Sources, pathways and sinks of particulate organic matter in Hudson Bay: Evidence from lignin distributions

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Introduction

• Terrigenous organic matter is an important source of carbon to the marine environment, especially in the Arctic
• It contributes to sedimentary carbon sink
• It integrates drainage basin processes
• It incorporates other major cycling elements (e.g., nitrogen, phosphorous)
  – modulate productivity of marine systems
• Distribution and fate of terrigenous organic matter (i.e., whether it contributes to sedimentary carbon sink or gets degraded and contributes to nutrient cycles) is controlled by
  – Nature of organic matter
    • Plant debris vs. mineral-associated soil organic matter
    • Density and particle size
    • Fresh or degraded on land
  – Timing and means of entry into marine system
    • Discharge in winter vs. during open water period
  – Efficiency of transport processes
    • Ice rafting vs. marine currents
We expect terrigenous organic matter to be particularly important in Hudson Bay

- Large amount of river discharge
- Massive and diverse drainage area
  - West to Pacific watershed, south to the Mississippi watershed of northern U.S.
Located at southern margin of Arctic

Hudson Bay and its watershed are now changing rapidly as part of global climate change
  - Altered river discharge
  - Changes in seasonal sea ice cover
Research Objectives

• Study the modern organic carbon cycle in Hudson Bay with aim of deciphering the importance and nature of terrigenous organic matter and how (or if) it has been influenced by recent environmental change
  – Assess sources, composition and distribution of terrigenous organic matter in surface sediments of the Bay
Lignin as a Geochemical Tracer

- Major component of terrestrial vascular plants (~30% of wood)
- Absent from marine phytoplankton
- Intrinsically stable
- Lignin from different plant sources has different chemical composition
- Composition also indicates degree of degradation

Hedges et al., 1988
Lignin distribution

- Approximately 30% of annual river discharge
- Approximately 50% of lignin yield
Lignin compositional ratios: syringyl, cinnamyl, vanillyl
Comparison to material carried by rivers

- Woody angiosperm (deciduous trees)
- Woody gymnosperm (coniferous trees)
- Non-woody angiosperm (grasses, herbs, tree leaves)
- Non-woody gymnosperm (conifer needles)

Hydrodynamic sorting

Northern River OM
Other compositional ratios: 3,5-dihydroxybenzoic acid

Coarse to fine particle size

Increasing degradation

Northwest & offshore

South & inshore
We hypothesize that old (glacigenic) deposits may represent internal reservoirs of highly degraded, non-woody angiosperm OM. Resuspension and lateral transport from coastal deposits may supply most of the OM to the central basins and parts of the northwest shelf—supported over long term by falling relative sea level due to post-glacial isostatic rebound.
Closing Remarks

• Simple conceptual model of sources, pathways and sinks of terrigenous OM in Hudson Bay
  – Regional sources
  – Redistribution from south to northeast with coastal current
  – Hydrodynamic sorting
    • Modern plant debris retained near coast
    • Mineral fraction distributed more widely
  – Importance of resuspension of old deposits
    • Supported in long term by falling relative sea level
• Conceptual model provides framework for understanding and interpreting ongoing and future change
  – Sedimentary (and OM) regimes in transition already?
  – Importance of sorting in coastal zone
  – Ice cover has leverage for change
    • Control of open water, effects of waves and storms
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