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Subterranean karst caves serve as methane sink: biological evidence and rethinking about the global methane budget

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Subsurface karst caves are proposed to be an important atmospheric methane sink besides soils in terrestrial ecosystems mainly based on measurements of methane concentration. Here we provided molecular evidence about the wide distribution of high-affinity methanotrophs, particularly upland soil cluster (USC) and their involvement in methane oxidation in karst caves. High throughput sequencing and quantification of functional gene *pmoA* indicated that USC dominated methanotrophs and distributed widely in karst caves with high gene copy numbers varying between 10^5~10^8 copies per gram dry sample. USC*r* outnumbered USC*a* as a result of niche differentiation due to the alkaline conditions. They oxidized methane in low concentrations with comparable oxidizing rate to those in aerobic soils as indicated by DNA-SIP and carbon isotope of individual fatty acid. In terms of the microbial interaction, methanogens occupied more nodes in the networks, whereas methanotrophs served as the keystone taxa, indicating the leading ecological role of methanotrophs in the network. Quantitatively methanotrophs outnumbered methanogens by 2~3 orders of magnitude and no methane was detected produced by methanogens. Collectively these data strongly supported caves as a methane sink. The roughly estimated annual methane consumption by USC was 1.99×10^7 kg based on the methane oxidizing rate by USC living on the surface of the weathered rocks in karst cave and the karst area of the world. It should be pointed out that this estimation may be underestimated by orders since the unknown karst area in subterranean karst caves was not included in the estimation. Taking microbial methane consumption at karst area into consideration may reduce the uncertainty of the estimation of the global methane budget.