

EXTENSIVE HIGH AFFINITY METHANOTROPHIC BACTERIAL POPULATIONS IN VOLCANIC SOILS

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A century of study has demonstrated the importance of methanotrophic bacteria in the Earth system as a sink for atmospheric CH₄ (high affinity methanotrophs) and as a robust barrier against CH₄ flux to the troposphere from anoxic environments (low affinity methanotrophs). While much has been ascertained about the phylogeny and metabolic biochemistries of these remarkable organisms, little is known about the fate of methanotrophically fixed carbon in the extensive range of natural and anthropogenic environments that they inhabit. Methanotrophic bacteria occur in every soil order being both an important sink for atmospheric CH₄ in well aerated soils and a highly efficiency filter that consumes >90% of upward diffusing CH₄ in anoxic Gelisols and Histosols. However, little work has been conducted on methanotrophs in Andisols (soils derived from volcanic ash).

In this study three contrasting Andisols from Tenerife were incubated under 2 ppmv ¹³CH₄ for up to 18 weeks using a technique developed for aerobic mineral soils (Maxfield *et al.*, 2006). The three Andisols included a well-drained Hapludand from a pine forest, an Ultic Fulvudand from a laurel forest and a more recent Vitrixerand situated at high altitude. The biomass and taxonomic identity of the high affinity methanotrophic populations were determined and compared with the relative rates of CH₄ oxidation at each site. This is the first detailed investigation into high affinity methanotrophic activity in Andisols. It was suspected that the unique properties of Andisols that yield soils with a very low bulk density, a high organic carbon content and relatively high water holding capacity would be conducive to atmospheric CH₄ oxidation.

Two of the three Andisols studied displayed high CH₄ oxidation rates and substantial levels of ¹³C incorporation following incubation under 2 ppmv ¹³CH₄. A high variability in CH₄ oxidation rates between the different sites was observed with rates ranging from 1.58 nM CH₄ g⁻¹ d.wt. h⁻¹ for the Ultic Fulvudand down to 0.03 nM CH₄ g⁻¹ d.wt. h⁻¹ for the Vitrixerand. PLFA profiles were similar but the high affinity methanotrophic populations determined through ¹³CH₄ PLFA labelling were very different. Substantial incorporation of ¹³C was observed, indicated by δ¹³C values in excess of 850‰ and 450‰ for the Hapludand and the Ultic Fulvudand, respectively. These values are far in excess of those observed for a

range of UK mineral soils (ca. 10 fold higher) incubated under identical conditions. This suggests that Andisols, a previously unstudied soil class with respect to methanotrophic bacteria may oxidise significant amounts of atmospheric methane despite their low areal coverage globally.

One implication of the high capacity for methane oxidation in Andisol soils is that the global atmospheric CH₄ sink due to bacterial CH₄ oxidation in soils may have been higher than it is today. Large scale plinian volcanic eruptions (e.g. Yellowstone) involved widespread deposition of volcanic ash, which yielded a far wider coverage of Andisols than at the present time. Whilst it is widely believed that anthropogenic activity has inhibited methanotrophic activity in a wide range of soils, to date less consideration has been given to natural environmental changes causing a similar effect.

Due to the high levels of ¹³C-label incorporation by methanotrophic bacteria in the Tenerife Andisols we have been able to assess the potential microbial groups that are utilising

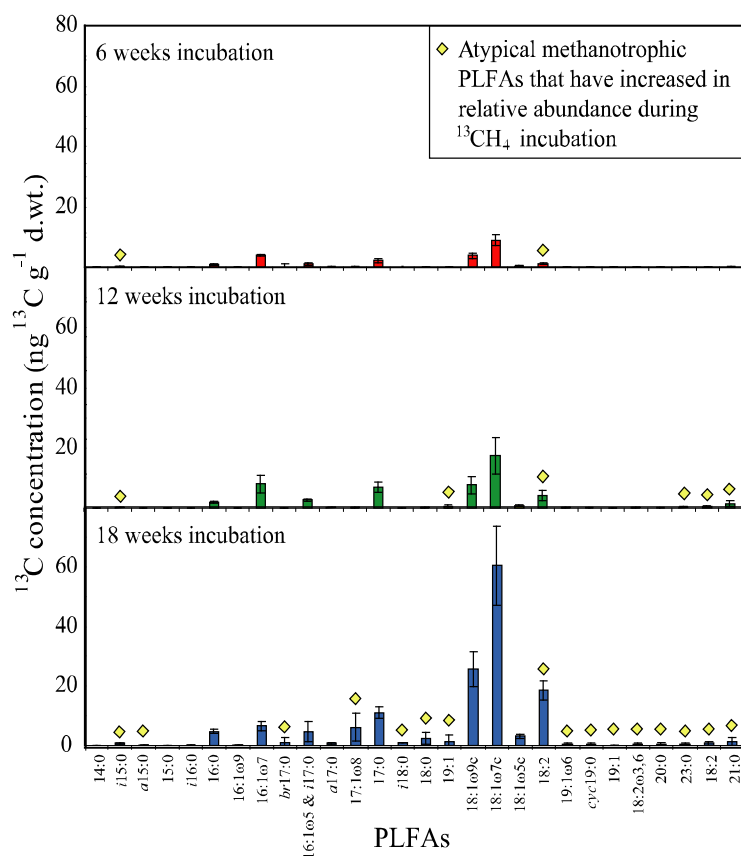


Figure 1: Tenerife andisol ¹³C PLFA concentrations following 2 ppmv ¹³CH₄ incubation. Only PLFAs that have incorporated the ¹³C-label have been displayed. Error bars represent ±1 s.d.

the carbon initially fixed through atmospheric CH₄ oxidation. This provides information about carbon flow, with respect to the scale of methane-derived carbon turnover within soils. It can be seen that a wide range of atypical methanotrophic PLFAs increased in relative abundance as ¹³CH₄ incubation proceeded (Fig. 1). For example, CH₄-derived carbon was utilised by fungi as ¹³C-label was incorporated into 18:2ω6 PLFAs, both of which are characteristic fungal biomarkers (Vestal and White, 1989), thereby indicating that fungi are involved in either direct methanotroph predation, or

the predation of other soil organisms that consume methanotrophic bacteria.