Long-range atmospheric transport of continental organic carbon to the western North Atlantic

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In collaboration with the Atmosphere-Ocean Chemistry Experiment (AEROCE), we have produced a 2.5 year time-series of the concentration and composition of terrestrially-derived lipid "biomarker" compounds in western North Atlantic aerosols sampled at Bermuda. This region is influenced by North American air masses about 50% of the year and Africa/southern European air masses about 20% of the year (principally in the summer and early fall when the Bermuda High Pressure system dominates).

Leaf waxes of higher plants are the most abundant biomarkers, comprising ~60-70% of extractable lipids and ~0.5-1% of the total organic carbon. Wax molecular composition exhibits three distinct groupings: two associated with North American sources and one with African sources. Strong seasonality in both molecular and isotopic composition that is independent of trajectories indicates that biogenic emissions from vegetation rather than soil deflation is the major contributing process.

North America is the main source of terrestrial organic carbon advected to Bermuda. Organic material from Africa/ Europe was estimated to comprise only ~5-10% of the total during our study, in stark contrast to mineral transport which is overwhelming dominated by Saharan dust.

Terrestrial biomarker concentrations in our biweekly-integrated samples exhibited a strongly log linear distribution indicative of highly episodic transport. No correlation exists between terrestrial biomarker and dust concentrations, consistent with other evidence that organic carbon transport to the western North Atlantic is largely independent of Saharan dust transport. Furthermore, carbon isotopic analyses indicate that leaf waxes in the African-sourced air masses are derived mainly from C_3 plants, rather than the C_4 plants characteristic of arid regions, which suggests that the terrestrial organic carbon in African-sourced air masses advected to the western North Atlantic comes primarily from forests south of the Sahel rather than the dust source regions. The highest biomarker concentrations observed over the entire time series occurred in samples that coincided with transport of smoke plumes from wildfires in Florida and Central America. This suggests that biomass burning is potentially responsible for a major fraction of the total terrestrial carbon transported to remote ocean regions.

Trace element partitioning between majorite garnet and silicate melt at lower mantle conditions

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We have determined the partitioning of 39 trace elements between majorite garnet and silicate melt at 25 GPa and temperature close to the peridotite solidus. Concentrations in crystalline and quenched melt phases were measured by both ion microprobe and laser ablation-ICPMS techniques with, in general, very good agreement. As anticipated from size and charge considerations, DLu (where DLu = [Lu]Majorite/[Lu]Melt = 0.77) is much greater than DLa (=0.02) and K, U and Th are strongly incompatible (D=0.02). Our data indicate that the crystallisation of majorite garnet during anhydrous melting in the deep mantle could lead to the generation of Al-depleted komatiites. The partitioning data have also been used to assess the potential effects of majorite garnet fractionation into the deep mantle during a putative magma ocean event in early Earth history. Crystallisation of a maximum of 14% majorite garnet would have slightly depleted the primitive upper mantle in Si and Al without disturbing the chondritic abundance patterns of other refractory elements. The resultant reservoir would have high Lu/Hf ratio, but chondritic Sm/Nd ratio and would not be enriched in heat producing elements.