Title
Effect of Combustion Temperature on Soil and Soil Organic Matter Properties: A Study of Soils from the Western Elevation Transect in Central Sierra Nevada, California

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Effect of Combustion Temperature on Soil and Soil Organic Matter Properties: A Study of Soils from the Western Elevation Transect in Central Sierra Nevada, California

A Thesis submitted in partial satisfaction of the requirements for the degree of Master of Science

in

Environmental Systems

by

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2014

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Abstract

Fire is a common ecosystem perturbation that affects many soil physical and chemical properties and soil organic matter (SOM). In my Master's thesis, I investigated the effect of combustion temperatures on the physical and chemical properties of five soils from an elevation transect that spans from 210 to 2865 m.a.s.l. along the Western slope of the Sierra Nevada. All soils were formed on a granitic parent material under either oak woodland, oak/mixed-conifer forest, mixed-conifer forest or subalpine mixed-conifer forest ecosystem. Soils show significant differences in SOM content and mineralogy owing to the effects of climate on soil development. Soils from 0 to 5 cm depth were combusted in a muffle furnace at six different temperatures within major fire intensity classes (150, 250, 350, 450, 550 and 650°C). I determined the effects of combustion temperature on aggregation; specific surface area; pH; mineralogy; cation exchange capacity; carbon (C) and nitrogen (N) content and ^{13}C and ^{15}N isotopic composition in bulk and in separate aggregate sizes; and quality of SOM trough infrared spectroscopy. Among other things, I found significant reduction of total C and N, accumulation of aromatic carbon functional groups, and loss of aggregation with implication to loss of protection of C as the combustion temperature increases. My findings demonstrate that most significant changes in the soils physical and chemical properties occur around 350°C. Findings from this study are critical for estimating the amount and rate of change in C and N loss, and other essential soil properties that can be expected from topsoils exposed to different intensity fires.

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1 Introduction

Fire is a common, widespread phenomenon in many ecosystems around the world. Vegetation fires burn an estimated 300 to 400 million hectares of land globally every year (FAO, 2005). In the US alone, over 88,000 fires were reported in 2010–including 71,000 wild-land fires, and 17,00 prescribed burns that burned over 1.3 million and 980,000 ha of land, respectively (National Interagency Fire Center, 2012).

Anticipated changes in climate are expected to have a significant effect on fires over the coming century (Westerling et al., 2006). Frequency of fires is expected to increase in the coming decades with global warming (Pechony & Shindell, 2010). Even though humans are responsible for causing a substantial proportion of vegetation fires (Caldararo, 2002), these fires are nevertheless natural phenomena with an important role in maintaining the health of many ecosystems.

Many ecosystems in the US and across the world depend on fires to maintain ecosystem health and productivity. Vegetation fires have a major influence on the Sierra Nevada landscapes (McKelvey et al., 1996). Lightning fires were historically common in the dry season in the upland forests of the Sierra Nevada Mountains, in addition to the use of fire by some Native American tribes to modify the environment for their needs (Parsons & van Wagtendonk, 1996).

Fire significantly affects the physical, chemical and biological properties of soils. The degree of alteration caused by fires depends on fire intensity and duration, which in turn depend on factors such as amount and type of fuels, air temperature and humidity, wind, topography; soil properties of moisture content, texture and organic matter content and properties of above ground biomass (L. F. DeBano et al., 1998). The first-order effects of fire on soil are caused by the input of heat causing extreme high soil temperatures in topsoil (Badía & Martí, 2003b; Neary et al., 1999). Other effects of fire on soil are a result of loss of SOM, changes in aggregation properties of soil, deposition of charred material, and other combustion products (Albalasmeh et al., 2013).

Fire has multiple, complex effects on carbon (C) dynamics in soil. Wildfires alone lead to the release of up to 4.1 Pg C yr^{-1} to the atmosphere in the form of carbon dioxide (CO_2), with an additional 0.05 to 0.2 Pg C yr^{-1} added to the soil as black (BC) or pyrogenic carbon (PyC) ash (Singh et al., 2012). The changes in SOM characteristics due to combustion include: 1) reduced solubility of OM due to loss of external oxygen containing functional groups, 2) reduced chain length of fatty acids, alcohols and other alkyl compounds, 3) higher aromaticity of sugars and lipids, 4) production of PyC, 5) formation of heterocyclic nitrogen (N) compounds, and 6) macromolecular condensation of humic substances (González-Pérez et al., 2004). Fires also impact soil by altering and removing above-ground vegetation and topsoil biomass, and increasing erodibility of soil (Carroll et al., 2007; Leonard F. DeBano, 1991), and leading to subsequent shift in plant and microbial populations (Janzen & Tobin-Janzen, 2008). Fires with longer durations typically cause more alterations of soil physical and chemical conditions, and loss of SOM than fast-moving, high temperature fires (González-Pérez et al., 2004).

