EVALUATION OF THE IMPACT OF TEMPERATURE ON THAUMARCHAEOTA IN SOILS THROUGH ENRICHMENT CULTURES AND MICROCOSM EXPERIMENTS

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The involvement of Archaea in biogeochemical cycles, especially carbon and nitrogen, is today clearly identified. Nevertheless, cultivation of Archaea remains difficult, considerably limiting their study. The phylum *Thaumarchaeota* has recently been defined within the domain Archaea (Brochier-Armanet et al., 2008). *Thaumarchaeota* are considered to play a key role in CO_2 fixation and aerobic ammonia oxidation, and are widespread in aquatic and terrestrial environments. In the latter, they could represent up to 5% of prokaryotes. In marine and lacustrine habitats, the distribution of their membrane lipids (isoprenoid glycerol dialkyl glycerol tetraethers, iGDGTs) is correlated with water surface temperature. This led to the development of the TEX_{86} temperature proxy (Schouten et al., 2002), which is widely used for marine and lacustrine paleoclimate reconstructions. The application of this index to soils remains questionable as, to date, the relationship between lipid distribution and growth temperature has not been systematically studied in soil *Thaumarchaeota*. Using thaumarchaeotal iGDGTs as environmental proxies in soils requires both a better knowledge of terrestrial *Thaumarchaeota* and of the mechanisms regulating the biosynthesis and structure of these lipids.

The objective of this work was to examine the impact of temperature on the diversity of Archaea, especially *Thaumarchaeota*, and the associated iGDGT profile in soil based on (i) enrichment cultures and (ii) microcosms. Enrichment cultures, achieved in liquid medium, targeted *Thaumarchaeota*, while microcosm incubations were based on bulk soil samples. Two contrasting soils – an organo-mineral soil and a plant compost from the Museum National d'Histoire Naturelle, both from Paris – were used for this study. Enrichment cultures and microcosms containing the organo-mineral soil were incubated for 9 months at 30, 37 and 42 °C. As compost contains *Thaumarchaeota* that can survive at higher temperatures than those in other soils, the corresponding cultures and microcosms were incubated at 37, 50 and 65 °C for 9 and 3 months, respectively. The iGDGT profile of core lipids (CLs) and intact polar lipids (IPLs - submitted to acid hydrolysis and quantified as CLs) was determined by high performance liquid chromatography coupled to mass spectrometry (HPLC-MS) at different time points. In parallel, archaeal diversity was monitored using polymerase chain reaction coupled to denaturing gradient gel electrophoresis (PCR-DGGE) using 16S rRNA and *amoA* genes for total archaeal and thaumarchaeotal populations, respectively.

In compost enrichment cultures, the abundance of crenarchaeol and its regioisomer (specific to *Thaumarchaeota)* relative to IPL-derived iGDGTs increased from *ca*. 35% at the beginning of the experiment to *ca*. 95 % after 7 months of incubation, whatever the temperature. The predominance of *Thaumarchaeota* among archaeal communities at the end of the enrichment was also reflected in the values of the ring index (i.e. average number of cyclopentyl rings in iGDGTs), which increased from 2 to ca. 3.5 after 7 months of

incubation.
In compost microcosms, no significant change in the relative abundance of CL and IPL-derived iGDGTs was observed after 12 weeks of incubation at all temperatures. This suggests that Archaea are growing slowly in compost, leading to a low lipid turnover and consequently no detectable changes in iGDGT composition. Similarly, laboratory and field experiments with peat cores (Huguet et al., 2014) showed that changes in soil temperature resulted in detectable changes in bacterial branched GDGT abundance after one year.
In contrast, temperatures higher than 37 °C led to changes in archaeal community composition of the plant compost (Figure 1), as shown by the appearance of Operational Taxonomic Units (OTUs) absent in the original compost sample. This shows that changes in temperature have a rapid effect on the archaeal community composition that is not reflected in the core lipid profile. Nevertheless, the nature of the polar head groups of IPL iGDGTs may have changed during incubation; IPL analyses are currently being performed to check this point. The lipid and microbiological results of the compost experiments will also be compared with the enrichments and microcosms containing organo-mineral soils. Such analyses will bring new knowledge on *Thaumarchaeota* and their adaptation to temperature change in soils.

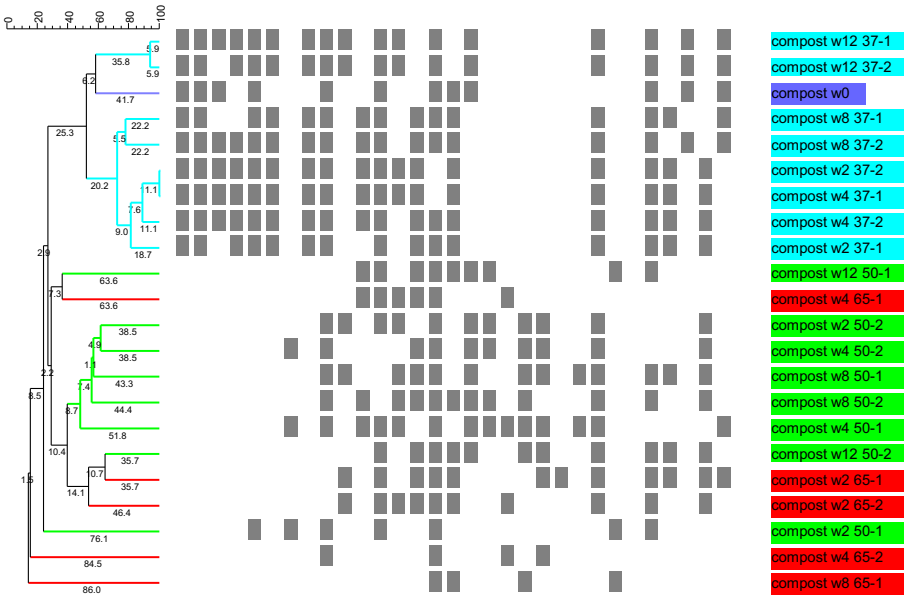

Figure 1. *Dendogram representing similarity in Operational Taxonomic Unit (OTU) composition based on the archaeal amoA gene for compost microcosm samples incubated at 37, 50 and 65°C for up to 12 weeks. Similarity percentages are displayed on the left side of the dendrogram. Each OTU is represented by a grey square.*

References

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