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Assessment of temperature peaks reached during a wildfire. An approach using X-ray diffraction and differential thermal analysis

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1. INTRODUCTION

Wildfires may induce important chemical and physical changes in soils, including changes in the soil composition, mineralogical changes, soil water repellency, aggregate stability or textural changes (Bodí et al., 2013; Granged et al., 2011a, 2011b, 2011c; Jordán et al., 2011, 2013; Mataix-Solera et al., 2011). As these changes usually occur after threshold temperature peaks, the assessment of these helps to explain many of the processes occurring during burning and in the postfire (Pereira et al., 2012, 2013; Shakesby, 2011).

In July 2011, a wildfire burnt a pine forested area (50 ha) in Gorga (Alicante, SW Spain), approximately at 38° 44.3' N and 0° 20.7' W. Main soil type is Lithic Xerorthent developed from limestone. The study of mineralogical changes in soil after a wildfire should help to assess fire temperature peaks reached during burning. In order to study the impact of fire temperature on mineralogical changes and determine temperature peaks during burning, burnt soil plots under shrubland were randomly collected (0-5 cm deep). Control samples from adjacent unburnt areas were also collected for control.

2. METHODS

Soil samples were ground using an agate mortar and then sieved (< 0.002mm) and analyzed by X-ray diffraction (XRD). XRD was conducted on a Bruker (model D8 advance A25) powder θ:θ diffractometer, which uses a Cu anticathode (40KV, 30mA), Ni filter in the diffracted bean and lineal detector. Powder samples were scanned from 3 to 70° 2θ, using a step size of 0.015° 2θ and a scan speed of 0.15° 2θ s^{-1}. Mineralogical phase identification and quantification of minerals was carried out with XPowder.

In order to study other possible reaction in burnt soil, unburnt soil samples were exposed to temperatures of 300, 500 and 700 °C in a Mufla furnace during 20 minutes. Unburnt control and treated samples were analyzed by differential thermal analysis (DTA) and thermogravimetric analysis (TG).

3. RESULTS

Diffractograms show that the blixita peak, found in the control sample, disappears in the diffractograms of burnt samples. Other significant peaks (calcite, quartz and microcline, for example) do not show significant changes between control and burnt samples. After semiquantitative analysis, the proportion of calcite increased in burnt soil samples (76.3%, on average) respect to control unburnt soil samples (62.3%). This increase may be explained by calcium carbonate released by ash after combustion of organic matter. Consequently, quartz proportion decreased in burnt samples (10.7%, on average) respect to control samples (26.1%).

After DTA analysis, a valley occurs between 400 and 700 °C in the control sample which is not present in 500 and 700 oC heated samples. This loss of energy is attributed to combustion of organic matter approximately between 400 and 500 °C, as well as thermal changes in iron oxides (which occurs approximately between 300 and 500 °C) and loss of structural water (>420 °C). In samples heated at 500 and 700 °C, these changes are not appreciated as they occurred during calcination. In the 300 °C heated sample, some of these changes partially occurred. Peaks observed approximately at 100 °C correspond to release of absorbed water. Peaks at 900 °C are a consequence of destruction of calcite. Finally a peak was observed at 680 °C in the control sample may be explained as a consequence of the destruction of blixite (Pb8(OH)2Cl4), which was present in control samples (1.1%) but not in burnt samples. This peak is probably masked in heated samples.

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