Effect of biomass type and pyrolysis conditions on the speciation of Carbon and Phosphorus in biochars as determined by solid-state ^{13}C- and liquid-state ^{31}P-NMR spectroscopy

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Introduction

Biochar sequestration is emerging as a potential strategy for mitigating carbon emissions because carbon is transferred from the fast biological-atmospheric carbon cycle into the much slower geological cycle. Moreover, phosphorus is effectively mineralized by fire, and it is most likely that the enhanced productivity observed in many burned soils is due to this mineralized P and other minerals.

Biochar is an important but poorly understood material. Despite the significant progress that has been made recently in understanding it, little is known about the effect of biomass type and pyrolysis conditions on the physical and chemical properties of biochar, as well as the speciation of phosphorus. We are currently studying the effects of combustion temperature, atmosphere (oxic versus anoxic) and biomass type on the different carbon and phosphorus forms in biochar.

Discussion of Results

Bulk and surface properties of biochar were characterized by 1- and 2- dimensional (in time) solid state ^{13}C-NMR techniques. RAMP-CP-MAS-^{13}C-NMR was used to quantitatively and qualitatively assess the alteration of the carbon functional groups under different experimental conditions, while Dipolar Dephasing (DD)-CP-MAS-^{13}C-NMR was used to determine condensation and degree of oxidation within the biochar. Phosphorus levels and forms in biochar residue and leachates were characterized by ^{31}P-NMR.

Initial results show that biochar produced at higher temperatures and from grass and hardwood has greater aromaticity and fewer O-containing functional groups relative to softwoods. Biochar produced in the presence of oxygen have lower aromaticity but greater O-containing functional groups.

Geochemical portray of the Pacific ridge using statistical techniques

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Recent advances in analytical mass spectrometry techniques dramatically increases the number of isotopic data. Nowadays, the complete analysis of Sr, Nd, Pb, Hf and He isotopic compositions for a set of samples has become achievable. Working with such a multidimensional dataset implies a new approach in data interpretation, preferably based on statistical analysis techniques. Principal Component Analysis (PCA) is a powerful mathematical tool to study this type of multidimensional data set. The goal of PCA is to reduce the number of dimensions in a data set by keeping only those that contribute most to its variance.

Samples collected during the PACANTARCTIC 2 cruise fill a sampling gap from 53° to 41° S of the Pacific Antarctic Ridge (PAR). Sr, Nd, Pb, Hf and He isotopic compositions of this new mid-ocean ridge basalt collection are shown together with published data from 66°S to 53°S and from the EPR. Using the PCA tool, it becomes possible to get a statistical picture of the geochemical variations along the entire PAR, from the Australian Antarctic Discordance (AAD) to the Juan Fernandez microplate. Based on the incomplete sampling of the ridge a previous study led to the identification of a large scale division of the south Pacific mantle with a limit at the latitude of Easter Island [1]. The complete dataset reveals a different geochemical profile. Along the Pacific ridge, a large scale variation reaches an extremum which corresponds to a less 'depleted' isotopic signature at the Juan Fernandez microplate latitude. Hot spot-ridge interactions are marked by anomalies superimposed on this curve. The PCA method allows to interpret this large scale variation as a progressive geochemical change of the depleted matrix of the mantle. This variation is unrelated to the effect of the hot spot-ridge interactions.

[1] Vlastélic et al. (1999) Nature 399, 345-350.