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A la mujer que más admiro, y sin la cual ninguno de mis logros hubiera sido posible, mi tía. Y a las montañas que siempre me han hecho soñar y encontrar paz.

RESUMEN

Las turberas juegan un papel esencial en el almacenamiento global de carbono. Sin embargo, aún queda mucho por descubrir sobre las turberas en Ecuador, especialmente las de montaña, por lo que es crucial comprender sus características y los factores de control. El material parental puede ser uno de ellos, al influir sobre las propiedades del suelo, la disponibilidad de nutrientes, la estabilización de la materia orgánica y, en última instancia, dos procesos clave para que se forme la turba: el crecimiento y la descomposición de las plantas. Para ampliar el conocimiento de la dinámica del carbono en este ecosistema estudiamos por primera vez las turberas del sureste ecuatoriano. Además, estas turberas se desarrollaron sobre rocas metamórficas y plutónicas, por lo que comparamos la profundidad, la concentración de carbono, la densidad aparente, la densidad de carbono, la edad y las tasas de acumulación de carbono con valores reportados para las turberas sobre rocas volcánicas en el noreste. A través de un muestreo intermitente de turba, pérdida por ignición y análisis de radiocarbono, identificamos las características de la turba. El estudio encontró que i) las turberas sobre rocas metamórficas y plutónicas tenían una mayor concentración de carbono que las turberas sobre roca volcánica, ii) las densidades de carbono eran comparables en todas las turberas estudiadas, iii) las turberas sobre rocas metamórficas y plutónicas mostraban valores LARCA más bajos que las turberas sobre roca volcánica, y que iv) las turberas metamórficas y plutónicas son más antiguas que las volcánicas. Estos hallazgos destacan que las turberas en diferentes materiales parentales tienen diferencias en su dinámica del carbono. Por lo tanto, alentamos a que los estudios futuros exploren más allá de un análisis descriptivo, para identificar la relación entre el carbono y la geología, y fomentar la gestión y conservación de las turberas.

Palabras clave: carbono, tasas de acumulación de carbono, turberas de montaña, material parental.

ABSTRACT

Peatlands play an essential role in global carbon storage. However, there is still a lot to discover about peatlands in Ecuador, especially the mountain ones, making it crucial to understand their characteristics and controlling factors. Parent material can be one of them, by shaping the soil properties, nutrients availability, organic matter stabilization, and ultimately two key processes for peat to form: plant growth and decay. To broaden the knowledge of carbon dynamics in this ecosystem we studied for the first-time peatlands in the southeastern Ecuador. Additionally, these peatlands developed on metamorphic and plutonic rocks, so we compared the depth, carbon concentration, bulk density, carbon density, age, and carbon accumulation rates with reported values for peatlands on volcanic rocks in the northeastern. The methodology included a field, lab, and collaborative work. Through an intermittent peat sampling, lost on ignition, and radiocarbon analyses we went deep into the peat and identified its characteristics that are the result of long-term process. The study found that i) peatlands on metamorphic and plutonic rocks had higher carbon concentration than peatlands on volcanic rock, ii) carbon densities were comparable across all studied peatlands, iii) peatlands on metamorphic and plutonic rocks exhibited lower LARCA values than peatlands on volcanic rock, and that iv) metamorphic, and plutonic peatlands are older than volcanic ones. These findings highlight that peatlands developed on contrasting parent materials have differences in carbon dynamics. Thus, we encourage future studies to explore beyond a descriptive analysis, to identify the relationship between carbon and geology, and foster peatlands management and conservation.

Key words: carbon, carbon accumulation rates, mountain peatlands, parent material.

TABLA DE CONTENIDO

INTRODUCTION

Peatlands are the most space-effective reservoir of carbon among terrestrial ecosystems. Considering above-and-belowground, they contain on average 3.5, 7 and 10 times more carbon per hectare than ecosystems on mineral soils in the subpolar, boreal, and tropical zones, respectively (Joosten & Couwenberg, 2008). Additionally, known peatlands cover only 3% of the global landmass but account for around 24% of the world soil organic carbon pool (Jackson et al., 2017; Xu et al., 2018). However, these values might represent an underestimation of this carbon sink, as new peatland systems are being found in the tropical lowlands and in mountainous landscapes throughout the world. In the face of rapid climate change and widespread land-use transformation, more accurate estimations of this carbon sink are needed, especially regarding its distribution, carbon stocks, and its patterns of accumulation (Lawson et al., 2015; Leifeld & Menichetti, 2018; Ribeiro et al., 2021).

The accumulation of soil organic carbon (SOC) in peatlands mainly depends on waterlogging conditions but there could be other factors. The balance between plant growth and organic matter decomposition in peatlands is controlled by rainfall or groundwater which directly contributes to biomass production and creates anoxic conditions in soils reducing biomass decay (Minasny et al., 2019). Nevertheless, there can be other drivers that, depending on the scale and with complex interactions among them, might influence peat development such as land use management, topography, vegetation, soil biota, and parent material (Gorham, 1957; Nave et al., 2021; Wiesmeier et al., 2019; Hribljan et al., 2023 [under review])). Even though, this last factor has received less attention, some studies have found that it might influence SOC storage in a temperate forest, alpine ecosystems, cropland soils, and in a subtropical forest (Angst et al., 2018; Barré et al., 2017; Mao et al., 2020; Moser et al., 2022).

