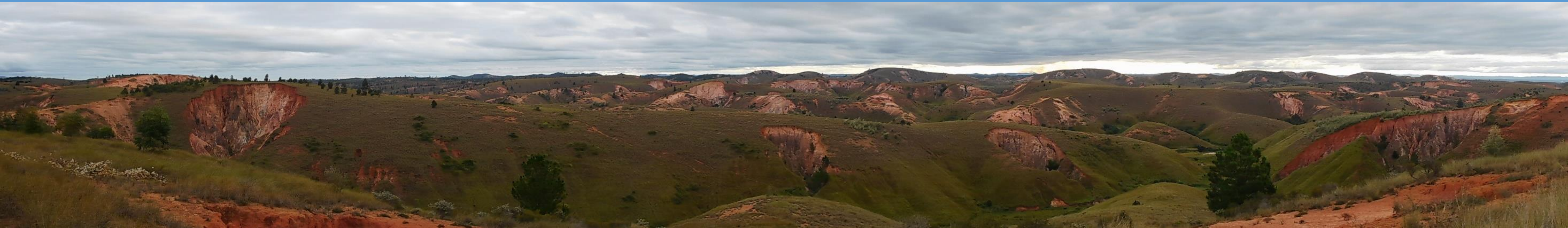
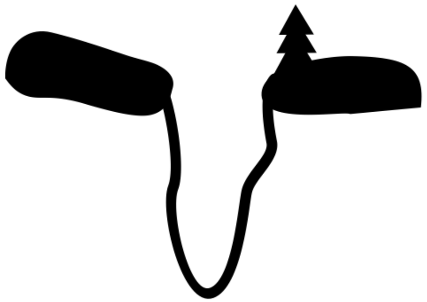
Sediment mobilisation in Lake Alaotra catchment, Madagascar

Vao Fenotiana Razanamahandry, Liesa Brosens, Marjolein Dewaele, Benjamin Campforts, Liesbet Jacobs, Tantely Razafimbelo, Tovonarivo Rafolisy, Nils Broothaerts, Gert Verstraeten, Gerard Govers, Steven Bouillon.
KU Leuven, Leuven, Belgium/University of Antananarivo, Antananarivo, Madagascar.