1.1 Research Objectives

The aim of this study is to investigate effects of combustion temperatures on soil physical and chemical properties and SOM transformations. Specifically, the objective of my thesis research is to determine:

1. How temperature of combustion affects critical soil physical and chemical properties,
2. The effect of temperature of combustion on quality and quantity of SOM,
3. The relationship of changes in soil physical and chemical properties with observed changes in SOM, and
4. Critical temperature thresholds for changes in soil properties.

Results of this study will contribute to a systematic evaluation of and development of capability to predict the effect of different intensity fires on soil physical and chemical properties.

2 Literature Review

Many ecosystems in the US and across the world depend on fires to maintain ecosystem health and productivity. Forest fires, for example, influence SOM dynamics through combustion of organic materials, production and deposition of charred necromass (PyC), increasing rates of soil erosion (Carroll et al., 2007), and by influencing several other soil physico-chemical conditions (C.I. Czimczik & Masiello, 2007; J. Lehmann et al., 2006; Schmidt & Noack, 2000). The effects of fire on SOM loss and other soil physical, chemical and biological properties depend on severity of fire, which in turn depends on moisture content, amount and type of fuel available, air temperature and humidity, wind, topography and fire intensity—where fires with longer durations cause more loss of SOM than fast moving, high temperature fires (González-Pérez et al., 2004).

The rate at which fire produces thermal energy is referred to as fire intensity. Based on maximum surface temperature reached, fires are often classified as low, medium or high intensity fires. Most forest fires burn at temperatures 200 to 300°C, whereas under heavy fuel loads surface temperatures might reach 500 to 700°C (Neary et al., 1999). Low intensity fires burn at surface temperature of up to 250°C, medium intensity fires reach surface temperatures of around 400°C, and high intensity fires burn at surface temperatures above 675°C (Janzen & Tobin-Janzen, 2008). Soil temperature thresholds for some important soil transformations are illustrated in Figure 2-1.

