Evolution of SOM quality in long-term bare fallow plots using thermal analysis

Purpose of the visit:

I have recently initiated the networking of six long-term bare fallow experiments located across Europe: Askov (Denmark), Grignon and Versailles (France), Kursk (Russia), Rothamsted (UK), and Ultuna (Sweden) (Barré et al., 2010). Alain Plante and I were highly interested in investigating SOM quality evolution in these bare fallow plots using thermal analysis. All sites but Kursk provided samples for this project. Where possible, we requested also samples from adjacent plots maintained under a management as close as possible as the one before bare-fallow implementation (typically cultivated for Askov, and Ultuna and grassland for Rothamsted) to provide a contrasting treatment generating significantly different SOM quality. Lastly, we also wanted to characterize the evolution in SOM quality in two treatments where SOM has accumulated to contrast with the bare fallow treatment (i.e., Ultuna +straw+N treatment, and Versailles +manure treatment) and one treatment where SOM decrease under bare fallow was attenuated by straw or composted straw addition (Grignon).

The purpose of my visit was to train in thermal analysis techniques, assist in running some of the samples, and begin the interpretation of the results of samples analyzed prior to my stay in Philadelphia.

Description of the work carried out during the visit:

I had several interesting discussion with Alain Plante and his team about thermal analysis technique. I assisted in running the samples from the Askov site. I contributed to analyze the data provided by the analysis of Versailles, Grignon and Rothamsted. We discussed the implication of these very interesting results and thought about an outline for a paper on these results.

Description of the main results obtained:

The thermal analyses conducted in Philadelphia provide thermogravimetry (TG) and differential scanning calorimetry (DSC) data (see on Figure 1). Several thermal indices of SOM quality can be derived from these data. We decided to focus on two indices: the energy densities and the temperature at which half of the SOM was oxidized (TG_{50}). The energy density (J mg^{-1} OM) is the energy content divided by the thermogravimetric mass loss. Total exothermic energy content (in J) was determined by integrating the DSC heat flux over the exothermic region 190-600°C, which was found to represent the temperature range in which SOM is oxidized. Thermogravimetric mass loss was determined for the same range. For details, see Rovira et al. (2008) and Plante et al. (2011).

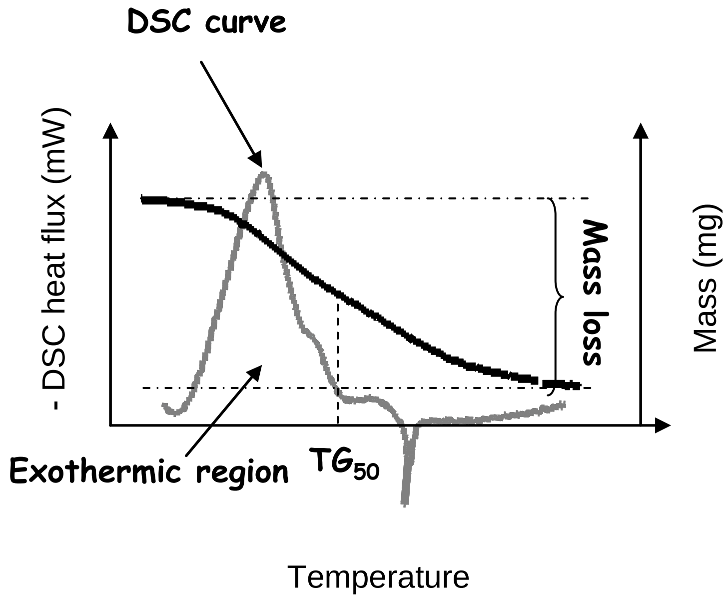

Figure 1: Example of ATG/DSC outputs.

During my stay, we calculated the energy densities and TG_{50} for the samples from Versailles, Grignon and Rothamsted. The analysis of Askov and Ultuna samples is in progress and the results are expected in July. The evolution with time of the energy densities and TG_{50} for the soils from Versailles and Rothamsted are presented on Figures 2, and 3. The data from Grignon look the same as Versailles and Rothamsted.

For both sites, the energy density of the organic matter (OM) decreases with time under bare fallow. On the contrary, the energy density is not changing over time in the adjacent grassland maintained under a management similar to the one before bare fallow implementation (Rothamsted) and is slightly increasing in the bare fallow manured plots (Versailles). For both sites, TG_{50} is increasing with time under bare fallow. TG_{50} did not change over time for grassland and manured plots. For Grignon, the similar trends were observed: energy density decreased with time under bare fallow whereas TG_{50} increased with bare fallow duration.
All together, the results show that stable OM is burning on average at a higher temperature and releases less energy than the labile OM. This strongly supports the fact that thermal analysis is a suitable method to assess SOM quality.