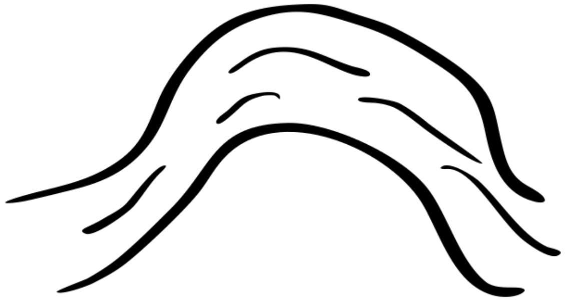


Project MaLESA

1.Initiation of Lavaka

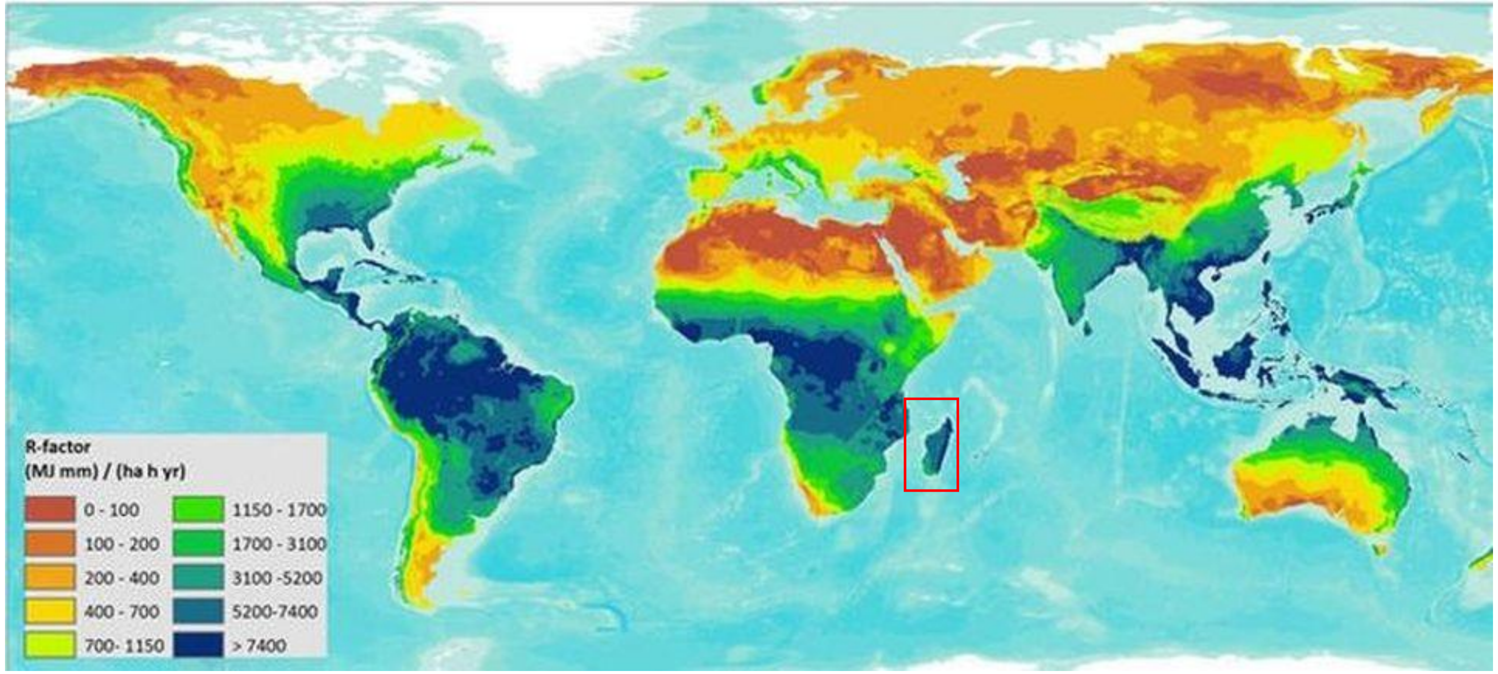


2.Carbon and Sediment transport



3.Sedimentary archives and Environmental reconstruction

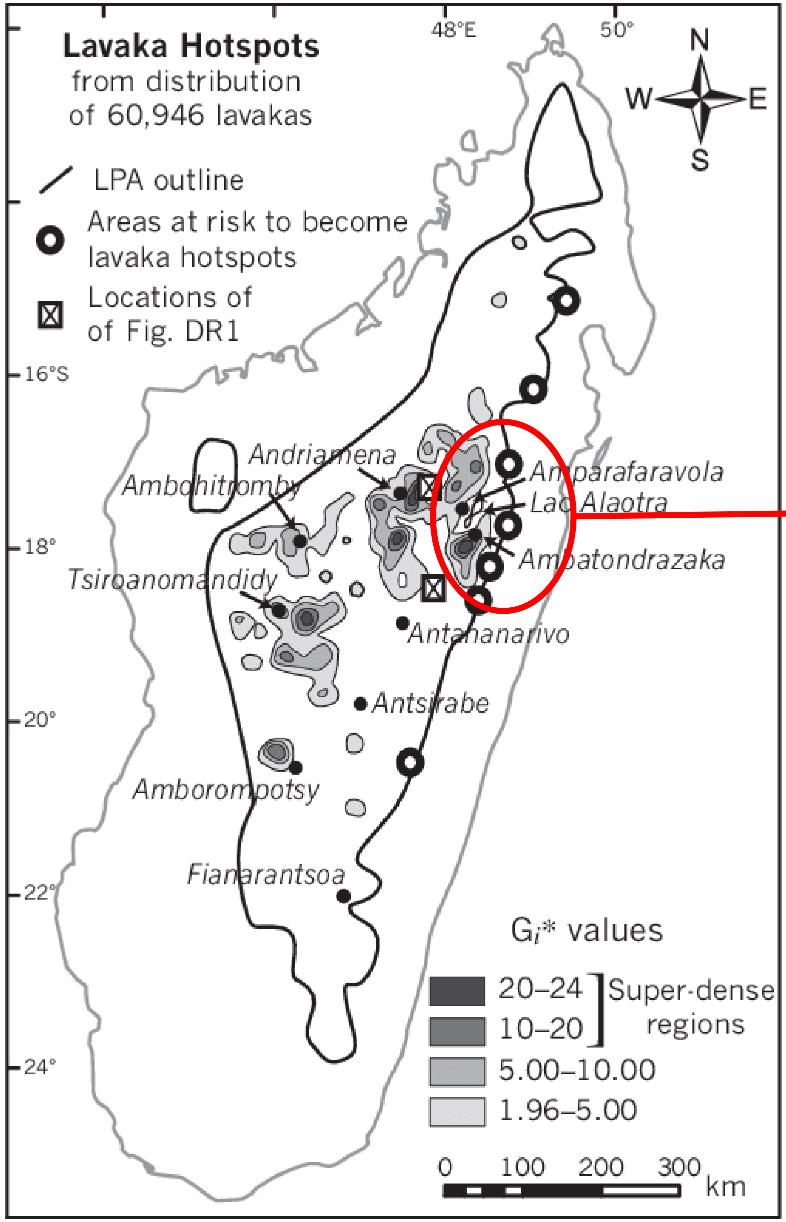
High erosion rate in Madagascar: human driven?



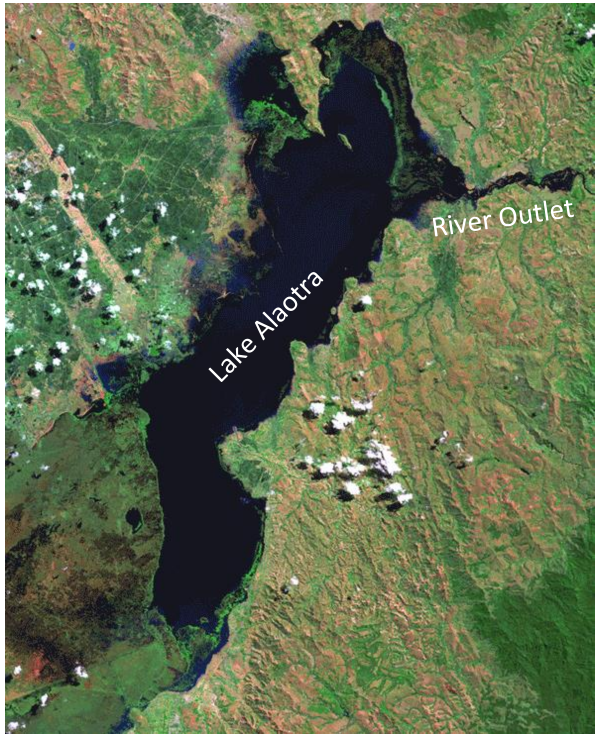
Global Rainfall Erosivity Map (Source: European Soil Data Centre, 2017)

LAVAKA (Malagasy word) = “gullies”, is a part of erosion features that occurs in many regions of Madagascar

Lavaka-prone regions in Madagascar



Lake Alaotra: largest lake in Madagascar



Source:
The Geological Society of America, 2010

APPROACHES

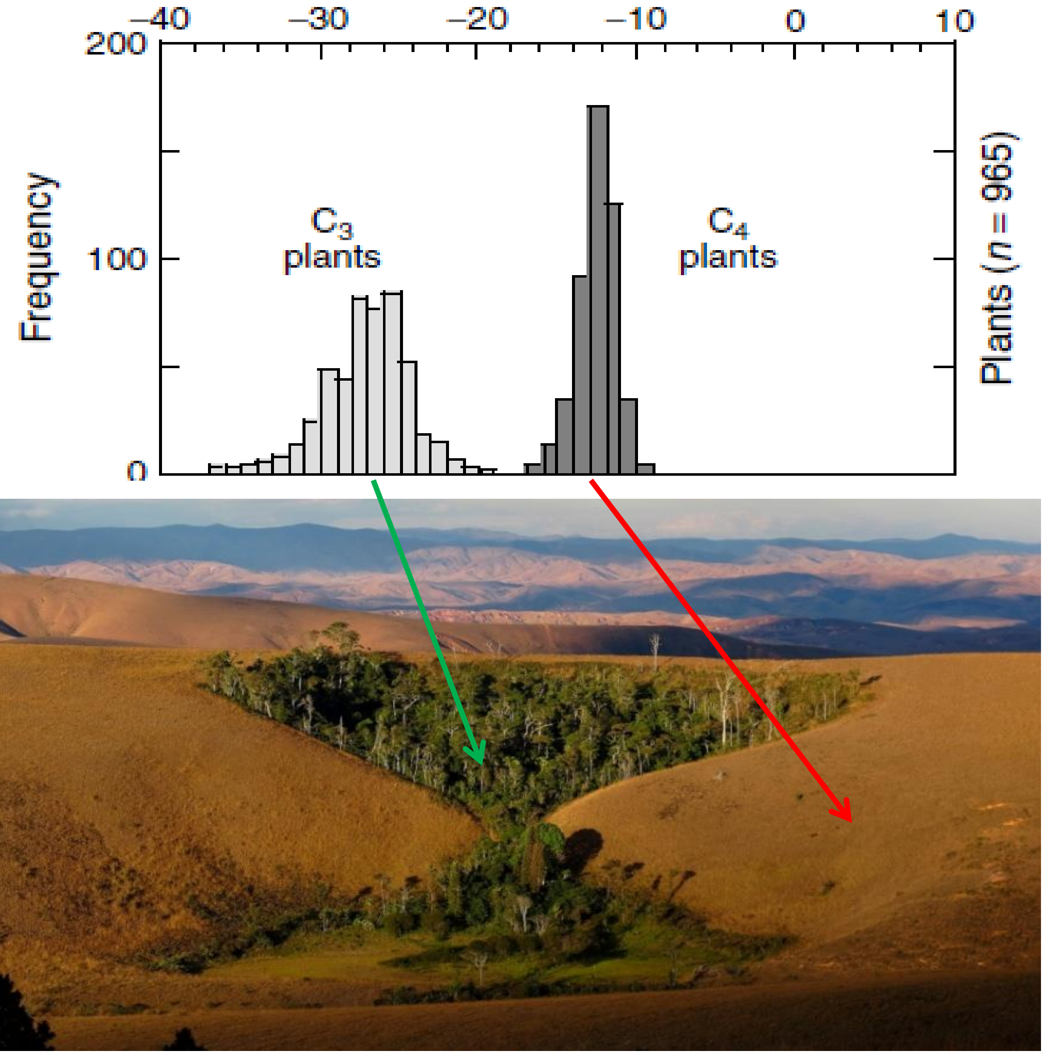
Tracing sediment and organic carbon transfer in lake Alaotra region sources, mobilisation and deposition.