Parent material could contribute to carbon accumulation mainly through two processes. First, through weathering of parental materials which releases nutrients to the ecosystem, enhancing or limiting primary productivity and thus, controlling the input of organic matter into the soils (Augusto et al., 2017; Porder, 2019; Porder et al., 2007; Zehetner et al., 2021). Second, through SOC stabilization due to soil physicochemical and biogeochemical interactions that reduce decay (Gorham, 1957; Matus et al., 2014). Indeed, volcanic rock has some properties that differentiate it from other parent materials, such as low bulk densities, and high levels of water retention, high phosphate retention, and more stable soil aggregates, that could account for a higher productivity and carbon stabilization (Buytaert et al., 2006) . However, Hughes et al. (2013) also showed that the addition of tephra materials through volcanic eruptions can alter plant composition and reduce organic matter accumulation, by changing the humification of peat.

The páramo of the Northern Andes offers a unique opportunity to assess the effects of parental material on the patterns of carbon accumulation and storage in tropical mountain peatlands. Although most of the páramo peatlands above 3800 m likely formed after the end of the last glaciation, there is a strong difference in geological origin between the páramos of the northern and central Ecuadorian Andes, formed on young volcanic ashes, and the páramos of the south which developed on plutonic and metamorphic rocks (Gómez et al., 2019). Moreover, the southern páramos correspond to a much older lift of the Andean cordillera (Boschman, 2021). In a previous study, Hribljan et al. (2016) reported on carbon accumulation rates on six páramo peatlands developed on young volcanic soils in northern Ecuador. Here we complement that study by estimating carbon accumulation rates in peatlands developed on non-volcanic soils in the páramo of southern Ecuador. Specifically, this study aimed to i) quantify depth, carbon concentration, bulk densities, carbon densities, ages, and long-term rates of C accumulation (LARCA) in peatlands developed on metamorphic and plutonic parent materials and ii) compare them with data from peatlands on volcanic rock (Hribljan et al., 2016).

METHODS

Study sites

This study was conducted in the páramo ecoregion of southeastern Ecuador, within the Marcos Pérez de Castilla Community Protected Area, and Yacuri National Park. These study sites have developed on metamorphic and plutonic parent material respectively, and they hereinafter will be referred by this characteristic (**Table 1** and **Fig 1**). Additionally, for peatlands developed on volcanic rock, we used depths, bulk densities, carbon concentrations, carbon densities, ages of peatlands and LARCA values from Hribljan et al., (2016) through the "Database of tropical wetlands carbon survey: Soil". We selected the volcanic sites that, as well as ours, do not show significant signs of recent human intervention.

All sites are located on the Eastern Cordillera of the Ecuadorian Andes. The Cordillera originated due to the subduction of the Nazca Plate beneath the South American Plate, which resulted in an uplifting process, volcanic plateau formation, volcanic eruptions and the interandean tectonic depression creation (Boschman, 2021; Coltorti & Ollier, 2000). But this mountain building process has not occurred evenly throughout the Ecuadorian Andes; the southeastern portion of the cordillera in Ecuador started to rise in the Cretaceous, while the western and northeastern Cordillera uplifted during the Paleocene, creating a complex landscape with a diverse geological substrate, active volcanoes, high peaks, and valleys, where peatlands formed after the melting of glaciers in the Pleistocene (Boschman, 2021).

The climate at all our study sites is perhumid. The volcanic and metamorphic sites are in a homogeneous precipitation region with an average annual rainfall of 1064 mm/year, while the plutonic site has an average annual rainfall of 1115 mm/year (Ilbay-Yupa et al., 2021). The landscape is composed of low-stature vegetation such as mosses, herbaceous plants, tussocks grasses and cushion forming plants. Information on the diversity and structure of peatland plant communities is scarce, especially regarding to potential differences between the branches of the cordillera (Suarez et al., 2022). However, a study in the northern Ecuadorian Andes suggests that elevation and water table levels might play an essential role in structuring plant communities (Suárez et al., 2023). Cushion forming plants and mosses tend to be more frequent in the northern and southern páramos, respectively. In this study, the volcanic, metamorphic, and plutonic sites have elevation ranges of 3919-4270, 3302-3317, and 3304-3477 m, respectively. Volcanic peatlands are minerotrophic, while the metamorphic and plutonic ones are ombrotrophic, showing acidic conditions with higher and lower values of pH respectively.

Soil sampling and carbon analyses

We sampled the peat profile trying to reach the substratum and used a Russian peat borer to avoid contamination (Hribljan et al., 2016). Once a single core was extracted from each peatland, it was cut into 5 cm sections (**Fig 2)**. We selected some sections characterizing the heterogeneity of peat and mineral soil and stored them in soil tins for further laboratory analysis (Hribljan et al., 2016).

Peatland age and carbon accumulation rates

From each peat core, we took four peat samples for C14 analysis including one sample approximately 5 cm below that soil surface, one sample from the base of the core, and two random samples to characterize the remainder of the core. These samples were transported to the laboratory, where a 1-g subsample was taken from the center of each section to avoid contamination. These subsamples were stored in plastic vials and sent to Michigan Technological University, where they were tested for tracer contamination, and graphitized in the Houghton Carbon, Water and Soils Lab, USDA-FS Northern Research Station. For this process, samples were weighed into quartz tubes, sealed under a vacuum, and then combusted at 900°C for 6 hours with cupric oxide (CuO) and silver (Ag) to form CO_2 gas. The CO_2 was reduced to graphite through heating at 570°C in the presence of hydrogen (H_2) gas and an iron (Fe) catalyst (Vogel et al., 1987). Then, the radiocarbon measurements were conducted at the DirectAMS facility, Bothell, WA using an accelerator mass spectrometer (Zoppi et al., 2007). Sample preparation backgrounds were subtracted based on measurements of ^{14}C-free wood. All results were corrected for isotopic fractionation according to the conventions of Stuiver and Polach (1977), with $\delta^{13}C$ values measured on prepared graphite using the AMS spectrometer. These values can differ from the $\delta^{13}C$ of the original material if fractionation occurred during AMS measurement, and therefore are not shown. Radiocarbon concentrations are given as fraction of the Modern standard, $\Delta^{14}C$, and conventional radiocarbon age, following the conventions of Stuiver and Polach (Radiocarbon, vol. 19, p. 355, 1977). Conventional age is in radiocarbon years using the Libby half-life of 5568 years. Then, the radiocarbon dates were calibrated using a southern hemisphere atmospheric calibration curve (Hogg et al., 2020) with Oxcal v. 4.4 (Ramsey, 2009), reporting the median value with the range of 2σ, and using these values to estimate the long-term apparent rate of C accumulation

