APPLICATIONS OF ORGANIC GEOCHEMISTRY TO PALEOLIMNOLOGICAL RECONSTRUCTIONS: EXAMPLES FROM THE LAURENTIAN GREAT LAKES.  P. A. Meyers, Department of Geological Sciences, The University of Michigan (2534 C.C. Little Building, Ann Arbor, MI 48109-1063, pameyers@umich.edu)

Introduction: The organic matter content of lake sediments provides information that can be used to reconstruct past environmental conditions, changes in climate, and the impacts of humans on local ecosystems. The elemental, isotopic, and molecular compositions of organic matter buried in sediment provide evidence of the biota that have lived in and around a lake. As the types and abundances of life change, the composition and amount of organic matter delivered to lake sediments changes.

Sedimentary records from the North American Great Lakes illustrate applications of organic geochemistry to paleolimnological reconstructions. These records date from retreat of the Laurentian ice sheet 12 kya, include the mid-Holocene hypsithermal, and show the impacts of human changes. Over the past 200 y, sources of organic matter to the Great Lakes have been progressively modified by clear-cutting of native forests, intensive agriculture, growth of cities, industrialization, and eutrophication.

Origins of Organic Matter: Low C/N ratios indicate that most of the sediment organic matter in the Great Lakes is from algal production [1], [2], yet ratios of biomarker molecules show that varying amounts of land-plant organic matter have also been delivered to the lakes. Ratios of waxy n-alkanes to algal n-alkanes are low in sediments deposited between 12 to 11 ka in the deep parts of Lake Huron [3] and Lake Ontario [1]. The low ratios indicate a paucity of land vegetation around the lakes at that time. The ratios increase as forests became established. They reach prehistoric maxima during the mid-Holocene hypsithermal, suggesting locally wetter climate and greater wash-in of land-plant debris. Briefly elevated wax/algal n-alkane ratios in late-nineteenth-century nearshore sediments [4] record times of forest clear-cutting.

History of Lake Eutrophication: Carbon isotopic compositions of organic matter derived from Great Lakes algae and C3 land plants are normally indistinguishable (δ13C ~ -27‰). However, the elevated algal productivity that accompanies eutrophication of lake waters is recorded as excursions to less negative δ13C values in the organic matter of sediments that were deposited in the 1960s and 1970s [2], [4], [5], [6]. Organic δ13C values return to pre-eutrophication levels in more recent sediments in response to improved water treatment since the mid-1970s.

Increased organic carbon mass accumulation rates mirror the isotopic excursions in most parts of the Great Lakes [4], [5], [7]. However, sediments of Green Bay, Lake Michigan, do not record an increase in the burial rate of organic matter despite containing isotopic and biomarker evidence of elevated productivity [6]. Organic matter recycling evidently increased as a consequence of increased organic matter production in this location.

Proportions of land-plant and algal biomarkers commonly reflect land-use changes that have occurred since European settlement of the Great Lakes basins. Ratios of C29/C27 sterols, C25/C17 n-alkanes, and C29/C16 n-alkanols decrease in sediments deposited between 1850 to 1975 as land runoff increased nutrient loading of Saginaw Bay, Lake Huron [8]. Similar changes occur in sediments of Lake Erie and Lake Ontario, but diagenesis in slowly accumulating sediments modifies the original biomarker character of deposited organic matter [9].

Delivery of Fossil Fuel Residues: A history of fossil fuel use by modern society is present in the sediments of the Great Lakes. Concentrations of pyrogenic polycyclic aromatic hydrocarbons peak in sediments of Green Bay and Lake Michigan in the early 1950s [6], [10], [11], which corresponds with the history of coal combustion in the Midwest. Atmospheric transport is implicated by the relatively similar sedimentary profiles in widely separated locations. In contrast, delivery of petroleum-derived residues is first evident around 1875 in Saginaw Bay [8], about 1920 in Lake Ontario [12], and around 1950 in the St Marys River between Lake Superior and Lake Huron [7]. The difference in appearance of the petroleum residues indicates that they are delivered by land runoff and fluvial transport from local sources instead of by air-borne particles.