Proxies: Organic carbon (OC) content and $\delta^{13}C$ of OC

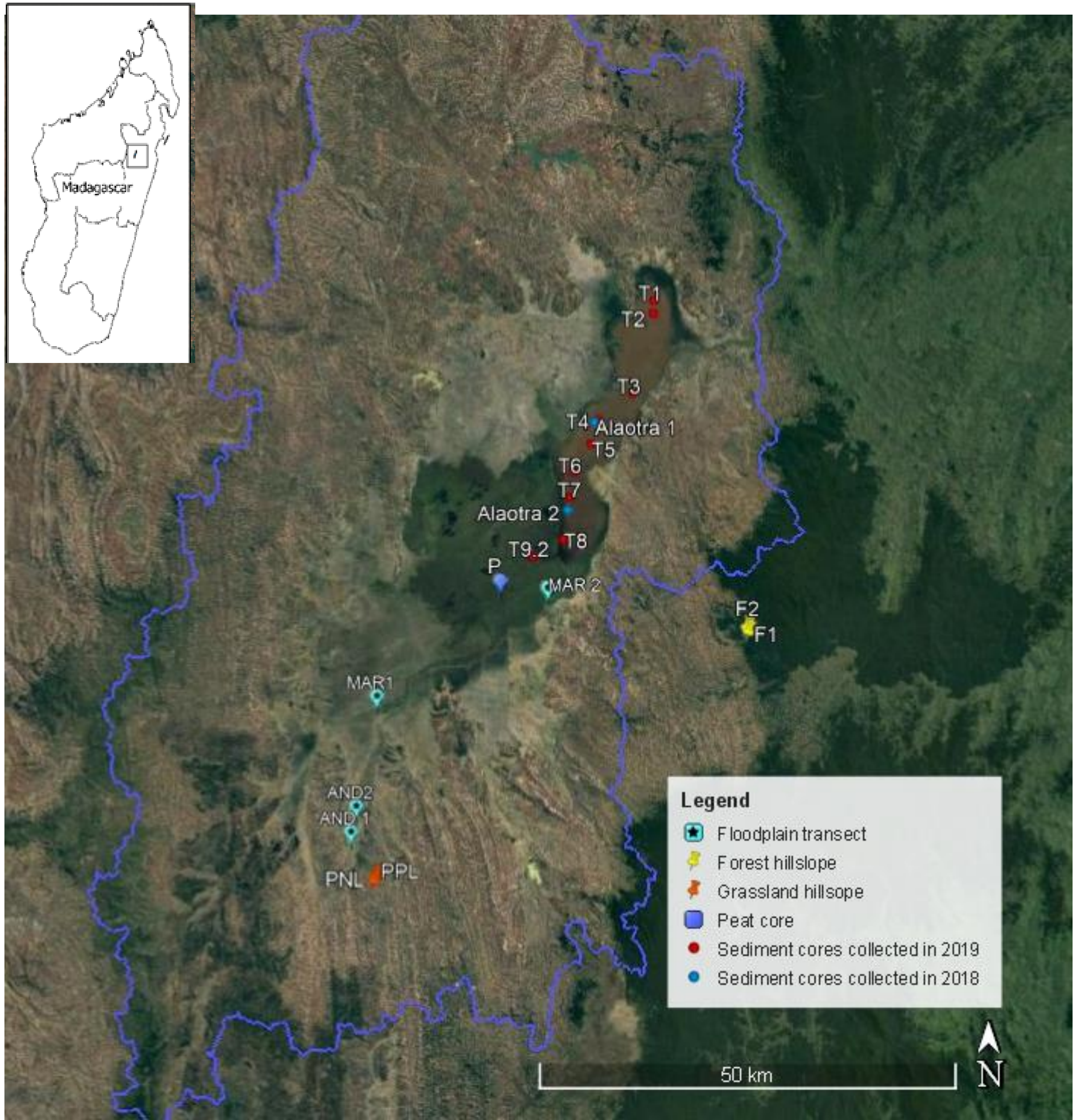
APPROACHES

Organic carbon fluxes and $\delta^{13}C$ of plants and soils:

Isotope fractionation of Soil organic carbon gives an information about past vegetation above ground



Study area: Lake Alaotra catchment and sampling points



- soil profiles (grassland and forest hillslopes)
- lake sediment cores
- marshes core
- floodplain cores
- riverine and lacustrine water sampling (regular sampling)

RESULTS

Grassland soil : OC content extremely low and decreases with depth

Forest soil profiles: OC% decreases with depth, OC % forest soil > OC % of grassland (OC stock of forest is two times higher)

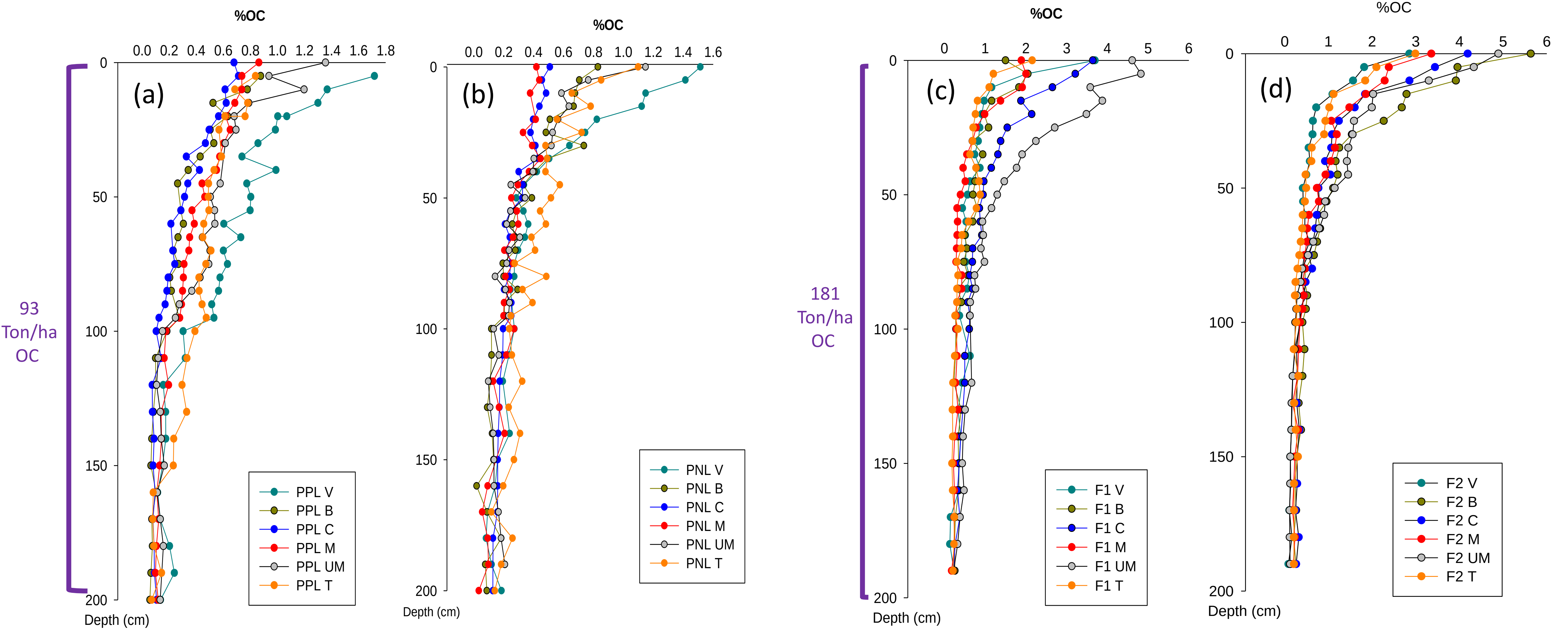


Figure 1 : Organic carbon content of soil profiles : 2 grassland profiles (a and b) and 2 forest soil profiles (c and d)

RESULTS

$\delta^{13}C$ of Grassland soil profiles decreases with depth and is between C_3 and C_4 signature

$\delta^{13}C$ of Forest soil profiles increases with depth and is consistent with long-term C_3 cover