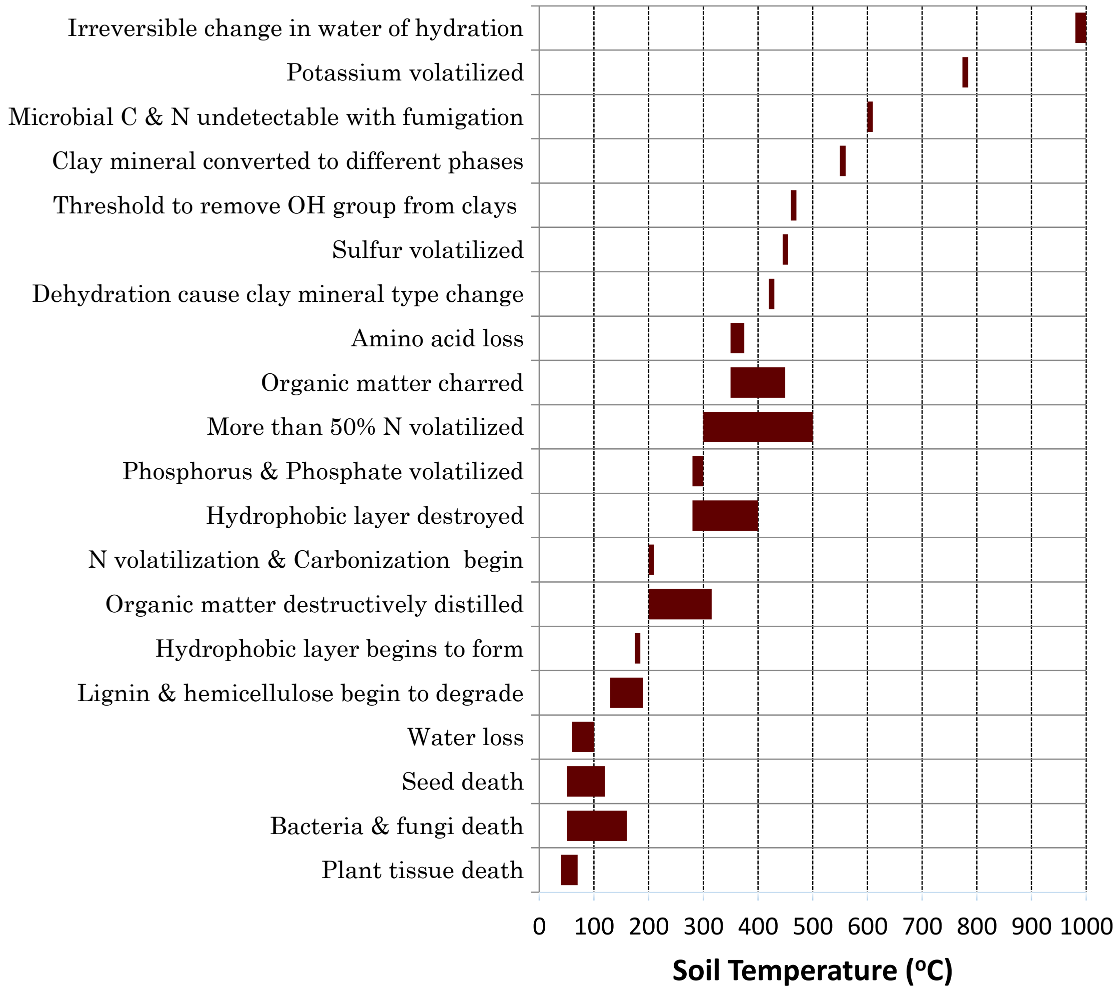

Figure 2-1 Temperature thresholds and ranges associated with various fire effects on some soil properties (from Massman et al. (2010). Lignin and hemicellulose threshold from Knicker (2007) and Microbial C and N threshold from Diaz-Ravina et al. (1992)).

Heat transfer through soil is a complex phenomenon involving conduction, convection and radiation (Michaletz & Johnson, 2007). Soil is a porous media that comprises the three states of matter (solid, liquid and gas) in one complex (Hillel, 1980). Penetration of heat down a soil profile depends on intensity and duration of fire as well as the ability of soil to transfer the heat (Steward et al., 1990). However only soil's heat capacity and thermal conductivity control soil heat flux during fires since conduction is the dominant mode of heat transfer during fires. In short duration or low severity fires temperatures typically reach 100 – 150°C at 5 cm depth with no significant change of temperature at 30 cm depth (L. F. DeBano, 2000). The ability of soil to conduct heat is also dependent on the soil water content. Until water completely vaporizes, soil subsurface temperature cannot rise above 95°C. However vaporized water carries latent heat through soils faster and deeper, implying that moisture initially protects soil against high temperature but the overall impact is it acts as a good heat conductor (Janzen & Tobin-Janzen, 2008).

SOM has a low threshold for transformation by fire and is the most affected constituent of soils. Soil carbon content generally decreases in surface layers immediately after fire. However, the effects of fire on SOM are typically numerous and complicated, including changes to SOM composition and rates of decomposition (Knicker, 2007). For example, in moderate intensity burns of around 400°C surface temperatures, temperatures reach about 175°C at 2.5 cm depth and 50ºC at 5 cm. Thus very significant charring of litter occurs at the surface with some charring of organic matter at 2.5 cm and the start of distillation of organic matter above 5 cm (Figure 2-1). In high intensity burns that reach surface temperature of 675ºC, significant distillation of volatile organic matter and some charring occurs up to depths of 5 cm (Janzen & Tobin-Janzen, 2008). Since SOM significantly controls many vital properties of soils, several of the changes in soil properties brought about by fire are attributed to changes in the SOM content and composition (DiCosty & Callaham, 2008). Some of the important soil properties that are influenced by changes in SOM amount and composition during fires include cation exchange capacity (CEC), soil structure, pore size distribution, and aggregation (Leonard F. DeBano, 1991).

González-Pérez et al. (2004) summarized the most important changes to SOM during fires as: 1) reduced solubility due to loss of external oxygen groups, 2) reduced chain length of fatty acids, alcohols and other alkyl compounds, 3) higher aromaticity of sugars and lipids, 4) production of PyC, 5) formation of heterocyclic N compounds, and 6) macromolecular condensation of humic substances. Latest studies in this area demonstrate that the molecular structure of plant biomass derived PyC depends on the combustion temperatures it was created under (Keiluweit et al., 2010). At combustion temperatures > 250ºC plant derived PyC retains most of its chemical constituents including amorphous lignin and hemicellulose, and crystalline cellulose. Between 350 – 450ºC the PyC increasingly undergoes dehydration and depolymerization of the biopolymers, leading to enrichment of small volatile dissociation products including ketones, aldehydes, carboxylic groups, and phenols. Above 450ºC the plant biomass derived PyC increasingly is characterized by aromatic, aliphatic, and O-containing components organized as an amorphous matrix surrounding turbostratic crystallites.