(LARCA). This accumulation index allows us to assess carbon storage per unit area over long periods of time. It is calculated by dividing cumulative C soil mass (carbon density) by the age of the correspondent segment, and even when it does not take into account decay process of peat, is a widely used method (Hribljan, 2015). With this method we assumed a linear relationship between cumulative carbon soil mass and age, and thus a constant accumulation rate through time. However, LARCA can vary due to fluctuations in climate, vegetation changes, or disturbance (Gorham, 1957; Benavides et al., 2013). Thus, a more detailed analysis will be done to take advantage of all the radiocarbon dated samples and provide more insights into C dynamic with its shifts over time.

Carbon content and storage

The peat core samples were dried up in the oven at 55°C until reaching a constant mass and weighted. Then, the samples were grounded, homogenized, and burned in the muffle furnace at 500°C for 4 hours to calculate the bulk density, %C and carbon density, following the loss on ignition method (LOI) as used in Thompson et al. (2021). We calculated the %C with equation 1 (Hribljan et al., (2016), with the equation:

$$\%C = 0.5324 * \%OM - 0.9986 \quad (1)$$

We calculated carbon density with equation 2 and expressed it in $\mathrm{MgC\ ha^{-1}}$.

$$C\ density = C * Bulk\ density * Height \quad (2)$$

We did a partial peat sampling, consequently we estimated the bulk density and the %C, for each missing segment, as an average of the upper and lower known segments (Chimner et al., 2014). When the missing segment was in the shallower depth, we duplicated the values of the closest to the ground segment. Total carbon density of each peatland was obtained by adding all the values through the profile and differentiating the mineral and the peat horizons. We averaged carbon concentration, bulk density, and carbon density to compare them based on the type of horizon and parent material Then, to identify if there was a significant difference in depth, bulk density, %C, carbon density and LARCA between parent materials we used the non-parametric test Kruskal-Wallis, while Wilcoxon-Mann-Whitney was used to compare carbon characteristics within parent material groups.

RESULTS

Carbon features

The deepest core was 300 cm in Oña13, at the metamorphic site, while the shallowest was 135 cm in Yac8, at the plutonic site, **Fig 3**. Out of 97 collected sections, 90% met the general guideline of peat, which means that have more than 12% of Soil Organic carbon content (Soil Survey Staff, 1975), while the rest was considered as mineral layers. We found that at the metamorphic sites carbon concentration displayed less variability than plutonic and volcanic sites. Regarding bulk densities we saw a pattern with the carbon concentration, in which bulk density increases when carbon concentration decreases.

We found similar %C in peat at the metamorphic and plutonic sites, with mean values of 40.70 ± 2.67 and 35.08 ± 3.47, respectively (**Table 2**). On the other hand, in the mineral horizon of the plutonic sites, the %C almost triple the one of the metamorphic sites, with mean values of 7.03 ± 3.09 and 2.42 ± 0.37, respectively, but in both cases are lower %C in comparison with peat, as we expected.

Related to this, average bulk density in peat was up to 4 and 5 times lower than in the mineral horizon in the metamorphic and plutonic sites, respectively.

Comparing our results with the previously reported ones, we found that in metamorphic and plutonic sites, peat contributes over 20 times more carbon density than mineral horizon as opposed to volcanic sites in which peat (771.20 ± 189.96 $Mgha^{-1}$) and the mineral horizon have a similar contribution (730.25 ± 131.62 $Mgha^{-1}$).

We also found differences in depth, carbon concentration, and bulk density, but no difference in carbon density. Depth was significantly different (p = 0.035 **Fig**. **4a**) between the volcanic (503.80 ± 73.31 m) and the plutonic sites (183.33 ± 25.22 m). However, there was no difference (p = 0.051) in depth between volcanic and metamorphic sites (243.33 ± 49.36 m) nor between metamorphic and plutonic sites (p = 0.400). The carbon concentration in peat was also significantly different, but this time within all the parent materials, **Fig**. **4b**; the volcanic and the metamorphic sites (p < 2.2e-16), the volcanic and the plutonic sites (p < 2.2e-16), and the metamorphic and plutonic sites (p < 0.001). The higher carbon concentration was reported in the metamorphic sites (40.70 ± 2.67), followed by the plutonic (35.08 ± 3.47) and the volcanic sites (22.00 ± 2.07). Regarding bulk density, there was a significant difference among parent materials (p < 2.2e-16; **Fig**. **4c**). The average of bulk density was significantly different between the volcanic and the metamorphic sites (p < 2.2e-16), the volcanic and the plutonic sites (p = < 2.2e-16), and the metamorphic and plutonic sites (p = 0.003). The average bulk densities were 0.19 ± 0.02, 0.10 ± 0.01, and 0.11 ± 0.02 gcm^{-3} for volcanic, metamorphic, and plutonic sites. Finally, for carbon density there was no significant difference among parent materials (p = 0.828; **Fig**. **4d**), and this variable ranged from 589.99 ± 156.69 to 771.20 ± 189.96 $MgCha^{-1}$.