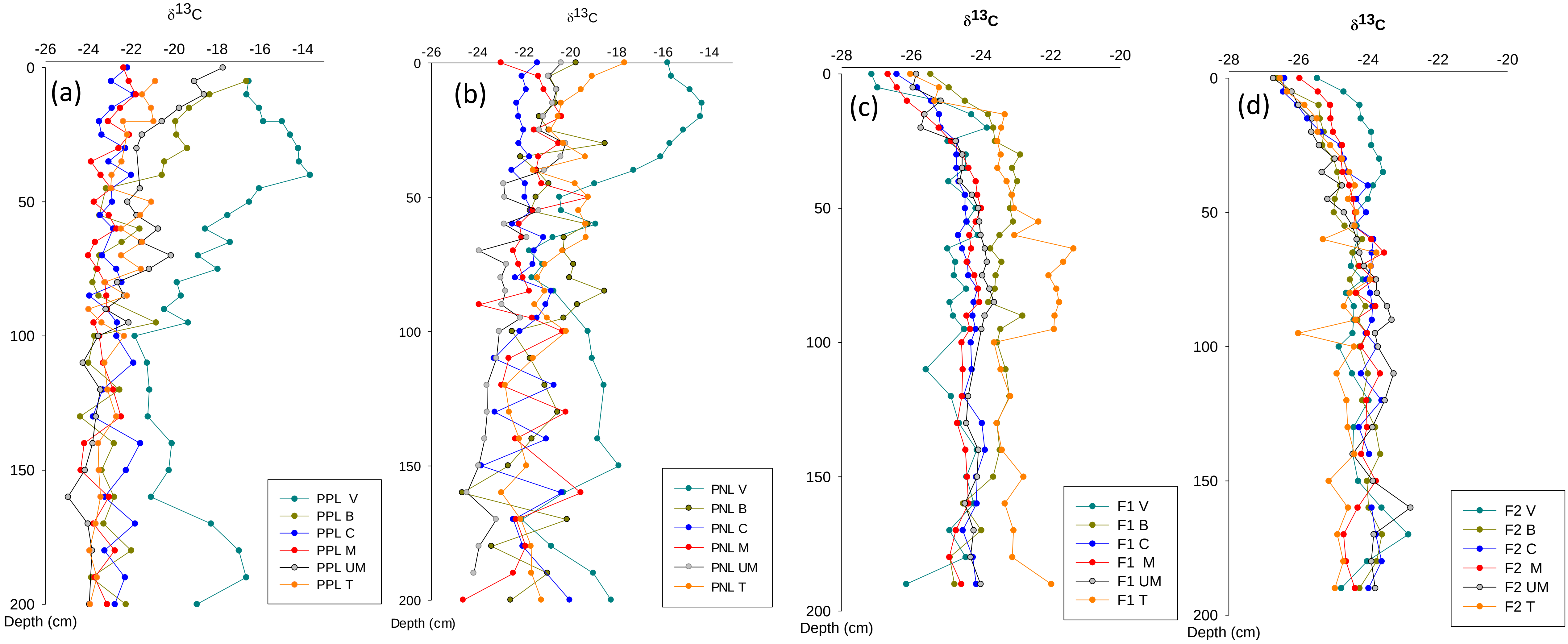
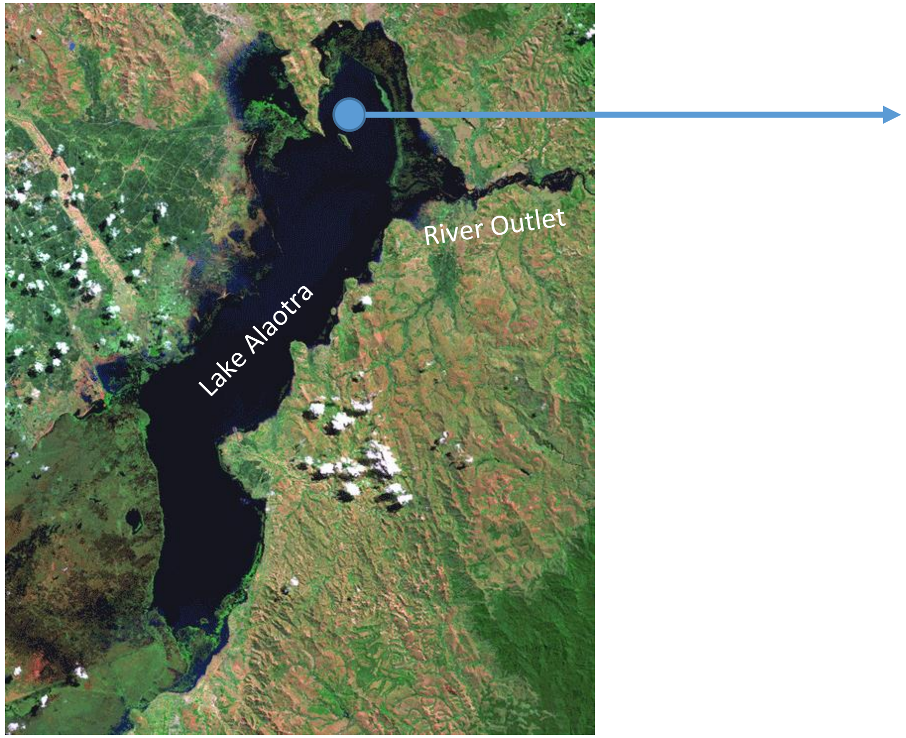


Figure 2 : $\delta^{13}C$ of Organic carbon of soil profiles : 2 grassland soil profiles (a and b) and 2 forest soil profiles (c and d)

RESULTS

OC of lake sediment core “T2” higher than soil OC and $\delta^{13}C$ ranges between -20 to -14 ‰



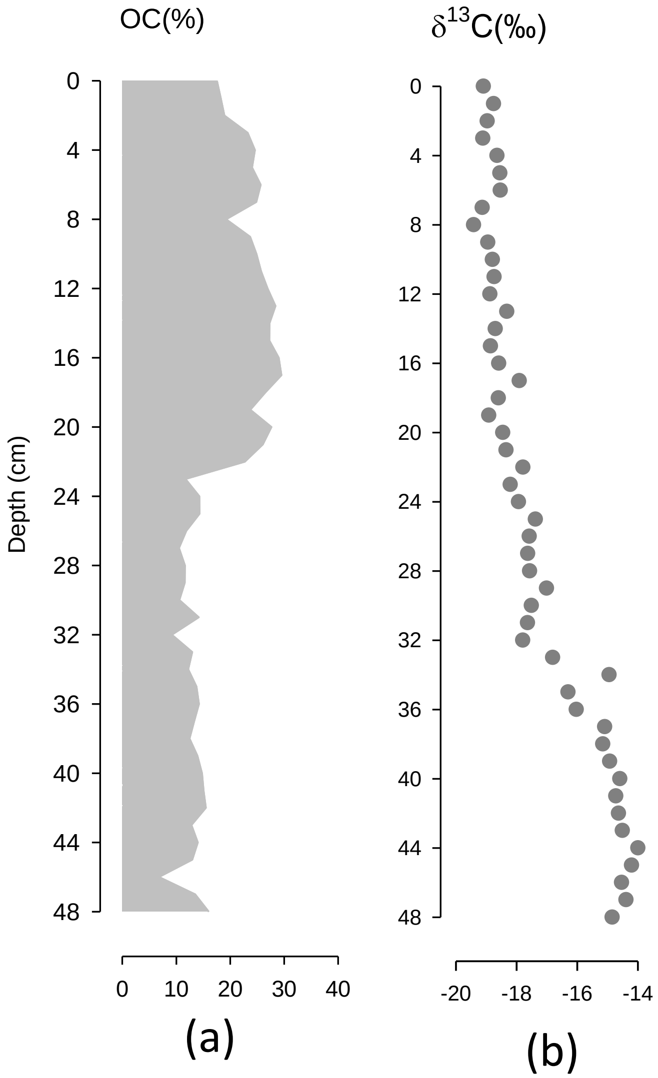


Figure 3: Characteristics of organic carbon of lake sediment core in the south of the lake “T2”
(a) Organic carbon content plotted against core depth,
(b) $\delta^{13}C$ of organic carbon plotted against core depth.