The changes in OM chemistry during fires are likely to lead to change in mineral-OM association in soil that have important implications for formation and stability of aggregates, and physical protection of OM from decomposition. Amount and chemical composition of OM in soil exerts a strong control on formation and stability of soil aggregates (Oades, 1995). Typically, high OM concentration and accumulation of condensed aromatic functional groups (such as those formed by combustion) tend to lead to formation of strong aggregates (Johannes Lehmann et al., 2008; Lichter et al., 2008; Sarkhot et al., 2007), that protect OM from decomposition (Blanco-Canqui & Lal, 2004) by physically isolating OM and making it inaccessible for decomposers (Six et al., 2000; Six et al., 1998; Six et al., 2002). Compared to the effect of fire on quality and quantity of SOM, the effect of forest fires on mechanisms of SOM stabilization has been investigated to a much lesser extent. The limited number of studies that are available show variable response of OM stabilization mechanism to fires, with some authors reporting a reduction in aggregation due to loss of binding agents (OM) (Fernandez et al., 1997; Giovannini et al., 1988). García-Oliva et al. (1999) reported that fire did not affect the micro-aggregates SOM pool, but decreased the macro-aggregate stabilized pool. On the other hand, some authors reported increased macro aggregation due to desiccation of soil gels and heat-induced changes in cementing metal (Fe and Al) oxides (Giovannini et al., 2001).

Effect of fire on soils also includes the addition of nutrient rich ash to soil (Badía & Martí, 2003b). The accumulation of ash has liming effect on soil which increase pH due to the accumulation of K- and Na-hydroxides and Mg- and Ca-carbonate rich ash, combined with the destruction of acid groups in the OM (Giovannini et al., 1990). This change in pH is especially significant with fires that burn at > 450°C. The liming effects of fire have been documented to have a positive role in biological recovery of soils after burn (Knicker, 2007). Electrical conductivity of soils also increases after fire mainly due to the release of inorganic ions from OM during combustion (Kutiel & Inbar, 1993). Cation exchange capacity (CEC), on the other hand, has been observed to decrease after burn due to loss in adsorption sites on SOM (Badía & Martí, 2003b; Knicker, 2007).

Fires have a drastic effect on soil biology. Most living organisms have fatal temperatures well below 100ºC (L. F. DeBano et al., 1998) and soil microbial biomass is concentrated in the topsoil, (Knicker, 2007). Threshold temperatures for bacteria and fungi are usually reached to a depth 5 cm or more in mineral soil during medium- or high-severity fires (Neary et al., 2008). The important documented effects of heating on soil microorganism include the direct killing of the microbial life forms or alterations of their environment, resource access, and community capabilities. In high intensity fires, for example, the entire topsoil is sterilized by fires (Knicker, 2007). Microbial groups differ in their sensitivity to changes in temperature or exposure to heat, for example, heterotrophic bacteria are generally more resistant than nitrifying bacteria while fungi are more sensitive than nitrifying bacteria (Leonard F. DeBano, 1991; Dunn et al., 1985). Soil moisture increases biological damage during fires since it is a better conductor and soil biology is more metabolically active in moist soils (Neary et al., 2008). For heterotrophic bacteria, a temperature of 120ºC in dry soil, or 120ºC in moist soil, reduces population size to 1%; while a temperature of 90ºC in dry, and 80ºC in moist soil is required to reduce the population size of nitrate oxidizing bacteria to 1%; and temperature of 60ºC in moist soil and 80ºC in dry soil is sufficient to reduce population size of soil fungi to 1% (L. F. DeBano et al., 1998). While there is a decrease in abundance of microbes in post-fire soils, the remaining microbes can have levels of activity that are greater than that of the pre-fire microbial community (Poth et al., 1995), leading to potential recovery of the affected microbial communities over annual timescales.

Formation of a hydrophobic layer is another alteration related to heating. Organic matter volatilization and subsequent condensation lower in the profile (within the upper 5cm of soil) forms a water-repellent layer (Leonard F. DeBano, 1991). Development of hydrophobic layer is observed at temperatures above 175ºC and is destroyed between 280 and 400°C temperature (L. F. DeBano, 2000). Development of a hydrophobic layer at or near the soil surface leads to changes to rates of water infiltration and hydrologic flow regimes in soil, with a potential to contribute to increasing rates of soil erosion post-fire (Carroll et al., 2007).

Effect of fire heating on aggregate strength is complex and depends on how fire has affected related properties such as organic matter, soil microbiology, water repellency and soil mineralogy (Mataix-Solera et al., 2011). So far there is no consensus in the literature on whether fire increases or decreases aggregate strength (Mataix-Solera et al., 2011). A recent study has found that low intensity fires that virtually do not affect SOM may weaken soil aggregation due to rapid pressure build-up inside pores as water is vaporized (Albalasmeh et al., 2013).

