**Title:** “Hiding in plain sight? Tracing cryptic anaerobic methane oxidation to the cosmopolitan deep biosphere phylum “Candidatus Bathyarchaeota”

**Abstract:**

The anaerobic oxidation of methane (AOM) is a significant biological sink in the global carbon cycle, consuming an estimated 90% of the annual net atmospheric flux from the deep subsurface biosphere. Recent breakthroughs have vastly improved our understanding of AOM, identifying a wide range of oxidants utilizable via diverse metabolic strategies in the anaerobic methane-oxidizing archaea (ANMEs) and the bacterium “Candidatus Methyloirabilis oxyfera”. However, the details of AOM’s contribution to the global CH$_4$ budget remains poorly constrained and includes systematic discrepancies such as the documentation of AOM in environments where known microbial mediators appear absent, as well as a global stoichiometric imbalance in observed fluxes of methane and oxidants into regimes where AOM is known to occur. The recent identification of a “cryptic” methane cycle – in which AOM and methanogenesis proceed concurrently along small and geochemically near-indiscernible temporospatial scales – may play a key role in filling our gaps in understanding.

The uncultured “Ca. Bathyarchaeota” is a deeply branching phylum whose members are among the most widespread and abundant archaea inhabiting the deep biosphere. Though a pure culture isolate remains elusive, recent studies have attributed diverse metabolic capabilities to the “Ca. Bathyarchaeota”, including acetogenesis, fermentation, methanogenesis, and denitrification. We recently identified “Candidatus Bathyarchaeota” archaeon BE326-BA-RLH, the first described member of the phylum “Ca. Bathyarchaeota” whose genome encodes proteins that appear to couple AOM to dissimilatory nitrate reduction. While initially discovered in continental subsurface fracture fluid from a South African gold mine, BE326-BA-RLH and closely related sister lineages have also been identified in sub-seafloor sediments from the Nankai Trough and coastal peatlands from Brunei. Here we will address preliminary evidence from high throughput sequencing coupled to radio, stable-, and clumped isotope geochemistry to consider a role that the “Ca. Bathyarchaeota” may play in cryptic AOM.