exhalations of volcanic carbon dioxide (CO_2), which migrates through the lower crust or upper mantle to the surface via tectonic faults. This extreme CO_2 partial pressure alters soil chemistry and formation, leading to a general low pH, anoxic conditions and increased soil carbon contents in mofette soils. Biological responses to the high CO_2 seepage were mainly studied with a focus on changes in vegetation, like reduced growth and increased plant C/N ratios. However, little is known about the effect of CO_2 venting on active microbial communities and the fate of soil organic matter (SOM) in an active mofette. To reveal changes in the SOM composition two drilling cores, one core from the centre of an active mofette and one reference core close to the mofette, were sampled.

The study area is located in Hartoušov (Czech Republic). This site is characterized by a mofette system being part of a larger degassing area (dimension: ca. 7 km in length and ca. 0.5 km in width), dominated by uprising mantle CO_2 (>99 %).

In this study a total of 14 samples from the two cores were analysed using gas chromatography-mass spectrometry (GC-MS) and Fourier transform-ion cyclotron resonance-mass spectrometry (FT-ICR-MS) equipped with an electrospray source operating in negative- and positive-ion mode and an atmospheric pressure photo ionization source using positive-ion mode. This powerful tool enables the detailed characterization of complex mixtures of heteroatomic and high molecular weight compounds occurring in SOM along depth profiles. The comparison of the organic inventory in the mofette and the reference core will be used to characterize the impact of degassing CO_2 on the SOM pool and the degradation behaviour of the indigenous microbial community in these specific soils.

Results

Bulk analyses of the SOM reveal that TOC values in the reference core show a classical soil profile with decreasing values from shallow (0 – 4 cm, 11.1%) to deep (274 – 279 cm, 0.2%). In contrast in the mofette core TOC values are generally higher and show a huge variety with no clear depth trend ranging from 1.8% to 20.1%.
$\delta^{13}C$ values in the top layer (0 – 24 cm) of the reference soil are lower (-28.5‰) compared to the mofette samples (-26.6‰) (Figure 1).

ESI(-) FT-ICR-MS analyses of the extracted SOM show that oxygen-containing compounds are dominant in all samples, among which the O_2 class makes up between 29.8% and 44.8% total monoisotopic ion abundance (TMIA). Within this O_2 class long-chained fatty acids (C_{20} to C_{36}) are the most abundant compounds, indicating the incorporation of plant biomass into SOM. The even over odd predominance of these fatty acids in all samples forms the basis for the even-over-odd preference index (EOPI*). This EOPI is higher in the mofette samples

($EOPI_{Mof}$ 4.8 – 9.7 versus $EOPI_{Ref}$ 3.7 – 4.5) and allows differentiating between the location with high geogenic CO_2 emission and the reference location with no degassing CO_2 (Figure 1). Interestingly, in mofette core the samples with the highest EOPI (9.7) also shows the highest $\delta^{13}C$ value (-25.3‰), while the opposite is true for the reference core, where the sample with the lowest EOPI (3.7) shows the highest $\delta^{13}C$ value (-25.9‰).

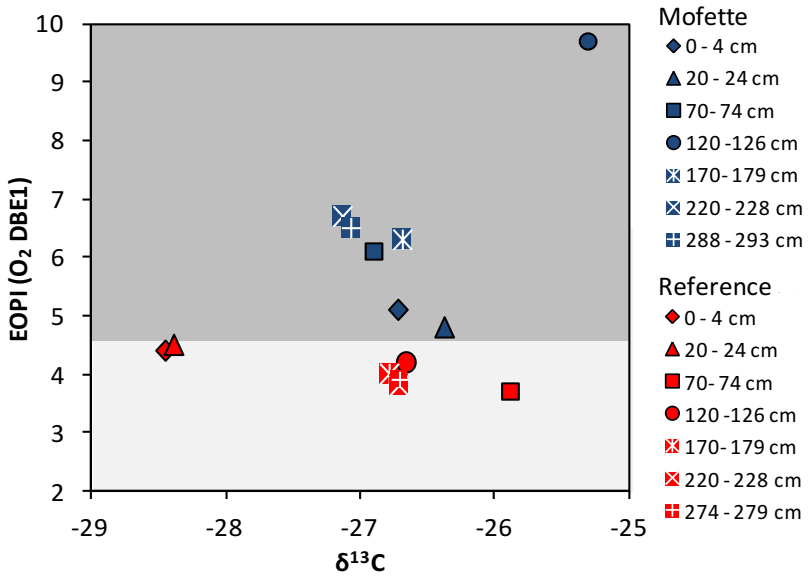

Figure 1 *Even-over-odd preference index (EOPI) values versus $\delta^{13}C$ values (‰) in the investigated mofette and reference cores.*

In addition to the oxygen-containing compounds, nitrogen-oxygen-containing compounds (especially N_1O_5 compounds) are abundant in the samples set. These compounds refer to ceramides, which belong to the class of plant-derived sphingolipids. Their abundance is higher in the mofette core (2.0 – 5.7 %TMIA) compared to the reference core samples (0.9 – 2.4 %TMIA).

*$EOPI=0.5 \times (C_{20+22+24+26+28+30})/(C_{19+21+23+25+27+29})+(C_{20+22+24+26+28+30})/(C_{21+23+25+27+29+31})]$
(C_x = fatty acids with x carbon numbers)

Conclusion

Generally higher TOC and EOPI values and higher abundances of ceramides were detected in the active mofette compared to the reference core. This might be related to the restricted and/or slower degradation of organic matter under anoxic condition by bacteria and fungi.

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References

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