RESULTS

OC of lake sediment core “Alaotra 1” are higher than soil and $\delta^{13}C$ ranges between -22 to -14 ‰

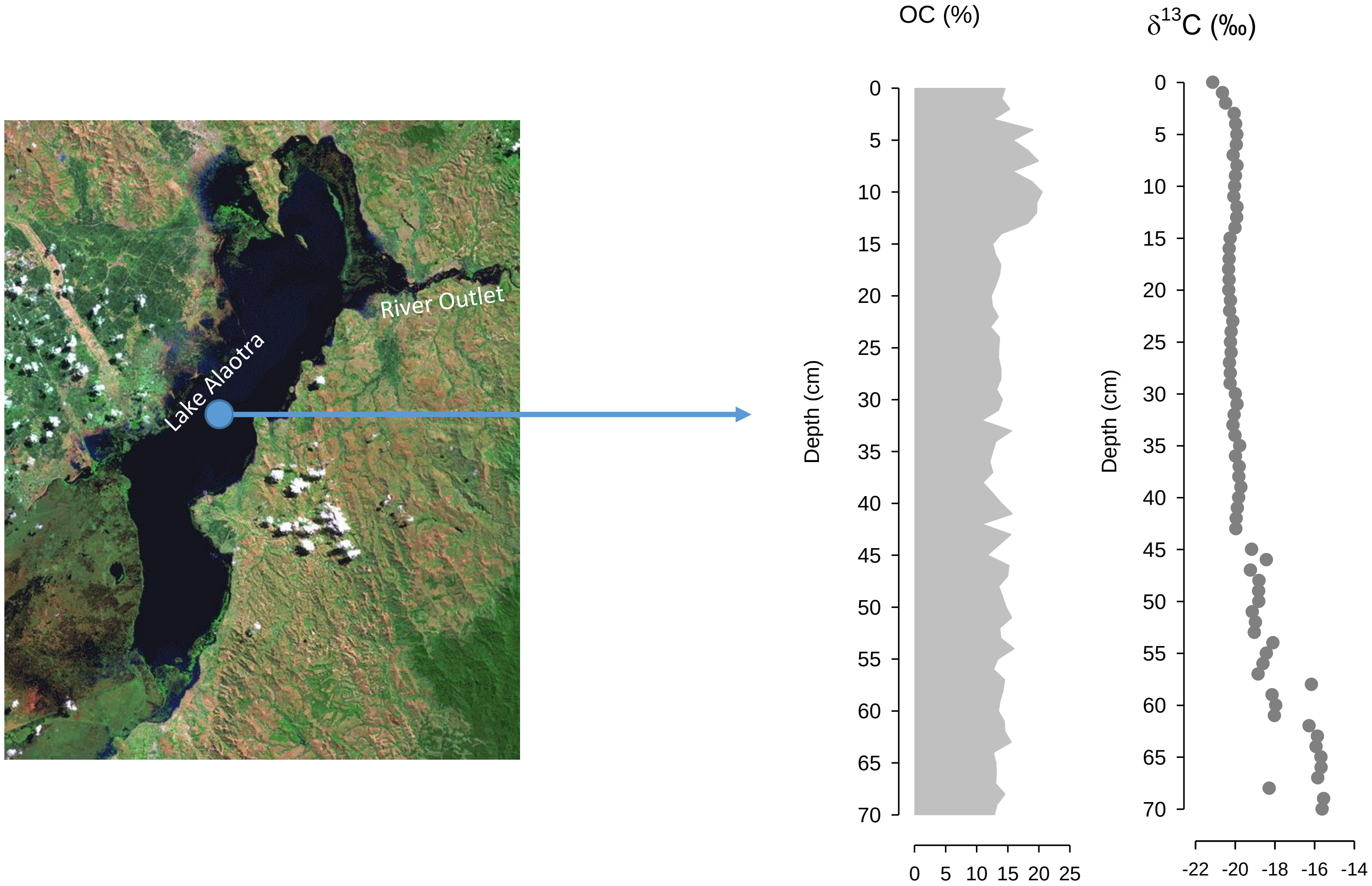
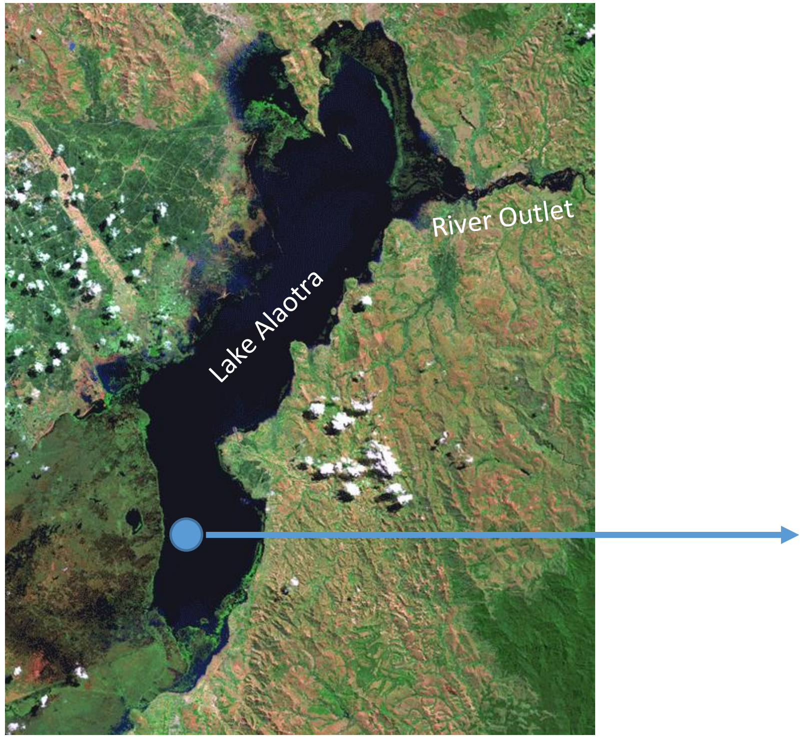


Figure 4: Characteristics of organic carbon of lake sediment core in the south of the lake “Alaotra 1”
(a) Organic carbon content plotted against core depth,
(b) $\delta^{13}C$ of organic carbon plotted against core depth.

RESULTS

OC of lake sediment core "Alaotra 2" are higher than soil and $\delta^{13}C$ ranges between -22 to -14 ‰



