BRANCHED GDGTS MEASURED ALONG AN ICELANDIC SOIL TEMPERATURE GRADIENT CHANGE ONLY WHEN THE BACTERIAL COMMUNITY CHANGES.

C. De Jonge[1], F. Peterse[2], J. Weedon[1], D. Radujkovic[1], I. Janssens[1]
1. University of Antwerp, Biology Dept, Universiteitsplein 1, 2610, Wilrijk, Belgium.
2. Utrecht University, Dept Earth Sci, NL-3584 CD Utrecht, Netherlands

Branched glycerol dialkyl glycerol tetraethers (brGDGTs) are bacterial membrane lipids that are abundant in soils. Their distribution in globally distributed soils correlates with the prevailing mean annual air temperature (MAAT) and soil pH (Weijers et al., 2007). This empirical relation allows their application as a palaeoclimate proxy.

To explain the correlation between brGDGTs and soil pH and temperature, the original paradigm was that the introduction of different brGDGT lipids in the cell membrane ensured an optimal membrane fluidity and permeability in different pH and temperature conditions. This was challenged by the discovery of the 5- and 6-methyl brGDGTs, compounds that only have a very subtle structural difference but show a completely different behaviour in a dataset of globally distributed soils (De Jonge et al., 2014). This observation recently led to the hypothesis that the observed co-variation with temperature and pH is possibly tracing a shift in microbial composition. To improve the accuracy and reliability of the palaeoclimate proxy, it is necessary to understand the biological mechanism that is responsible for the observed temperature-dependence on a global scale.

We have studied the brGDGT composition and the composition of the bacterial community, based on the diversity of the 16S rRNA. To study the unique effect of temperature, we have sampled along five permanent research transects in a long-term (>70 years) geothermally warmed grassland soil. This geothermal warming only influences the soil through heat radiation, and does not influence the soil pH or other chemical characteristics. At each sample site (n=30) we compare the brGDGT distribution directly with the in-situ measured soil temperature, and with the composition of the bacterial community. This allows us to present evidence that the brGDGT fingerprint is mainly controlled by the composition of the microbial community, rather than being a biochemical response of an unchanged community. We have also analysed the precursors of the brGDGT lipids; iso-C15 fatty acid and the characteristic iso-diabolic acid (Sinninghe Damsté et al., 2011). For the first time, this will allow to reconstruct the proposed production pathway of brGDGTs in soils.

Fig. 1A shows preliminary results of 1 transect. The GDGT fingerprint remains remarkably stable, although the mean annual soil temperature increases from 6-13 °C. Evaluating the composition of the bacterial community, we observe that this limited response is coeval with an unchanged bacterial community. Only a minor change in the lipid profile is thus produced by an unchanged community exposed to different growing temperatures.
Fig. 1B shows that a strong shift in the composition of the bacterial community is observed in the warmest soils (> 20°C mean annual temperature), including changes within 6 Acidobacterial subdivisions. In these soils a significant shift in the brGDGT signature is observed, with a larger proportion of tetramethylated compounds, that results in a warmer reconstructed temperature. Although a shift in the bacterial community is needed for a change in brGDGT composition, it can be caused by an increase in temperature. This is in line with the current application of using the brGDGT lipids as a ‘thermometer of the past’.

