

## UNVEILING THE TEMPERATURE AND FIRE INTENSITY OF WILDFIRE THROUGH NUCLEAR MAGNETIC RESONANCE AND STABLE ISOTOPE ANALYSIS

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### Introduction

Fire is considered one of the main disturbing factors of ecosystems at global scale. Causing physical and chemical changes on soil organic matter (SOM) (González-Pérez et al., 2004). One of the main consequences of burning is the formation of refractory material with a high degree of aromatization, black carbon (BC) (Hedges et al., 2000). The chemical composition of BC and the intensity of fire impacts on SOM depend strongly on fire conditions (De la Rosa et al., 2008). Therefore, fire intensity and duration may help to understand these processes. Nonetheless, *in situ*-determination is difficult.

Burning experiments under laboratory conditions and traditional analytical techniques have provided contradictory results with respect to the impact of temperature and time of heating. Therefore the present research studies the relations between temperature and fire duration (are you sure that this is the right word?) with the composition of the resulting fire-affected organic matter. To achieve this, litter samples were collected below well-developed oak-canopy (*Quercus suber*) in the Doñana National Park (SW Spain). Litter was air dried and heated at 250, 300 and 350 °C in a muffle furnace during two different time periods (5 and 15 minutes). Unburnt air-dried litter samples were used as control. After heating, litter samples were analysed using solid-state CPMAS <sup>13</sup>C-NMR spectroscopy and carbon isotope ratio mass spectrometry (C-IRMS).

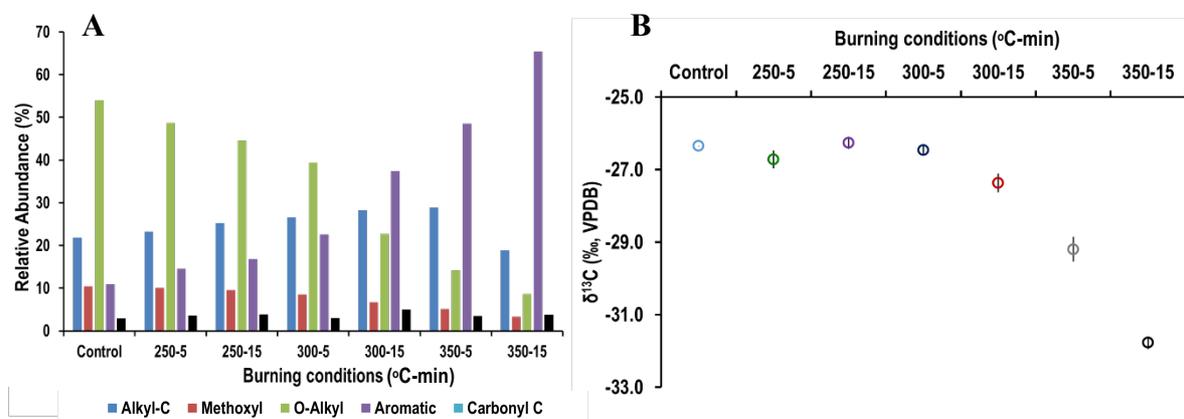
### Results

<sup>13</sup>C-NMR analyses (Fig. 1A) showed that both, increasing temperature and heating-time contributed to an increase of aromaticity (110-160 ppm) at expenses of O-Alkyl C compounds (60-110 ppm, carbohydrates) and methoxyl or N-alkyl C (45-60 ppm,). Litter samples heated at 350 °C during 15 minutes showed the highest aromaticity (65%). The increasing of aromaticity is related to cyclization and/or condensation processes of thermolabile-organic compounds (polysaccharides, peptides) (Almendros et al., 2003). On the other hand, lignin defunctionalization may also occur (Knicker, 2007).

The  $\delta^{13}\text{C}$  values (Fig. 1B) showed no significant differences among treatments below 300 °C and 15 minutes of heating compared to the control. Above this threshold, burnt samples showed a progressive <sup>13</sup>C-depletion, reaching a minimum value of -31.8 ‰ at 350 °C and 15 minutes of heating (5.4 ‰ lower than control). The <sup>13</sup>C-depletion may be explained by the combustion and preferential removal of isotopically heavy compounds (carbohydrate-like compounds) and the condensation of other biogenic compounds *i.e.* lignin charring resulting in compounds with higher aromatization degree (Bird and Ascough, 2012) or both processes.

## Conclusions

The highest aromatization was observed in samples heated at 350 °C during 15 minutes. It is also observed that biomass C isotopic composition changes when the proportion of aromatic C as seen by  $^{13}\text{C}$ -NMR exceeds the proportion of O-alkyl C. These results suggest that, in the case of medium-high temperature and duration wildfires, the combination of these techniques may be used as a proxy surrogated to temperature peaks and fire duration.



**Figure 1:** A) Different C forms as seen by the  $^{13}\text{C}$  NMR integration regions for fire-affected leaf samples; and B) Bulk carbon isotope composition of fire-affected leaf samples.

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