Peatlands age and accumulation rates

We found out that peatlands developed on plutonic rock were older than the ones developed on metamorphic rock, except for peatland Yac8 that seemed to be the youngest one (**Table 3**), and that their basal age is not statistically different (**Fig 4e**).

Comparisson of depth vs peat age among peatlands developed on contrasting parent materials (**Fig 5a)**, shows that most of the peatlands on metamorphic and plutonic rocks started storing carbon from 15124 to 9894 cal. yr. BP, during the late Pleistocene (except for Yac8 whose basal age is 1853 cal. yr. BP). In contrast, the volcanic peatlands started to develop between 7792 and 3412 cal.yr. BP, during the early Holocene (except for C5 whose basal age was before that period, in 10837 cal. yr. BP).

We calculated the cumulative soil C mass (kgm^{-2}), which is the carbon density for different sections until reaching the whole profile and plotted it vs age (**Fig 5b**). From this figure, we calculated LARCA as the slope of the regression lines. Peatlands developed on metamorphic and plutonic rocks have similar LARCA values (metamorphic: 5.63 $\pm$ 1.04; plutonic: 7.93 $\pm$ 3.24 $gm^{-2}year^{-1}$). LARCA was significantly different between peatlands on volcanic and metamorphic sites ($p = 0.035$), but not between volcanic and plutonic ($p = 0.142$), and metamorphic and plutonic sites ($p = 1$) (**Fig 4f**).

DISCUSSION

Carbon features

Overall, depths of the plutonic and metamorphic peatlands that we studied are lower than those reported for the volcanic sites, which reach up to over 600 cm (Comas et al., 2017; Hribljan et al., 2016). At metamorphic and plutonic sites, we obtained higher carbon concentrations (40.70 ± 2.67, 35.08 ± 3.47) than those reported at the volcanic sites (22 ± 2.07). As expected, the mineral contribution is negligible to carbon accumulation in contrast to the volcanic sites in which multiple thick layers of ash contribute to the total carbon density, as reported by Hribljan et al., (2016).

The carbon trends in both the mineral and peat layers are similar to the ones found in the first survey of C stocks and accumulation rates in mountain peatlands of the region by Hribljan et al., (2023 [under review]), that shows an average bulk density of 0.46± 0.04 gcm^{-3} and an average %C of 6.7 ± 0.57 for mineral layers, and lower bulk densities and higher %C for peat (0.18 ± 0.02 g cm-3 ; 30.0 ± 1.74 %C). However, in our study, peatlands developed on metamorphic and plutonic rocks exhibited higher carbon concentrations (40.70 %C ± 2.67; 35.08 ± 3.47) than those reported on volcanic sites (22 %C ± 2.07) by Hribljan et al., (2016). Peat at metamorphic and plutonic sites has lower mean pH values than volcanic sites, and this could inhibit microorganism activity, hindering the decomposition of organic matter (Bragazza et al., 2007; Moore & Basiliko, 2006). For example, Chimner et al., (2014) reported that carbon concentrations in upper peat vary between peatlands with different pH, with *Sphagnum* dominated peat exhibiting lower pH values (pH:3.9) and higher carbon concentration (457 gkg^{-1}) than a *Fraxinus* dominated one with a pH of 5.8 and a carbon concentration of $387gkg^{-1}$.

Additionally, we found that in volcanic and plutonic sites carbon concentration varies through depth, while for the metamorphic peatlands it seems to be constant, until falling in the deepest section.

Finally there was no significant difference of carbon density among parent materials. This was not expected since peatlands developed on volcanic rock are deeper, and their physicochemical properties could improve nutrient availability and carbon stabilization, which could foster carbon accumulation, as has been shown to happen in upland páramo soils developed on volcanic substrates (Tonneijck et al., 2010). The ash can have this effect due to the allophanic conditions, in which Al, Fe and Si form organomineral complexes, or by hampering microbial activity, inhibiting decay and enhancing long-term carbon stabilizing

(Buytaert et al., 2006; Gerd et al., 2001; Möckel et al., 2021). However, in this case the metamorphic, and plutonic peatlands showed comparable carbon densities, even when they are shallower and have no significant contribution of mineral depositions as in the volcanic sites and make us think on nutrients availability as another mechanism that can be influencing carbon balance on these peatlands.

Peatlands age and accumulation rates

We found that metamorphic and plutonic peatlands are older than the volcanic ones. Additionally, we found that peatlands developed on metamorphic and plutonic rocks have lower average C accumulation rates (5.63 $\pm$ 1.04, 7.93 $\pm$ 3.24 $gm^{-2}year^{-1}$) than the ones developed on volcanic rock (20.68 $\pm$ 6.45 $gm^{-2}year^{-1}$) reported by Hribljan et al., (2016), which is consistent with Hribljan et al., (2023 [under review]) that found older peatlands generally occur at lower elevations and have lower C accumulation rates. These carbon accumulation rates of peatlands on metamorphic and plutonic sites are also very low in comparison with other tropical peatlands in the region (47- 37 $gm^{-2}yr^{-1}$) (Hribljan, 2015) and worldwide (24-300 $gm^{-2}yr^{-1}$) (Ribeiro et al., 2021).

Low LARCA values in peatlands developed on non-volcanic substrates could be explained by the decomposition process of organic matter as peatland ages (Clymo & Fogg, 1997), but it also could suggest our hypothesis about the possible influence of parent material in carbon dynamics, in which higher mineral content in volcanic sites (Hribljan, 2015) could account for a faster forming of its carbon pools though nutrient enrichment, in contrast to metamorphic and plutonic sites. Volcanos release phosphorus, which is a common limited nutrient in soils, and for example Ratcliffe et al. (2020), found a positive correlation between phosphorus and carbon accumulation, and a rapidly increasing of it after eruptive events.

