A Comparison of Sedimentary Organic Carbon Processing by Unique Microbial Communities in Mobile/Fluid Muds of the Mississippi and Yangtze River Plume Regions

Draft PROJECT SUMMARY for Microbial Systems (DEB) and Chemical Oceanography NSF Programs

INTELLECTUAL MERIT- Continental margins are dynamic regions that receive terrestrial and marine organic carbon (OC) from a range of sources with differing reactivities and microbial communities. Rivers such as the Mississippi and their associated deltaic environments are thought to be major pathways for the delivery of terrestrial OC to margin regions and the deep sea through transport of fluid/mobile muds. Characteristics of the Mississippi and Yangtze Rivers make them promising candidates for comparisons to be made on the role of fluid/mobile and their associated microbial assemblages in decomposing terrestrially-derived organic carbon (T_{err}OM). Preliminary results from our research groups suggest that labile organic matter, likely produced by *in situ* diatom production in the Mississippi River plume, may enhance the decay of T_{err}OM through possible mechanisms of co-metabolism. In fact, other work on the Amazon and Fly River deltas have suggested that there are distinct microbial groups associated with mobile/fluid muds that have greater capabilities to breakdown T_{err}OM in these unique fluid/mobile mud environments commonly found along river-dominated margins (RiOMars). High primary production has also been shown to be associated with the Yangtze River plume, yet no work has been conducted on the biogeochemistry of mobile/fluid muds. Based on these findings our working hypothesis is that: ***Seasonal and interannual changes in the composition, and diagenesis of sedimentary organic matter (SOC) in Mississippi and Yangtze River mobile/fluid muds are largely determined by distinct microbial assemblages associated with these unique sedimentary environments***. A better understanding of the processing of organic matter in mobile muds will enhance our understanding of how: 1) much organic C gets exported to continental slope versus what gets preserved as a function of 'incineration' processes; 2) mobile muds act as potential 'hotspots' of greenhouse gas production CO_2 and N_2O because of elevated respiration rates; and 3) other more physically-controlled mechanisms control the pulsed delivery from changes in Mississippi and Yangtze River discharge, shelf circulation, winter and tropical storms, affect gravity flows and benthic nepheloid layer transport.

Our APPROACH for testing the hypothesis involves a detailed biogeochemical study of mobile/fluid and under contrasting hydrologic regimes supplemented by geophysical mapping (i.e. CHIRP surveys). The proposed project has 4 objectives:

1) **Determine *in situ* microbial community structure, including the fraction associated with depositional organic matter degradation, within fluid/mobile muds of the Mississippi/Atchafalaya and Yangtze river-dominated margins.**

Approach: Temporal and spatial variations in the *in situ* microbial community structure will be determined qualitatively and quantitatively using high-resolution pyrosequencing and real time PCR. Specific gene (DNA) and gene transcript (mRNA and rRNA) targets will be used to describe composition and activity of the total community (SSU rRNA), and lineages associated with sulfate reduction (*dsrA*), iron reduction (*gltA*) and lignin degradation (*pcaH*). Microcosm-based culture experiments will be used to determine variations in community structure linked to alterations of different components of sedimentary organic carbon (SOC).

In addition, specific fractions of the microbial community directly associated with the assimilation of SOC will be tracked using stable isotope probing (SIP).

2) Describe benthic sediment organic and inorganic geochemistry associated with fluid/mobile muds of the Mississippi/Atchafalaya and Yangtze river-dominated margin.

Approach: Lipid biomarkers (fatty acids, sterols, *n*-alkanols, and branched and isoprenoid tetraethers) will be used to determine the major fractions of marine and terrestrially-derived sedimentary organic carbon (SOC) in the mobile/fluid muds over two distinct hydrological periods with varying river discharge and storm events. Stable carbon ($\delta^{13}C$) and radiocarbon ($\Delta^{14}C$) isotopic compositions of SOC and selected terrestrial and marine components, using compound-specific stable isotope analysis of selected lipid biomarkers, will be used to refine our assessment of organic carbon sources and the age of organic carbon derived from specific sources. This information will be corroborated with biomarker distributions, and interpreted using grain size and sediment surface area, and fine-scale stratigraphy (X-radiography). Standard geochemical assays with the addition of microelectrodes will be employed to determine the oxygen penetration depth and the relative importance of iron, manganese and sulfate reduction in diagenesis. CO_2 and N_2O will also be measured in the field and microcosm experiments to examine the associated by-products of microbial processing mobile/fluid muds systems.

3) Identify Mississippi/Atchafalaya and Yangtze riverine-derived depositional inputs contributing to alterations in the observed fluid/mobile margin muds geochemistry within of the river-dominated.

Approach: Particle-reactive radionuclides (^{210}Pb, ^{234}Th, ^{7}Be, and ^{137}Cs) will be used to determine seasonal sediment deposition, sediment accumulation rates at decadal timescales and biological/physical mixing rates as they relate to spatial sediment delivery patterns and how they affect OC composition and burial. Tri-pods will positioned along transects to collect fluid muds along the dispersal system from the river-mouth to the inner shelf-mid shelf region.

4) Determine recovery rates of microbial community metabolic activity and structure post physical disruption of geochemical/geophysical environment.

Approach: Microcosm based culture assays will be used to simulate deep sediment mixing and monitor recovery of the microbial system to pre-disruption rates and structure. Metabolically active fractions of the total microbial community will be quantitatively and qualitatively described at regular time intervals using high-though put sequence analysis. Microelectrodes and standard geochemical assays will be used to monitor oxygen, nitrogen, iron and sulfur cycling and organic carbon degradation at different depths. Opportunistic sampling of *in situ* populations post large scale natural mixing events (storms, flood) will be used to gauge predicted lab based models.

BROADER IMPACTS - This project will have a strong educational component targeting under-represented groups All Co-PIs will support graduate students on this project. Linkages to Ocean University in China...