3 Methods

Soil samples were heated to six temperatures in muffle furnace. The resulting changes on soil properties were analyzed, including: mass loss, aggregate strength, aggregate size distribution, specific surface area, soil mineralogy through powder XRD spectroscopy, pH, cation exchange capacity, C and N concentrations (in bulk soil and in separate aggregate sizes) and C and N stable isotopic composition, and SOM composition through Fourier Transform Infrared (FTIR) spectroscopy. All methods listed below were used to analyze the samples. Three replicate samples were collected from five sampling sites for a total of 15 original samples. Seven sub-samples were taken from each sample for combustion treatment—six temperatures plus one unburnt control—for a total of 105 total samples.

The research process is illustrated in Figure 3-1.

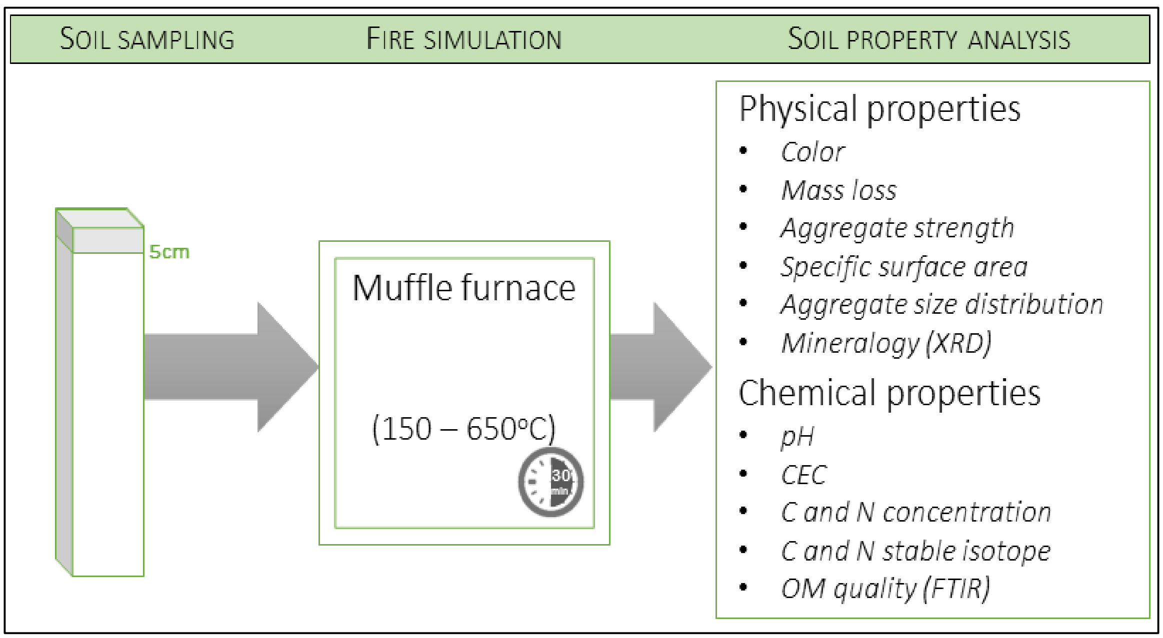

Figure 3-1 Research organization flow chart

3.1 Site description

Soils for this study were collected from the western slope of central Sierra Nevada of California (Figure 3-2). Soils in the elevation transect in the western slope of the Sierras provide a nearly ideal series of soils from a Climosequence where soil development is controlled by the large variation in climate over a relatively short distance (Dahlgren et al., 1997). The Sierra Nevada ecosystems are fire adapted and fire is a common perturbation that controls ecosystem health and plant productivity in the region.