CONCLUSIONS

This is the first study to characterize depth, carbon concentration, bulk density, carbon densities, age, and C accumulation rates in mountain peatlands of the southeastern Ecuador. The studied peatlands differed mainly on carbon concentration and accumulation rates, and could be due to the two controlling processess for peat to form. Higher carbon concentrations on metamorphic and plutonic peatlands might be the result of an incomplete decomposition process, and in addition to the lower accumulation rates in comparison to the volcanic sites, we suggest that in metamorphic and plutonic sites there is also lower primary productivity. Nutrients could be limiting factor for biomass production in the metamorphic and plutonic sites, meanwhile the nutrient release through volcanic activity could have helped volcanic peatlands to increase plant growth through time and have comparable carbon densities, even when they have had less time to form the peat than the metamorphic and plutonic sites, because we found that peatlands on metamorphic and plutonic sites of the southeastern Ecuador are older than the peatlands on volcanic sites in the northeastern. As the first attempt to compare the carbon features of peatlands developed on contrasting parent materials, we encourage future studies to explore how much of the variance on carbon stocks and carbon accumulation rates are explained by this geological material that can shape peatlands, through the physical-chemical soil properties, fertility, mineralogy, and their complex interaction with other forming soil factors such as age, climate, topography, and biota (Jenny, 1994), with a special focus on the processes of plant growth and decay. Discovering more about carbon dynamics and peat formation drivers will not only meet our needs to understand the world in where we live but will also allow us to improve carbon inventories and foster the conservation of this inspiring ecosystem.

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Tables

Table 1. Sites description

Parent Material	Peatland	Latitude	Longitude	Elevation (m)	pH	Conductivity (ms/cm)
	C1	-0.310410	-78.19239	4270	5.7	-
Volcanic	C2	-0.319160	-78.20001	4270	-	-
	C3	-0.312090	-78.19226	4254	5.5	-
	C5	-0.327000	-78.20210	4136	5.1	-
	C6	-0.328749	-78.21520	3919	6.2	-
Metamorphic	Oña8	-3.584446	-79.08595	3302	3.48	12.93
	Oña13	-3.587371	-79.08209	3317	2.63	11.47
	Oña23	-3.583029	-79.06609	3302	2.95	9.65
	Yac1	-4.738841	-79.42658	3439	4.54	20.28
Plutonic	Yac2	-4.732326	-79.42810	3477	4.00	28.7
	Yac8	-4.754458	-79.42240	3304	4.54	21.37

Table 2. Carbon density, bulk density, and carbon concentration by type of horizon and parent material.

		Parent Material		
		Volcanic	**Metamorphic**	**Plutonic**
	%C	22 ± 2.07	40.70 ± 2.67	35.08 ± 3.47
Peat	Bulk density (gcm^{-3})	0.19 ± 0.02	0.10 ± 0.01	0.11 ± 0.02
	Carbon density ($Mgha^{-1}$)	771.20 ± 189.96	728.97 ± 125.58	589.99 ± 156.69
	%C	6.58 ± 0.15	2.42 ± 0.37	7.03 ± 3.09
Mineral horizon	Bulk density (gcm^{-3})	0.48 ± 0.01	0.42 ± 0.08	0.59 ± 0.20
	Carbon density ($Mgha^{-1}$)	730.25 ± 131.62	26.21 ± 18.55	28.08 ± 16.73

Table 3. Radiocarbon ages (^{14}C) corrected for mass-dependent fractioning using measured $\delta^{13}C$ and calibrated ages (cal. year BP, BP=1950).

D-AMS #	Peatland	Depth (cm)	^{14}C age BP	±	Cal year BP	Median -2 σ	Median +2 σ
D-AMS 050047	Oña8	40-45	1880	20	1778	1828	1718
D-AMS 050048		140-145	7555	40	8336	8405	8195
D-AMS 050049		250-255	9860	70	11232	11617	10891
D-AMS 050050		275-280	11020	40	12901	13069	12776
D-AMS 050051	Oña13	40-45	1855	35	1741	1833	1613
D-AMS 050052		140-145	3055	35	3213	3345	3074
D-AMS 050053		205-210	5375	45	6120	6279	5952
D-AMS 050054		260-265	10900	60	12801	12919	12731
D-AMS 050043	Oña23	25-30	435	30	465	509	327
D-AMS 050044		90-95	4760	50	5458	5583	5321
D-AMS 050045		115-120	5775	20	6535	6635	6443
D-AMS 050046		130-135	8865	35	9894	10150	9695
D-AMS 050063	Yac1	30-35	2260	15	2241	2328	2138
D-AMS 050064		75-80	3980	30	4387	4519	4247
D-AMS 050065		110-115	9570	60	10873	11137	10596
D-AMS 050066		190-195	12390	60	14420	14845	14103
D-AMS 050059	Yac2	45-50	1970	35	1876	1995	1749
D-AMS 050060		105-110	5360	40	6104	6273	5946
D-AMS 050061		150-155	7015	35	7809	7929	7695
D-AMS 050062		200-205	12720	45	15124	15276	14970
D-AMS 050055	Yac8	40-45	615	30	592	635	523
D-AMS 050056		75-80	1180	25	1015	1176	960
D-AMS 050057		100-105	1595	30	1446	1527	1371
D-AMS 050058		115-120	1950	30	1853	1927	1747

Table 4. LARCA values of peatlands on volcanic, metamorphic, and plutonic rock.