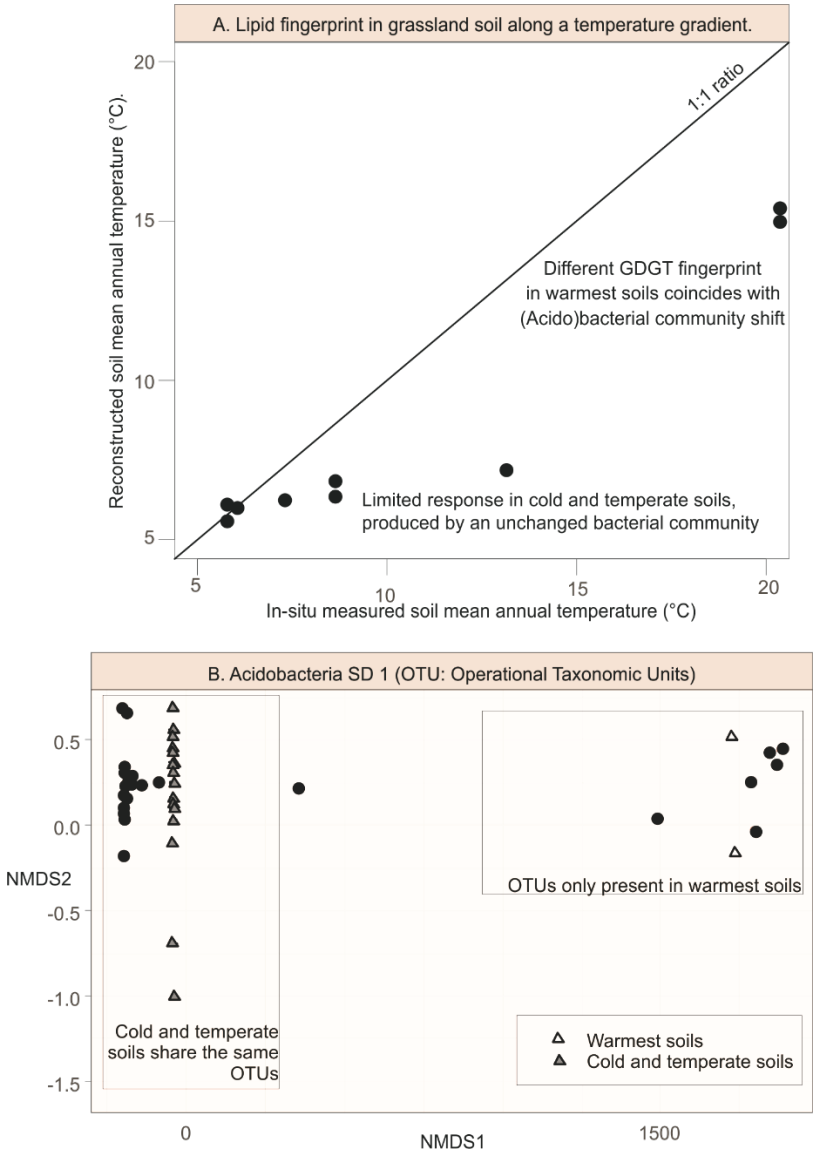

Figure 1 *Preliminary data on A) the brGDGT lipid distribution, expressed as the reconstructed MAT using the De Jonge et al. (2014) calibration and B) an example of the observed shift in the composition of the bacterial community. In both datasets, a shift is observed only in the warmest soils.*

References

De Jonge, C., Hopmans, E.C., Zell, C.I., Kim, J.-H., Schouten, S., Sinninghe Damsté, J.S., 2014. Occurrence and abundance of 6-methyl branched glycerol dialkyl glycerol tetraethers in soils: Implications for palaeoclimate reconstruction. Geochimica et Cosmochimica Acta 141, 97–112.

Sinninghe Damsté, J.S., Rijpstra, W.I.C., Hopmans, E.C., Weijers, J.W.H., Foesel, B.U., Overmann, J., Dedysh, S.N., 2011. 13, 16-dimethyl octacosanedioic acid (iso-diabolic acid), a common membrane-spanning lipid of Acidobacteria subdivisions 1 and 3. Applied and environmental microbiology 77, 4147–4154.

Weijers, J.W.H., Schouten, S., van den Donker, J.C., Hopmans, E.C., Sinninghe Damsté, J.S., 2007. Environmental controls on bacterial tetraether membrane lipid distribution in soils. Geochimica et Cosmochimica Acta 71, 703–713.