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Application of Spectroscopic Techniques (FT-IR, 13C NMR) to the analysis of humic substances in volcanic soils along an environmental gradient (Tenerife, Canary Islands, Spain)

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Andosols and andic soils are considered as efficient C-sinks in terms of C sequestration. These soils are usually developed from volcanic materials, and are characterized by a predominance of short-range ordered minerals like allophanes, imogolite and other Fe and Al oxyhydroxides. Such materials occur commonly associated with organic compounds, thus generating highly stable organo-mineral complexes and leading to the accumulation of a high amount of organic carbon. Spectroscopic methods like FT-IR and 13C NMR are suitable for the analysis of the chemical structure of soil humic substances, and allow identifying distinct functional groups and protein, lipids, lignin, carbohydrate-derived fragments.

In this work we study the structural features of four soils developed on Pleistocene basaltic lavae in Tenerife (Canary Island, Spain), distributed along an altitudinal climatic gradient. The soil sequence comprises soils with different degree of geochemical evolution and andic character, including a mineral 'Hypersalic Solonchak' (Tabaibal de Rasca), a slightly vitric 'Luvic Phaeozem' (Los Frailes), a degraded and shallow 'Endoleptic, fulvic, silandic Andosol' (Siete Lomas), and a well-developed and deep 'Fulvic, silandic, Andosol' (Ravelo). Samples of the raw soil and humic and fulvic acids isolated from the surface horizons were analyzed.

The results show a low content of organic carbon in the mineral soil, the inherited humin predominating, and a very high content of humic and fulvic acids in Andosols.

The FT-IR and 13C NMR spectra of the raw soil samples show a low resolution, related to interferences from mineral complexes signals, particularly in soils with lower organic carbon content. 13C NMR shows a predominance of O-alkyl carbon (derived of carbohydrates) in andic soils, whereas O-alkyl and aromatic fractions are most evident in the mineral soil.

The humic acids spectra are characterized by a dominance of alkyl and aromatic fractions with a high degree of maturity, and a minor presence of O-alkyl and carbonyl carbon. The humic acids of the mineral soil are rich in lignin fragments, whereas those of the andic soils are more aromatic and have a higher degree of oxidation. O-alkyl carbon dominates in fulvic acids, exhibiting an enrichment in aromatic compounds and a lower oxidation degree in the mineral soil.

These results point to a poorly-transformed organic matter resulting from direct humification processes, in the non-andic soil. On the other hand, the humic substances in the andic soils show a high degree of maturity, with a low presence of lignin fragments and a higher oxidation degree.