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THE $\delta^{13}C$ OF SOIL ORGANIC CARBON AS INDICATOR OF ECOSYSTEM CHANGES AND OF THE ORGANIC MATTER TURNOVER

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The carbon isotope composition of plants is known to vary with the type of photosynthetic cycle. As a general rule, trees and crops of the temperate and cold regions, using C_3 photosynthesis have a lesser ^{13}C incorporation than plants with a C_4 photosynthetic cycle. These latter plants are essentially gramineae of the tropical regions, even those, as Corn (Zea mays), cropped in temperate regions. C_3 type plants have a $\delta^{13}C$ varying between -25 to -28 ‰ (vs. PDB), whereas in C_4 - type plants, the values varies between -13 to -15 ‰ (figure 1).

As soil organic matter has a carbon isotopic composition comparable to that of the parent plant material from which it is formed, it can be assumed that every change in vegetation between C_3 - and C_4 - types will lead to a similar change in the ^{13}C value of the soil organic matter.

Using the assumption it is possible to identify the type of the past parent vegetation which gave rise to organic matter present in soil, and to study the organic matter turnover in soil cultivated intensively with C_4 type plants following long term C_3 type crops. Examples are given.

In intertropical area, $\delta^{13}C$ measurements of organic matter are used to verify hypotheses on vegetational changes.

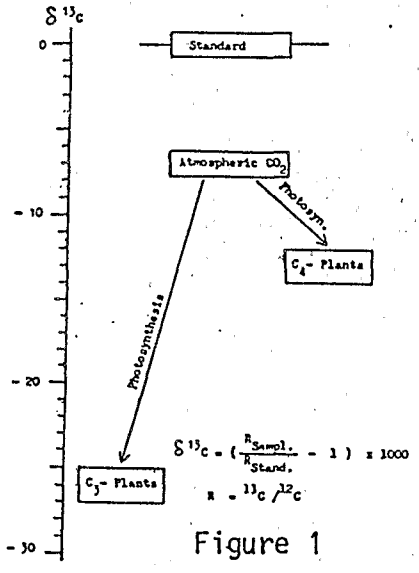


Figure 1

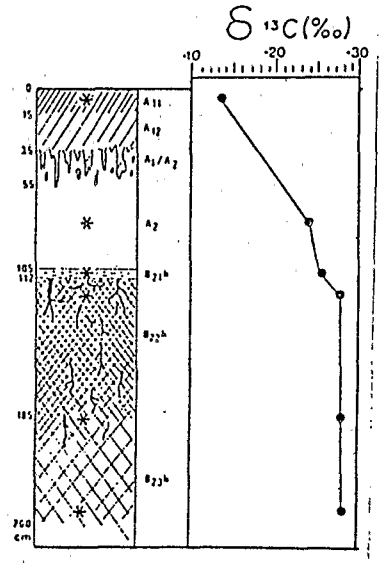


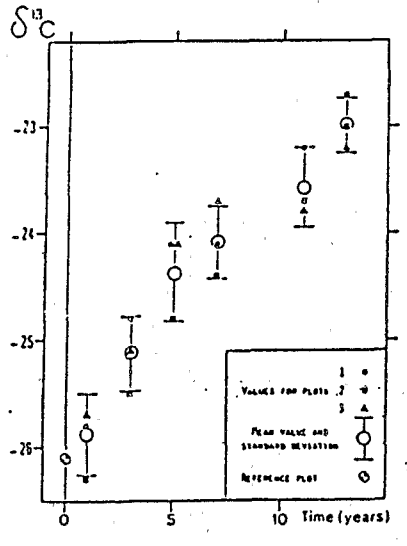
Figure 2

In the Popular Republic of Congo, soils of the Batéké sands have A_1 horizon organic matters which give $^{13}C/^{12}C$ ratios similar to those found in the present savanna vegetation. In forest ecosystem, ratios are typical of C_3 plants ($\delta^{13}C$ = -26.6 to -28.8 ‰) whereas those of savannas indicate C_4 plant origin. Moreover, the $\delta^{13}C$ of horizons of a giant-podzol (figure 2) show that the present grass vegetation does not take part in the podzolization process. The $\delta^{13}C$ of the organic matter in the spodic Bh horizon (-27.5 ‰) demonstrates that such humic enrichment occurred under forest vegetation, dated of 30 000 Yrs at least.

The Guasca valley, near the Sabana of Bogota in the Colombian eastern cordillera, is an open landscape, which was considered as the result of human forest degradation. The soils are distributed as a function of altitude : planosols occur in lowest and dryest zones of the valley whereas ferrisols and andosols occur at higher altitude. By $^{13}C/^{12}C$ ratios of the soil organic matter, it was shown that in no part of the valley, a pure andean forest had developped. For example, the organic matter of planosols and ferrisols, ^{14}C dated of 10000 yrs and less, has $\delta^{13}C$ varying from -20 to -17 ‰. These high values do not confirm forest conditions but rather the existence of open vegetation formed by a mixture of C_3 plants (herbs, shrubs and some trees) and of tropical grasses with C_4 photosynthesis pathway.

In temperate regions, a method for measuring the long - and medium - term turnover of soil organic matter can be deduced from repeated crops of Corn ($\delta^{13}C$ = -13 ‰) on a soil which has never carried such plant. By turning vegetation from C_3 type into C_4 type, changing the ^{13}C content of the organic inputs to the soil is equivalent to a true labelling in situ of the organic matter.

Two cases of continuous corn cultivation on soils whose organic matter had initial average $\delta^{13}C$ of -26 ‰ were studied. The quantity of organic carbon originating from corn, that is the quantity which had turned-over since the beginning of the continuous cultivation was estimated using the ^{13}C natural abundance date. After 13 yrs of continuous cultivation, the organic matter $\delta^{13}C$ is found egual to -23 ‰ (figure 3), that corresponds to 22 % of total organic carbon which had turned-over.



← Figure 3

Particle size (µm)	C in % of soil C	C/N	x (%)
Level 0-30 cm			
Litter	-	-	-
200-2000	10	23	61
50-200	17	14	31
20-50	3	15	17
2-20	37	16	12
0.3-2	29	10.5	18
0-0.3	4	8.5	26

x = percent of organic C derived from corn

* forest soil

o corn cultivated soil

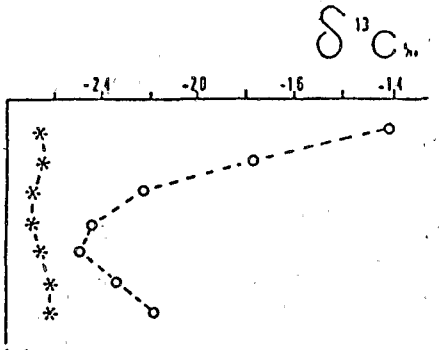


Figure 4

Particle size fractionations show that fractions coarser than 50 µm and smaller than 0.2 contain the youngest organic matter (figure 4). The turnover rate of the silt fraction was the lowest.