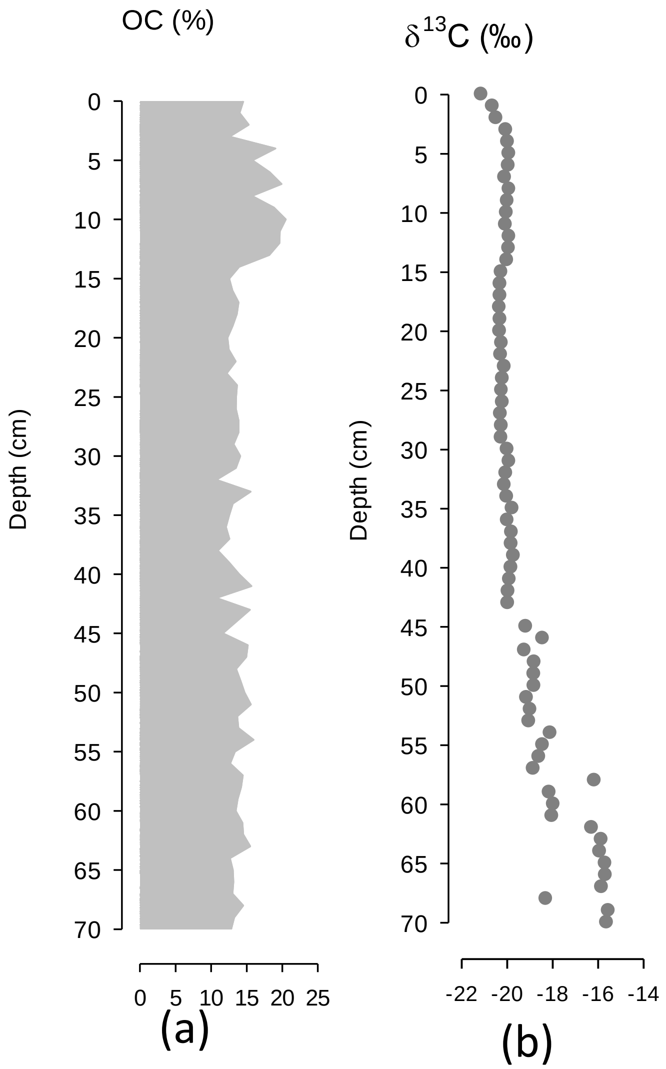


Figure 5: Characteristics of organic carbon of lake sediment core in the south of the lake "Alaotra 2"
(a) Organic carbon content plotted against core depth,
(b) $\delta^{13}C$ of organic carbon plotted against core depth.

RESULTS

3 potential sources of OC in lake sediment core of Lake Alaotra

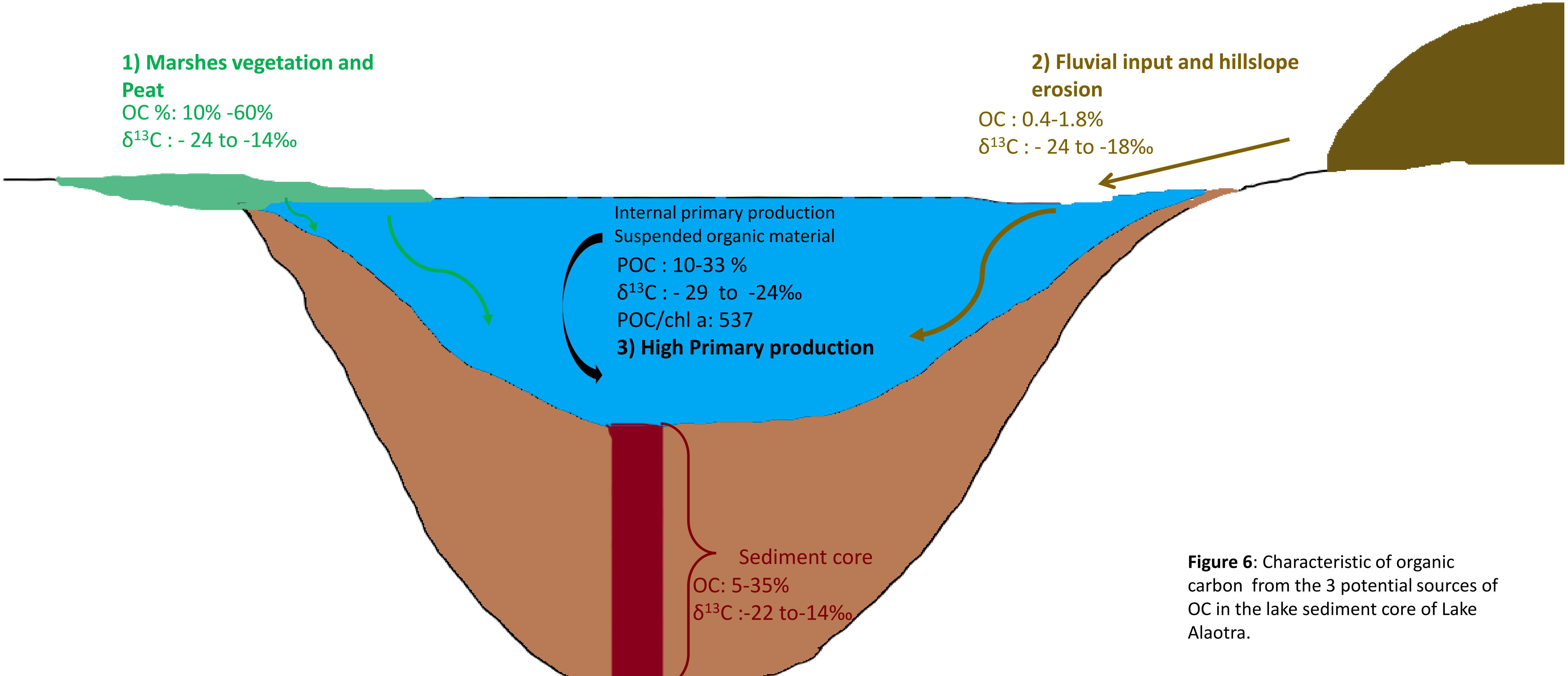


Figure 6: Characteristic of organic carbon from the 3 potential sources of OC in the lake sediment core of Lake Alaotra.

Application of isotopic mixing model (MixSIAR) on Lake Sediment core "T2"
Marshes are the primary sources of organic carbon

