Spatial distribtuion of methanotrophy and methanogenesis in terrestrial mud volcanoes of eastern Taiwan

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Terrestrial mud volcanoes represent an important natural source of methane emission. The exact microbial processes controlling carbon flow in such methane-charged environments remain largely unexplored. This study analyzed cored sediments retrieved from various sites of the Lei-Gong-Hou mud volcanoes in eastern Taiwan to uncover the spatial distributions of biogeochemical processes and community assemblages involved in methane cycling. The profiles of methane concentration and carbon isotopic composition revealed various orders of the predominance of specific methane-related metabolisms along depth. The methanogenic zone either overlaid or was sandwiched by anaerobic methanotrophic zones. The anaerobic methanotrophic zone was characterized by high copy numbers of the ANME-2a 16S rRNA gene, dissolved Fe and/or Mn concentrations, copy numbers of the *Desulfuromonas*/*Pelobacter* 16S rRNA gene, and TOC concentrations. Gene analyses and incubation experiments revealed that methanogenesis was primarily mediated by methylotrophic methanogens and could proceed at salinities as high as 2000 mM Cl^-. These lines of evidence suggest that anaerobic methanotrophy is potentially dependent on metal reduction, fixes methane-derived carbon for TOC accumulation, and dominates over aerobic methanotrophy for the removal of methane produced *in situ* and migrating from a deep source. Near-surface halo-tolerant methanogenesis contributes to the methane emissions from the mud platform. The alternating arrangements of methanogenic and methanotrophic zones at different sites suggest that the interactions between surface (mud deposition, evaporation, and oxidation) and subsurface fluid transport modulate the assemblages of microbial communities and methane cycling in different compartments of terrestrial mud volcanoes.