Parent Material	Peatland	LARCA ($gm^{-2}yr^{-1}$)
	C1	10
Volcanic	C2	9.9
	C3	45.1
	C5	18.9
	C6	19.5
Metamorphic	Oña8	7.7
	Oña13	4.4
	Oña23	4.8
	Yac1	5.1
Plutonic	Yac2	4.3
	Yac8	14.4

Figures

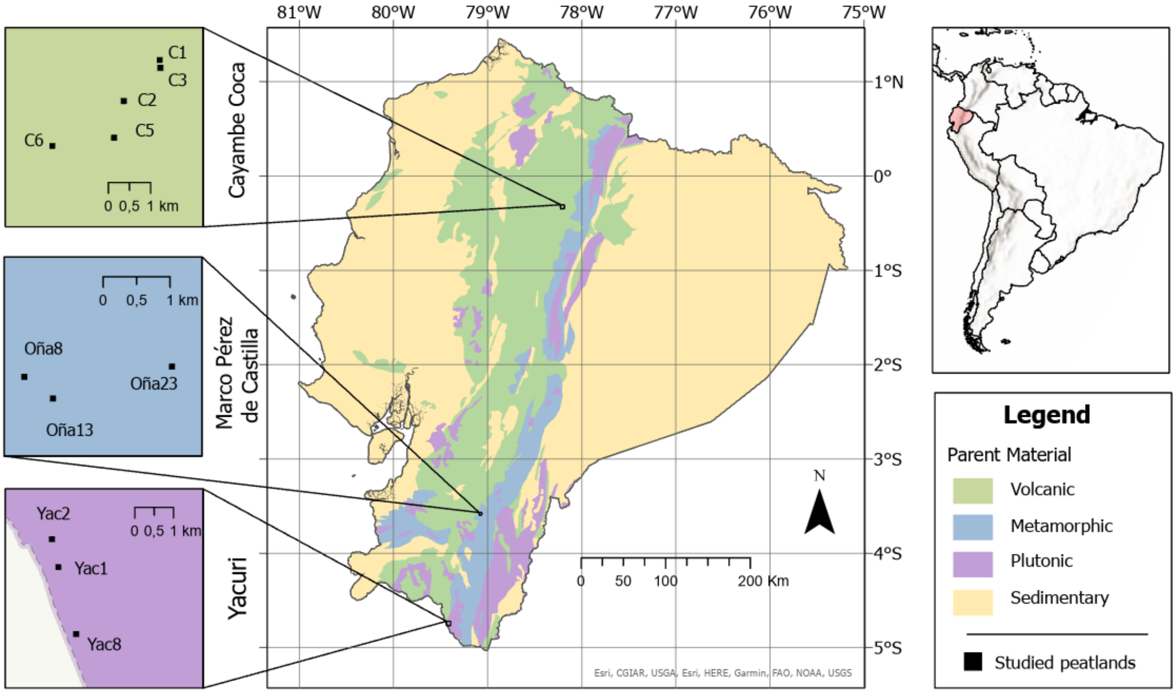

Fig 1. Study sites.
Elaborated by the authors using the geological data from Gómez et al., (2019), and the location of studied peatlands in volcanic rock from Hribljan et al., (2016).

