

Resistant macromolecular material in soil organic matter: origin, chemical structure and dynamic of this new pool of C

N. Augris
A. Mariotti

UMR UMPC - INRA - CNRS 162, 4 place Jussieu, cc 120, 75252
Paris cedex 05, France

J. Balesdent

Laboratoire d'Ecologie Microbienne de la Rhizosphère, DEVM -
CEA - Centre de Cadarache, 13108 Saint-Paul-lez-Durance,
France

C. Largeau
S. Derenne

UMR CNRS 7573 ENSCP, 11 rue P. et M. Curie, 75231 Paris
cedex 05, France

Organic matter in soil is the most important surficial pool of carbon on continents. This soil organic carbon reservoir is now included in the global carbon cycle for modelling the past, present and future evolution of atmospheric CO₂. When carbon dynamics is considered, three different pools can be distinguished (Balesdent *et al.*, 1988). The first one is characterized by a rapid turnover (less than a few years), the second one by a relatively low turnover (decades) and the oldest carbon found in soil appears to be millenary. CO₂ fluxes continually occur through the soil-plant-atmosphere continuum thus leading to an equilibrium. The latter can be disturbed by any change in one condition, and significant CO₂ fluxes can be generated between soil and the atmosphere if the balance between the different carbon pools are modified. As a result, it is especially important to understand the processes which are implicated in OM preservation in soils, which can acts as a sink for atmospheric CO₂. Physical protection processes are usually considered (Oades, 1995). However recent studies, on a new family of biomacromolecules, lead to hypothesize that intrinsic resistance of some organic constituents might also be an important process. Indeed, insoluble and non-hydrolysable biomacromolecules (cutans, suberans) were discovered in protective layers of higher plants. These compounds (de Leeuw and Largeau, 1993) are characterized by an unusually high resistance to hydrolyses and microbial degradation and exhibit a highly aliphatic character; they are known to survive, unaffected, fossilization after deposition in aquatic environments. However their ability to survive in soils had not been considered so far.

Preliminary study

We previously tested the occurrence of resistant biomacromolecules in an organic-rich soil from Lacadée, South West of France (Augris *et al.*, 1998). To this end, the <10 µm fraction from this acid, loamy, forest soil was separated so as to exclude fresh organic debris and most of the OM with a rapid turnover. This fraction was submitted to the classical treatments used to obtain humin, the insoluble part of humic substances. Then, a protocole adapted from the one used to isolate biomacromolecules from higher plant was applied to this humin. The chemically resistant organic residue (ROR) thus obtained accounts for 5% of the total C of soil. Examination by spectroscopic (FTIR and solid state ¹³C NMR) and pyrolytic methods indicated that the ROR comprises two different types of moieties. The first one corresponds to melanoidin-like macromolecules derived from random condensation occurring in soils and the second and less abundant consists in highly aliphatic macromolecules likely inherited from higher plants.

Present study

The occurrence and the main chemical features of this ROR being established, it was important to determine the turnover and age of this new pool of C in soil. The forest soil used to test the presence of resistant macromolecular material, belongs to a batch of several adjacent plots, that were successively converted to continuous intense maize cropping. We selected a second plot which has been cultivated for 35 years and isolated the chemically resistant residue

from this crop soil and compared it with the ROR from the forest soil. Maize input to this residue was assessed from bulk, stable carbon isotope composition. Indeed, forest vegetation (C3-type photosynthetic pattern) and maize (C4-type) are characterized by different $\delta^{13}\text{C}$ values (-26 and -12% , respectively). Such differences are also noted in the corresponding soils. The ROR is heterogeneous, as shown above by its chemical composition. As a result, the turnover rates (input of maize-derived products to the ROR fraction of the crop soil; degradation of the ROR constituents present in the forest soil before conversion to maize cropping) derived from bulk carbon isotope composition only reflects an average value. So as to specify the turnover rates of the aliphatic part of the ROR, the individual $\delta^{13}\text{C}$ values of the *n*-alkanes and *n*-alk-1-

enes from the pyrolysate were measured by GC/irMS. ^{14}C isotope datations are also under progress to determine to which pool of soil carbon, the chemically resistant material belongs.

References

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