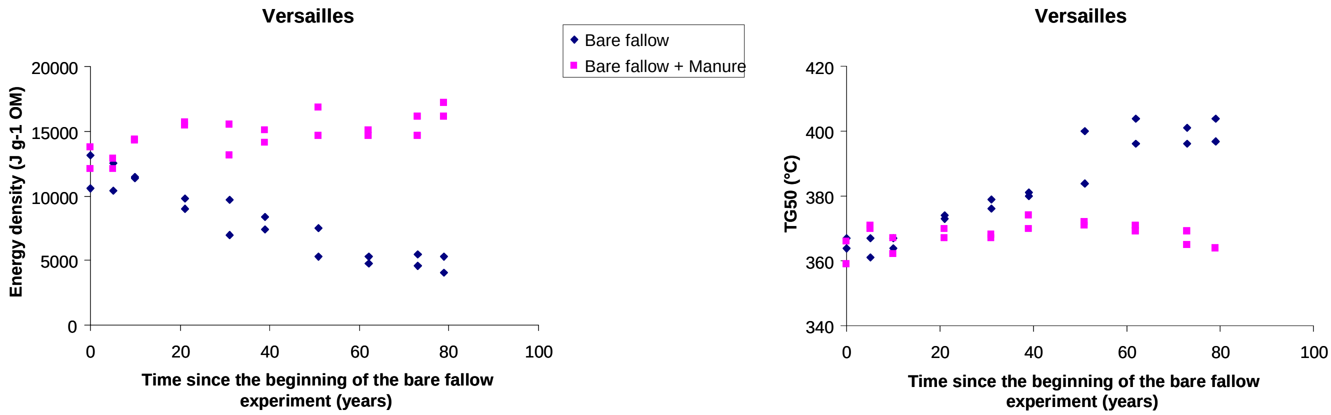

Figure 2: Evolution with time of energy density and TG50 for the Versailles' soils

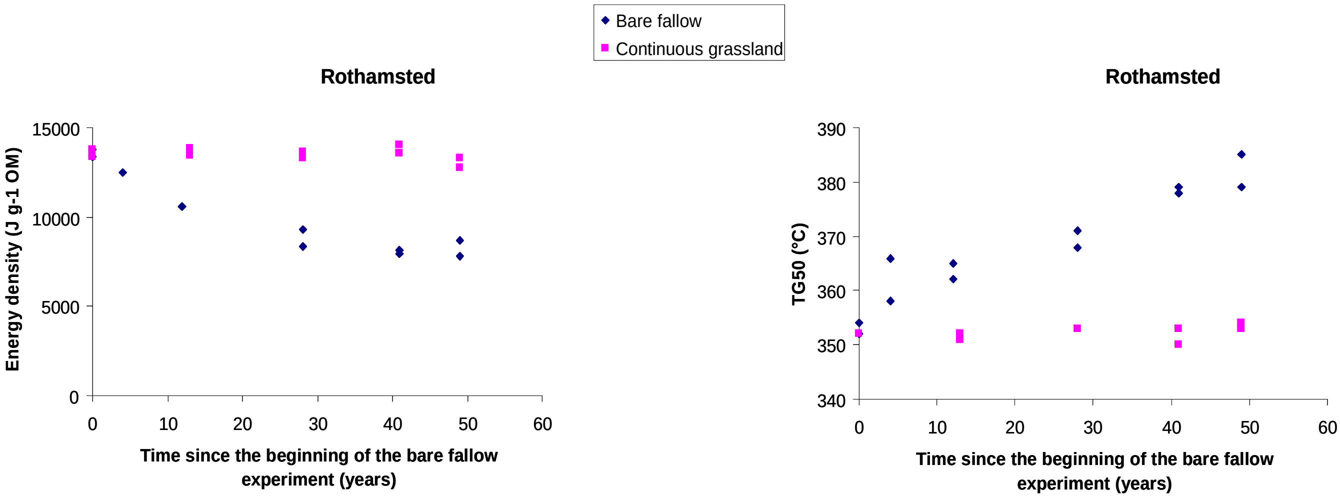

Figure 3: Evolution with time of the energy density and TG50 for the Rothamsted's soils.

Future collaboration with the host institution:

1) Short-term

- Analyze the data of the analyses of Askov and Ultuna and write a paper out of this work.

2) Middle term

- The soil samples will be analyzed using NIRS and MIRS techniques. The IR results will be discussed at the light of the thermal analyses results.
- I know the principle and the potential of ATG/DSC method and I am looking forward to using this technique again in future projects.

Projected publications/articles resulting or to result from the grant:

We will write a paper whose title could be something like: "Thermal stability equates to biological stability as evidenced by soils originating from 5 long-term bare fallow experiments"

References:

Barré P., T. Eglin, B.T. Christensen, P. Ciais, S. Houot, T. Kätterer, F. van Oort, P. Peylin, P.R. Poulton, V. Romanenkov and C. Chenu. Quantifying and isolating stable soil organic carbon using long-term bare fallow experiments, Biogeosciences, 7, 3839-3850.

Plante A.F., J.M. Fernandez and J. Leifeld (2009) Application of thermal analysis techniques in soil science, Geoderma, 153, 1-10.

Plante A.F., J.M. Fernandez, M.L. Haddix, Steinweg J.M. and R.T. Connant. Biological, chemical and thermal indices of soil organic matter stability in four grassland soils, Soil Biology & Biochemistry,43, 1051-1058.

Rovira, P., Kurz-Besson, C., Couteaux, M.M., Vallejo, V.R., 2008. Changes in litter properties during decomposition: a study by differential thermogravimetry and scanning calorimetry. Soil Biology & Biochemistry, 40, 172-185.