Fig 2. Peat sampling

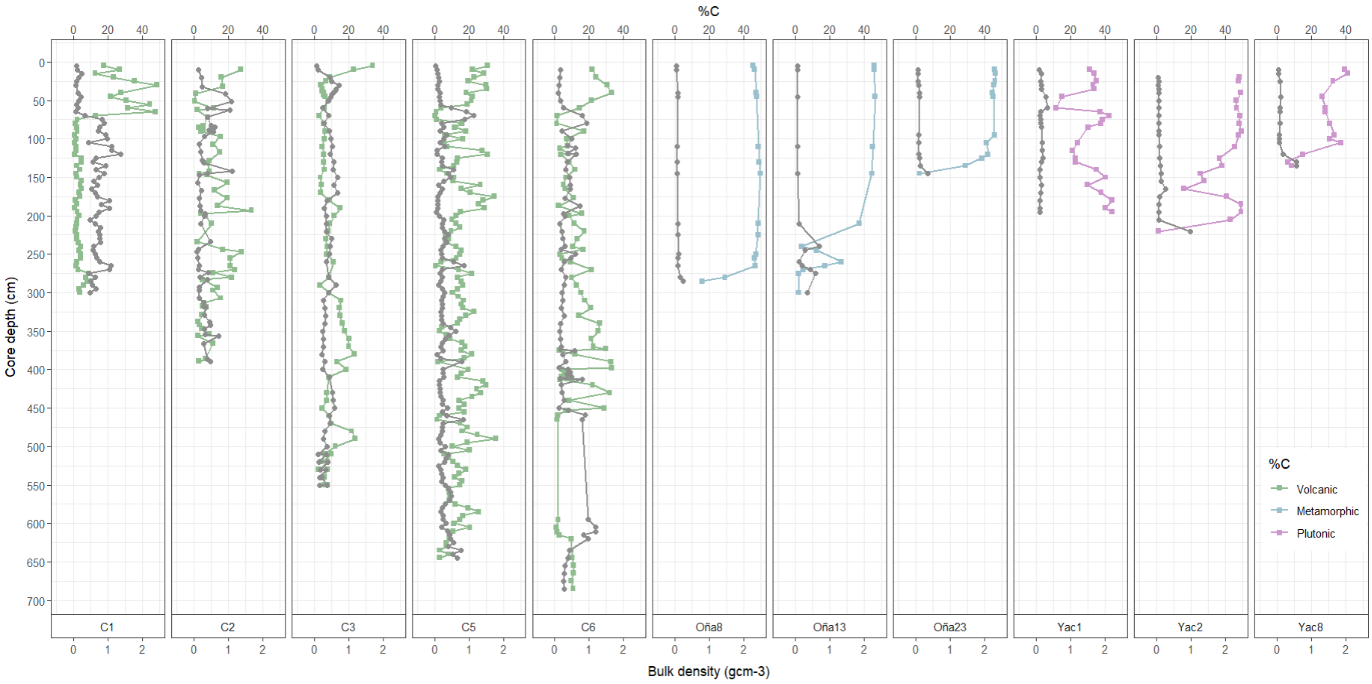

Fig 3. Cores depth, carbon concentration and bulk density

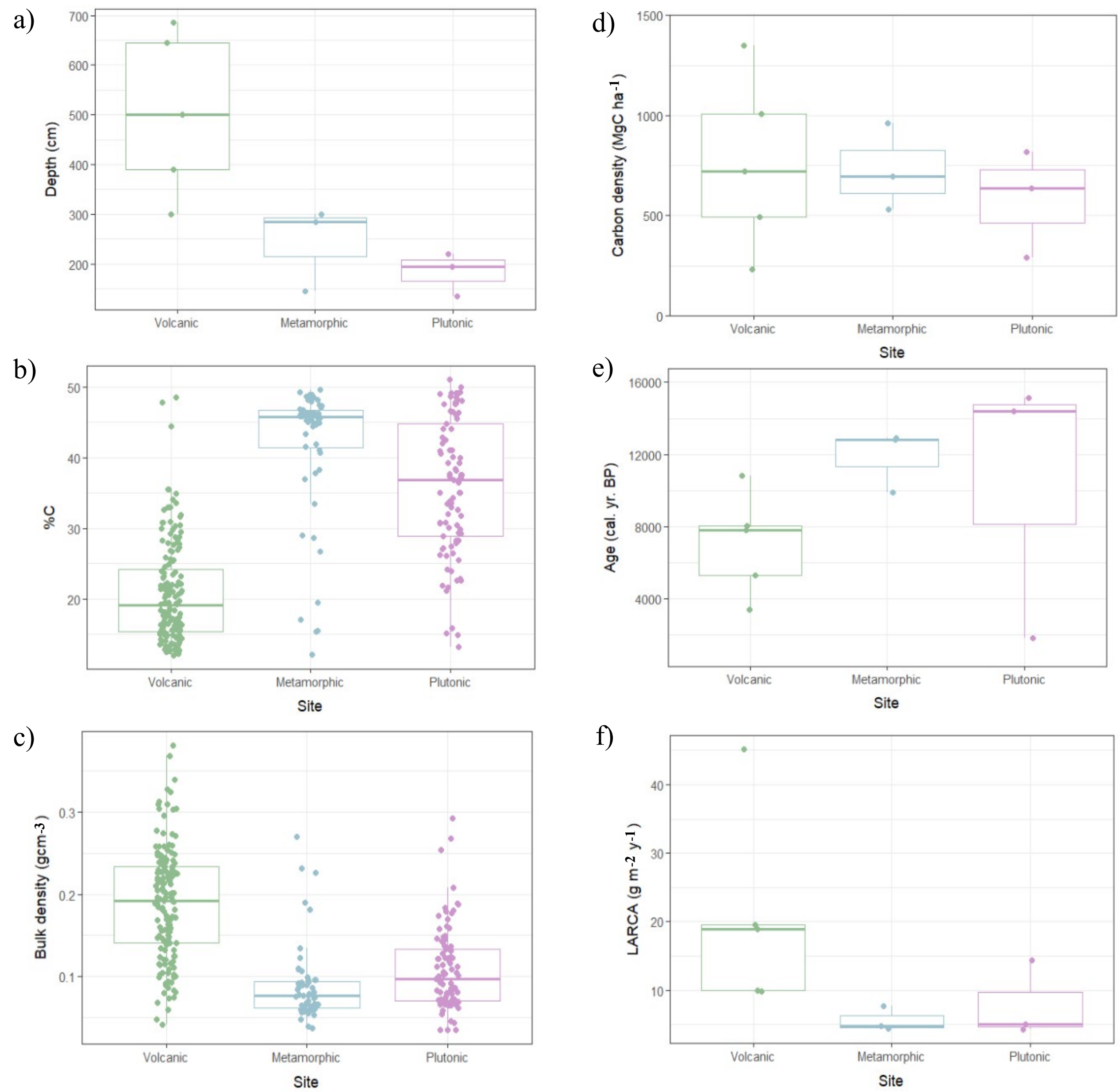

Fig 4. a) Depth, b) %C, c) Bulk, d) Carbon density, e) Age, and f) LARCA vs parent material