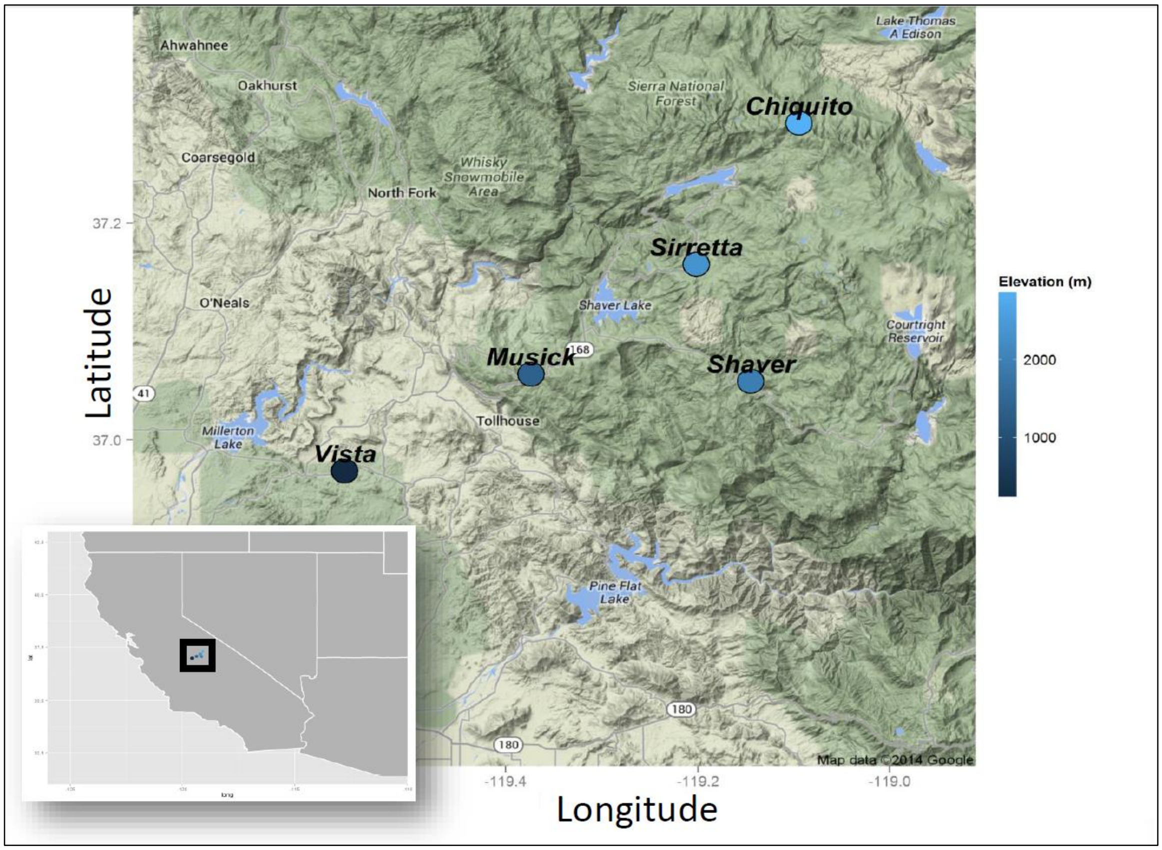

Figure 3-2 Sampling locations and soil series names.

3.1.1 Climate

The climate in the study sites is characterized as Mediterranean with warm to hot, dry summers and cool to cold, wet winters. The mean annual air temperature ranges from 16.7 at the lower site to 3.9°C at the highest elevation site and the mean annual precipitation ranges from 33 to 127 cm (Table 3-1). The winter snowline along the elevation transect occurs at about 1590 m elevation (California Department of Water Resources, 1952-1962), The majority of precipitation above this elevation (areas where our Shaver, Sirretta and Chiquito soil series are located) falls as snow while lower elevation precipitation is dominated by rain (where the Vista and Musick soil series are found) (Dahlgren et al., 1997; Rasmussen et al., 2007).

3.1.2 Vegetation

Vegetation across the elevational transect varies as a function of climate into four distinct zones. Vista soil series range lies within the oak woodland zone (elevations < 1008 m), Musick soils series range lies within oak/mixed-conifer forest (1008—1580 m) and mixed-conifer forest (1580—2626 m). Shaver and Sirretta soil series ranges lie within the mixed-conifer forest range while the Chiquito soil series range lies within the subalpine mixed-conifer forest range (2626—3200 m) (Figure 3-3).