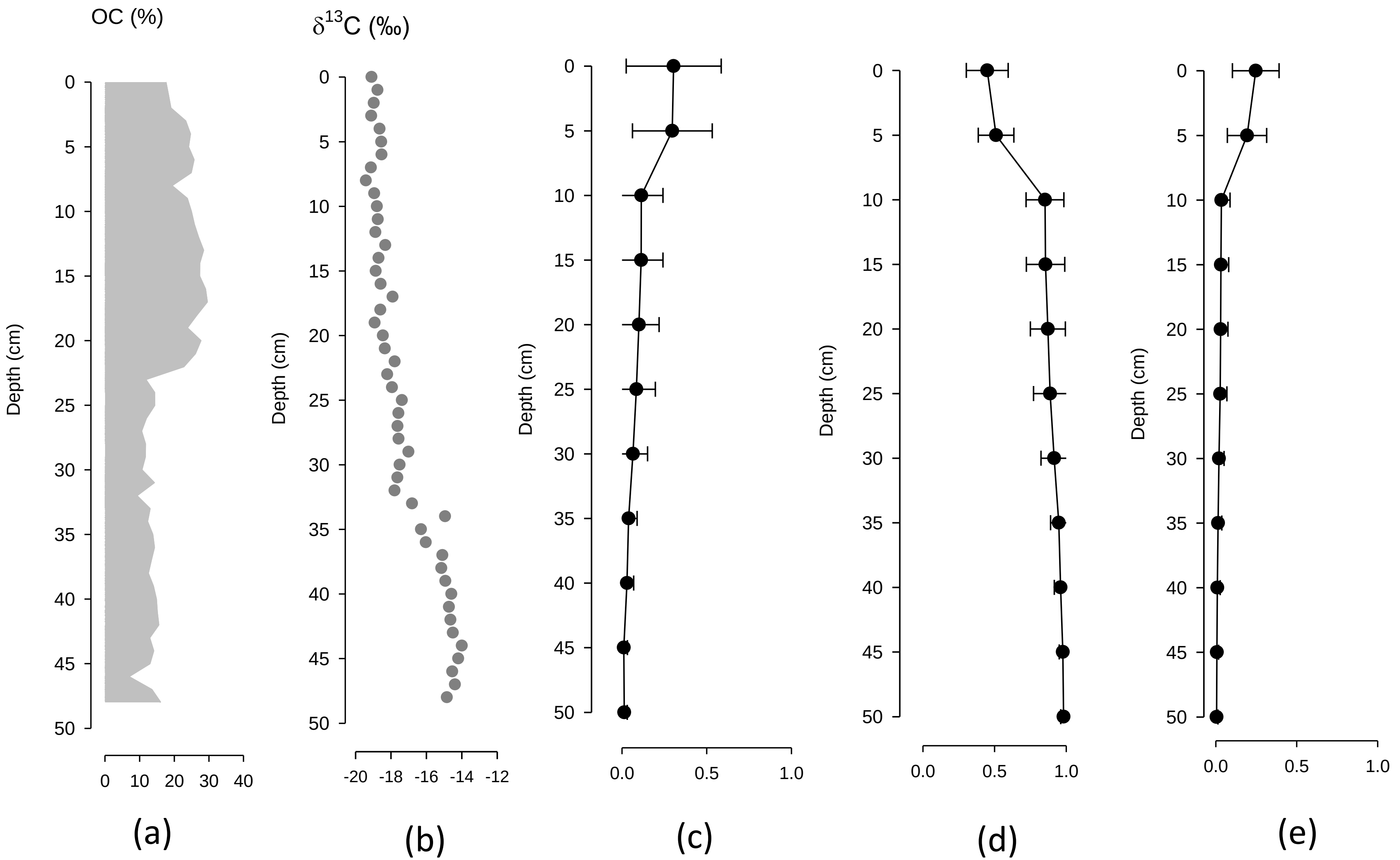


Figure 7: Estimated proportion of organic carbon from potential sources in lake sediment core "T2" by using δ^{13}C of organic carbon**,**

(a) Organic carbon content plotted against core depth and age (cal a BP),
(b) δ^{13}C plotted against core depth,
(c) Proportion of Soil-derived organic carbon plotted against core depth,
(d) Proportion of Marshes-derived organic carbon plotted against core depth,
(e) Proportion of internal primary production-derived organic carbon in lake sediment core plotted against core depth.

Application of isotopic mixing model (MixSIAR) on lake sediment core “Alaotra 1”
Marshes are the primary sources of organic carbon

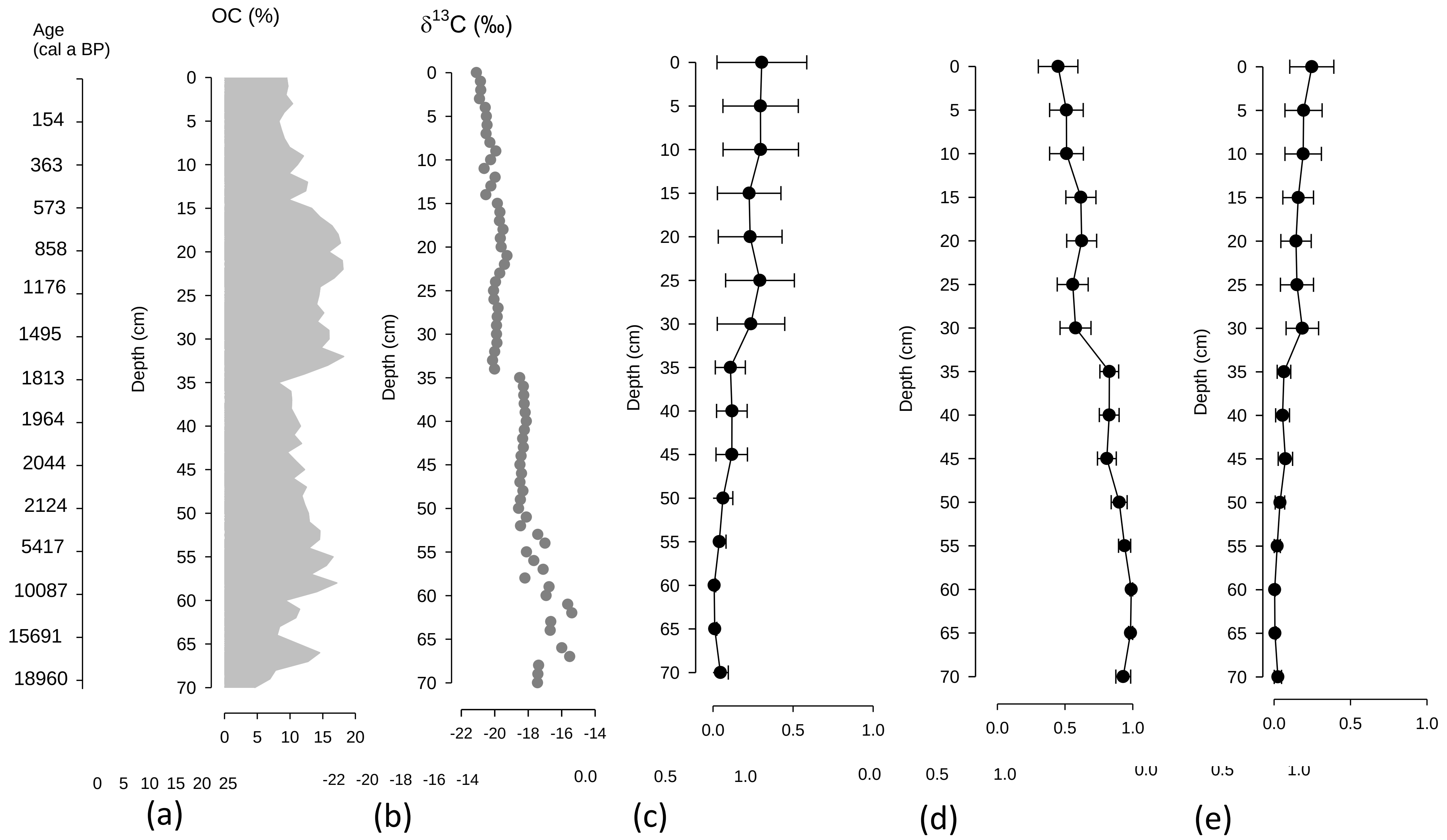


Figure 8: Estimated proportion of organic carbon from potential sources in lake sediment core by “Alaotra 1 ” by using $\delta^{13}C$ of organic carbon,

(a) Organic carbon content plotted against core depth,

(b) $\delta^{13}C$ plotted against core depth

(c) Proportion of Soil-derived, organic carbon plotted against core depth,

(d) Proportion of Marshes-derived organic carbon plotted against core depth,

(e) Proportion of internal primary production-derived organic carbon in lake sediment core plotted against core depth.

Application of isotopic mixing model (MixSIAR) on lake sediment core "Alaotra2"
Marshes are the primary sources of organic carbon