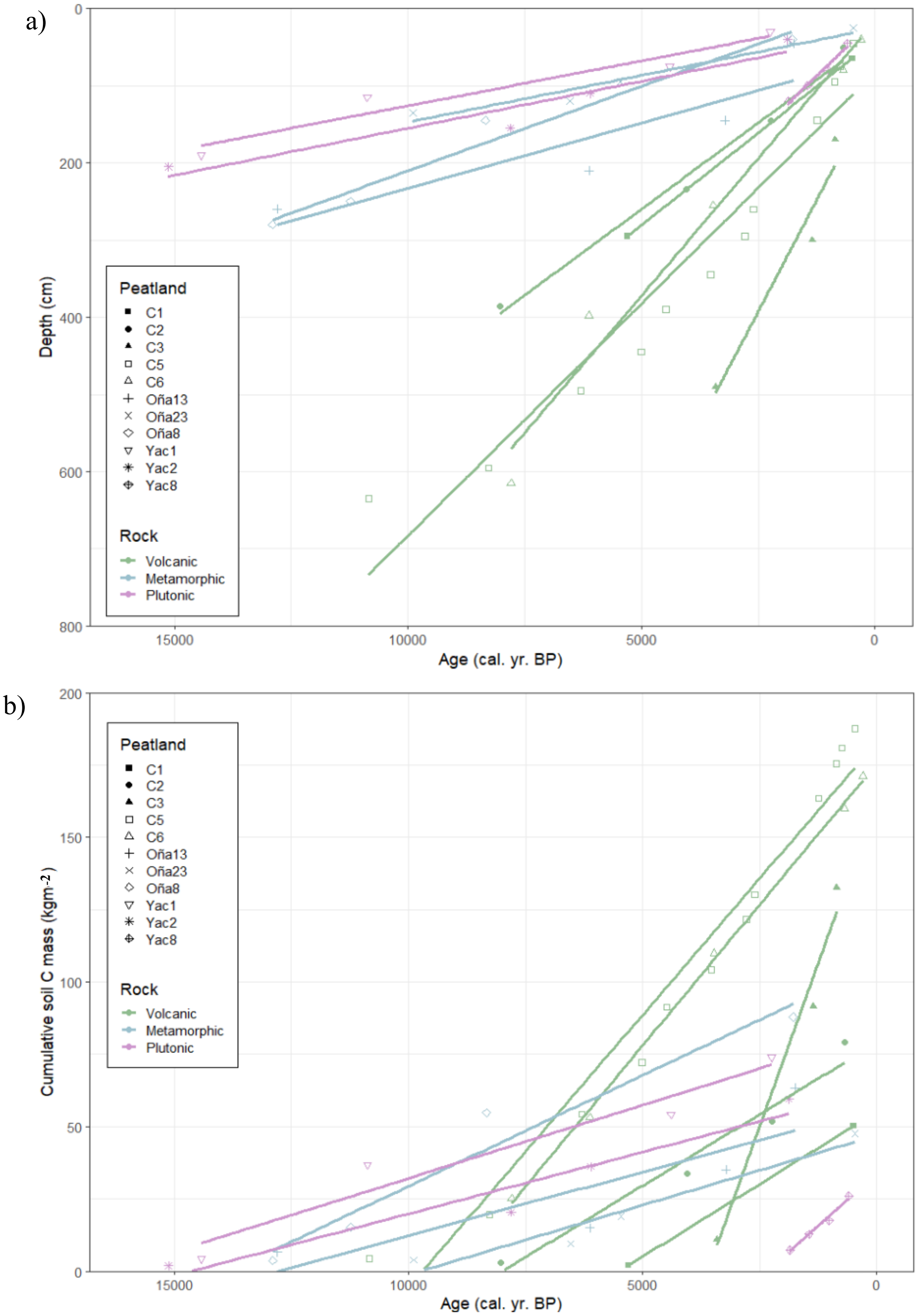

Fig 5. a) Depth vs Age, b) Cumulative soil C mass vs Age

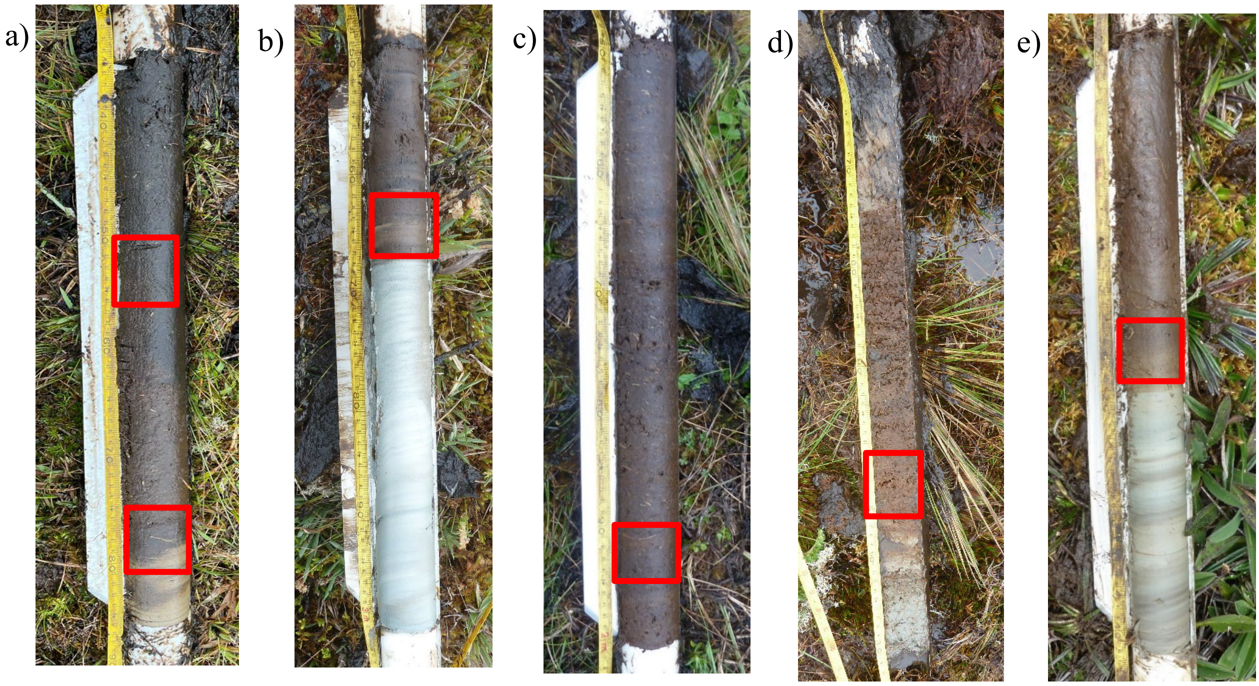

Fig 6. Deepest core of a) Oña8, b) Oñ13, c) Yac1, d) Yac2 and e) Yac8.

Picture for Oña 23 is not available but the deepest core was extracted with the open gauge and looked like the one for Oña13. Red squares are the section that were radiocarbon dated.