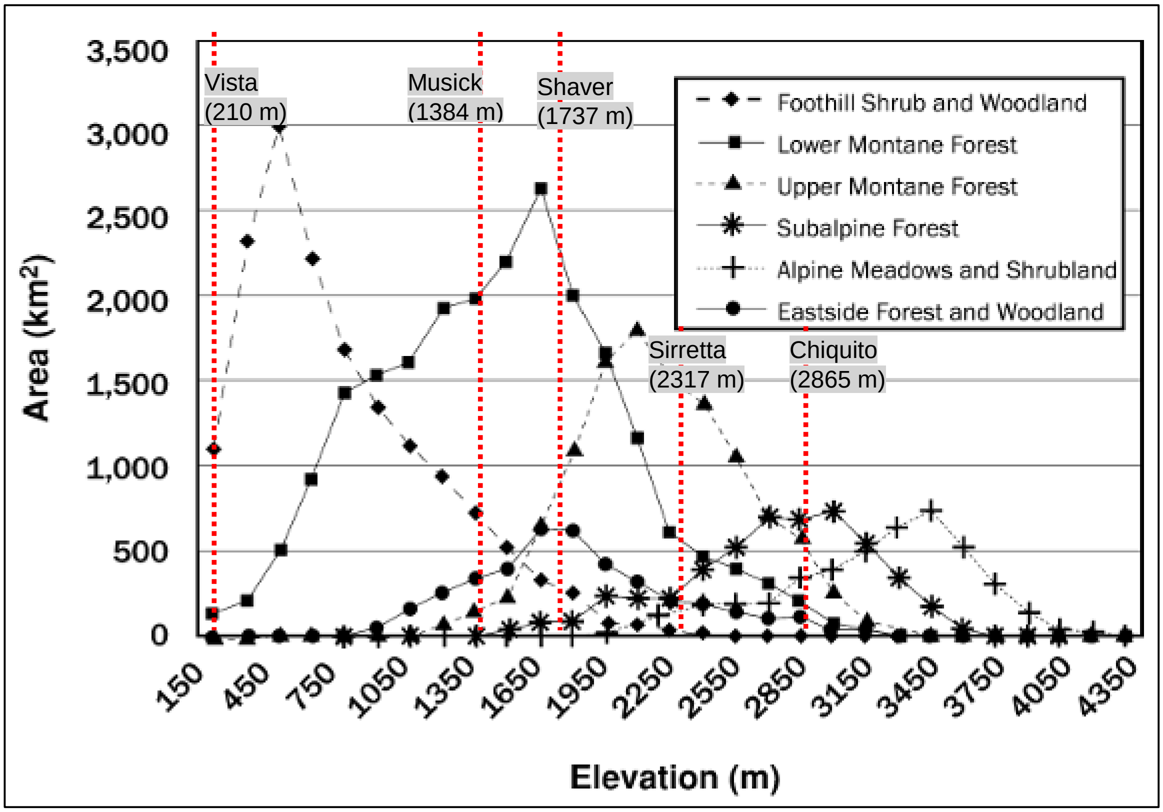

Figure 3-3 Area of ecological zones of Sierra Nevada by 500-m elevation bands (van Wagtendonk & Fites-Kaufman, 2006) with elevation of sampling sites annotated.

3.1.3 Soil

All the soils we sampled along the western slope of central Sierra Nevada are formed on granitic parent material. The major differences in soil properties are due to variability in climate and its implications on vegetation dynamics. The soils along this elevation transect have been previously characterized (Dahlgren et al., 1997; Harradine & Jenny, 1958; Huntington, 1954; Jenny et al., 1949; Trumbore et al., 1996). The location of study sites was based on a comprehensive study of soil characteristics of our sampling sites and soil development throughout the transect that was previously done by Dahlgren et al. (1997). Their study found that soil pH and base saturation generally decreased with elevation while organic carbon concentration in top 18 cm soil increased with elevation (10 to 30 g/kg), soil organic carbon, base saturation and clay mineralogy change in continuous progression with elevation while pH, soil color and clay and secondary Fe oxide concentration show a step change at about 1600 m (elevation of present-day average effective winter snow-line). With increase in elevation, increase in desilication and hydroxyl-Al interlayering of 2:1 layer silicates was also observed.

Table 3-1 Soil classification and site description for the five sites along elevational transect in the western slopes of the Sierra Nevada (adapted from Dahlgren et al. (1997))

Soil Series	**Elevation (m)**	**Ecosystem**	**MAT[a] (°C)**	**MAP[b] (cm)**	**Precip[c]**	**Dominant vegetation (listed in order of dominance)**	**Soil taxonomy (family)**
Vista	210	Oak woodland	16.7	33	Rain	Annual grasses; *Quercus douglasii*; *Quercus wislizeni*	Coarse-loamy, mixed, superactive,thermic; Typic Haploxerepts
Musick	1384	Oak/mixed-conifer forest	11.1	91	Rain	*Pinus ponderosa*; *Calocedrus decurrens*; *Quercus kelloggii*; *Chamaebatia foliolosa*	Fine-loamy, mixed, semiactive, mesic; Ultic Haploxeralf
Shaver	1737	Mixed-conifer forest	9.1	101	Snow	*Abies concolor*; *Pinus lambertiana*; *Pinus ponderosa*; *Calocedrus decurrens*	Coarse-loamy, mixed, superactive, mesic; Humic Dystroxerepts
Sirretta	2317	Mixed-conifer forest	7.2	108	Snow	*Pinus jeffreyi*; *Abies magnifica*; *Abies concolor*	Sandy-skeletal, mixed, frigid; Dystric Xerorthent
Chiquito[d]	2865	Subalpine mixed-conifer forest	3.9	127	Snow	*Pinus contorta murrayana*; *Pinus monticola*; *Lupinus* species	Sandy-skeletal, mixed; Entic Cryumbrept

[a] Mean annual air temperature, calculated from regression equation of Harradine and Jenny (1958);
[b] Mean annual precipitation.
[c] Dominant form of precipitation.
[d] Tentative soil series

3.2 Sample collection

I collected soils from the top 5 cm depth of five sites along the elevation gradient (between 210 to 2865 meters above sea level) on the western slopes of central Sierra Nevada mountain ranges (Table 3-2). Soils samples were collected from sites that were previously investigated by Dahlgren et al. (1997). Sampling was conducted on October 1, 2013.