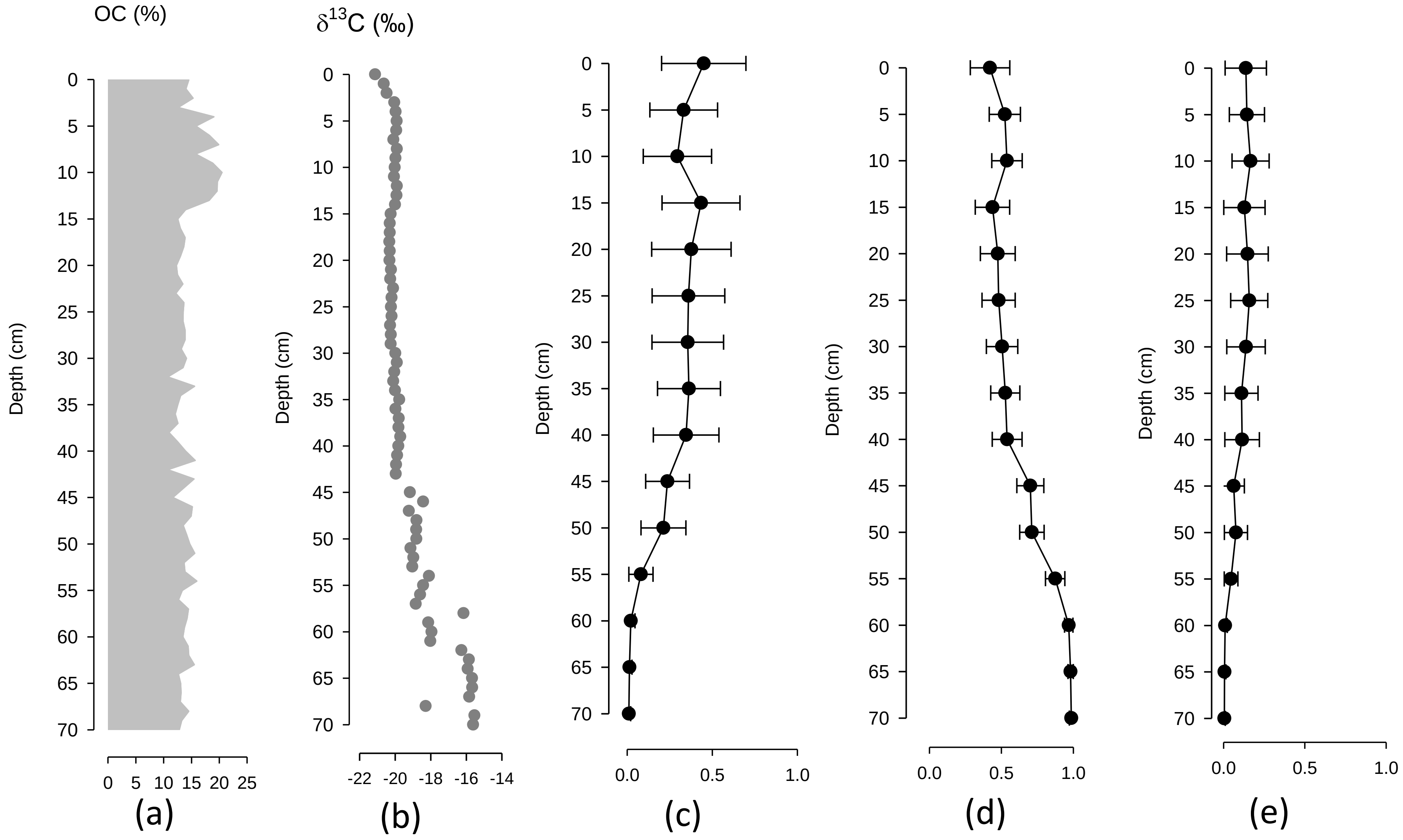


Figure 9: Estimated proportion of organic carbon from potential sources in lake sediment core "Alaotra 2 " by using $\delta^{13}C$ of organic carbon,
(a) Organic carbon content plotted against core depth,
(b) $\delta^{13}C$ plotted against core depth,
(c) Proportion of Soil-derived organic carbon plotted against core depth,
(d) Proportion of Marshes-derived organic carbon plotted against core depth,
(e) Proportion of internal primary production-derived organic carbon in lake sediment core plotted against core depth.

Floodplain are likely a key sink of soil-derived sediment

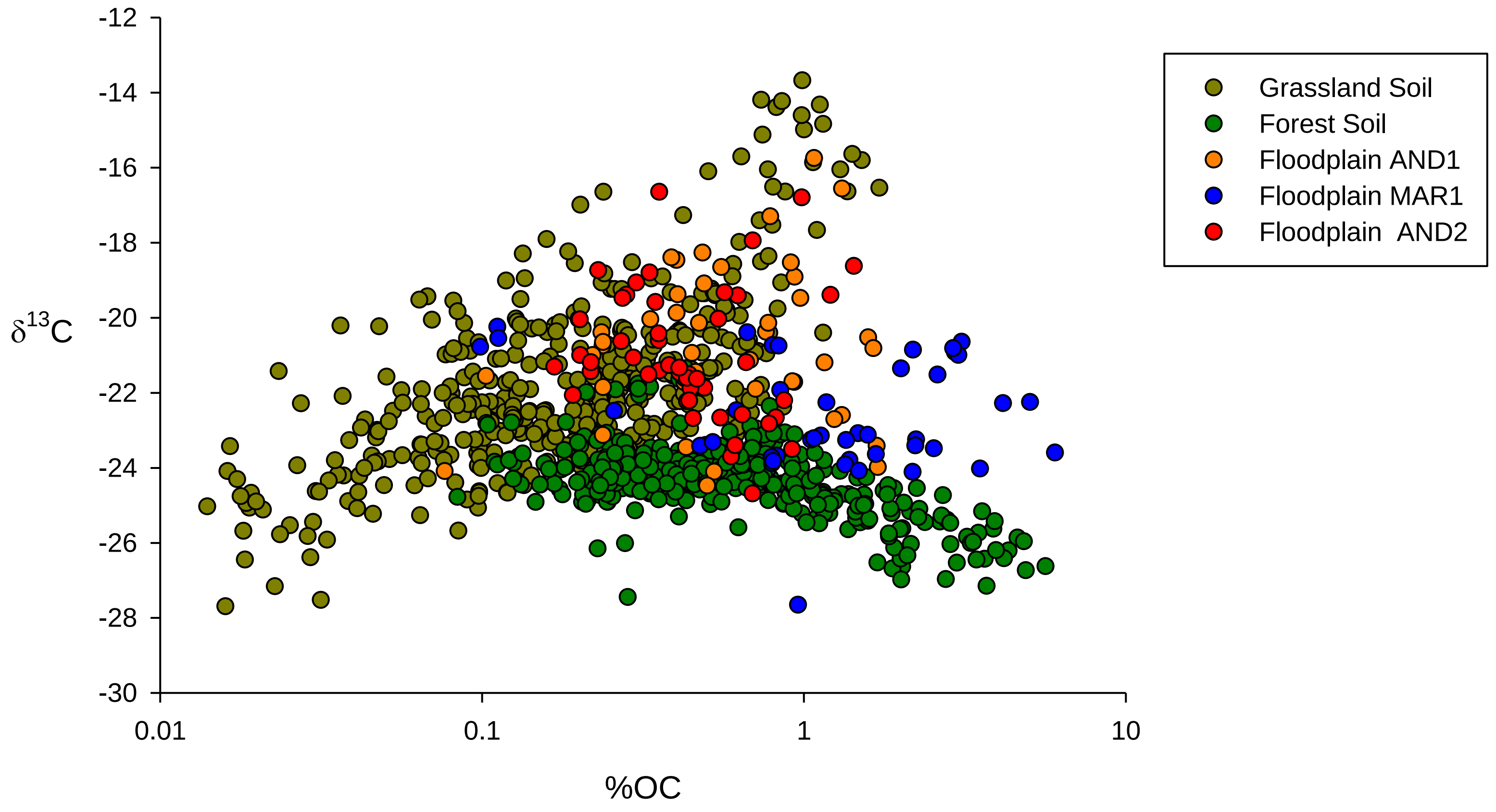


Figure 10: $\delta^{13}C$ plotted against organic carbon content of grassland and forest soil profiles and floodplain cores.

CONCLUSIONS

- Soil in the grassland and forest hillslope has a lower OC content (0-2% for grassland soil)
- $\delta^{13}C$ of Grassland soil profiles: indicates a shift of C3 to C4 vegetation
- Lake sediment core has a high organic carbon content.
- Majority of lake sediment OC is not soil-derived, but originates from surrounding marshes.
- Floodplains are likely a key sink for soil-derived sediments.

$\delta^{13}C$ and OC tracers

➢ give an information on environmental change : carbon content change and marshes vegetation,

➢ not Insufficient to understand the entire sediment and carbon transfer in the Malagasy landscape

Consider another proxies : pollen or charcoal in lake sediment core .