Table 3-2 Elevation and coordinates of the locations where the soils for this study were collected

Site elevation (m)	Soil series	Geographic coordinate (degrees)
210	Vista	36.97141 N, 119.56800 W
1384	Musick	37.06073 N, 119.37348 W
1737	Shaver	37.05405 N, 119.14498 W
2317	Sirretta	37.16189 N, 119.20198 W
2865	Chiquito	37.29214 N, 119.09464 W

Three replicates were sampled from each site. The replicates were taken approximately 10 meter apart from each other in a triangular formation. Soils were stored at 15°C overnight and air dried. Air-dried soils were sieved and, I used the fraction of the soils that passed a 2mm sieve for all the analyses in my research. Along with the bulk samples, I collected core samples from each location for measurement of bulk density by hammering cylindrical cores (5 cm long) into the ground. The collected soil was oven dried overnight at 105°C and weighed for bulk density and gravimetric moisture content calculation. Bulk density and selected properties of the five soils are presented in Table 3-3.

Table 3-3 Bulk density, water content, pH, C concentration, cation exchange capacity (CEC), specific surface area (SSA) and particle size distribution for the five soils (mean ±standard error, n=3)

Soil series and elevation (m)	**Bulk density (g/cm^3)**	**Gravimetric water content (%)**	**pH ($CaCl_2$)**	**Carbon (%)**	**CEC ($cmol_c/kg$)**	**SSA (m^2/g)**	**Particle size distribution (%)***		
							Sand	**Silt**	**Clay**
Vista (210)	1.26 ±0.07	0.7 ±0.0	5.53 ±0.0	1.51 ±0.2	8.40 ±1.1	1.75 ±0.2	79	11	10
Musick (1384)	0.90 ±0.06	9.3 ±1.6	4.67 ±0.1	7.66 ±0.8	25.20 ±2.0	4.98 ±0.3	60	27	15
Shaver (1737)	0.98 ±0.06	8.3 ±1.1	4.85 ±0.3	2.84 ±0.2	10.67 ±2.1	3.08 ±0.3	80	15	5
Sirretta (2317)	0.61 ±0.09	9.9 ±2.2	4.54 ±0.1	4.74 ±0.8	12.23 ±2.6	6.63 ±0.8	80	15	5
Chiquito (2865)	1.17 ±0.03	6.1 ±1.9	3.96 ±0.1	4.10 ±0.2	6.03 ±1.8	1.00 ±0.04	80	16	4

* particle size distribution of top soil profile: 0 – 6 cm for Chiquito and Sirretta, 0 – 4 cm for Shaver, 0 – 29 cm for Musick, and 0 – 14 cm for Vista soils (from Dahlgren et al. (1997)).

3.3 Combustion process

Samples were placed on 7 cm diameter porcelain flat capsule crucibles. To ensure consistent combustion of the entire sample and avoid creating a gradient of temperature exposure within the sample, the sample was packed at a constant 1 cm height from the base of the crucible. Soils were heated in muffle furnace to six temperatures (ambient, 150, 250, 350, 450 and 650°C). A heating rate of 3°C min^{-1} was followed and samples were held at the selected temperature for 30 min and slowly cooled to touch and stored in air-tight bags prior to analysis.

The temperature range used in this study was selected based on previous studies that investigated the effect of fire on soil. The temperature range was chosen to correspond to the three categories of fire intensity that are based on maximum surface temperatures reached, that is: low intensity surface temperature (250°C); medium intensity (400°C); and high intensity (675°C) (L. F. DeBano et al., 1977; Janzen & Tobin-Janzen, 2008; Neary et al., 1999). This temperature range also correspond to temperature thresholds that produce the most important thermal reactions of soils, as evidenced by differential thermal analyses (Giovannini et al., 1988; Soto et al., 1991; Varela et al., 2010).

A slow, 3°C min^{-1} heating rate (Fernandez et al., 2001; Fernández et al., 1997; Varela et al., 2010) is preferred to prevent sudden combustion when the soil's ignition temperature is reached at about 220°C (Fernández et al., 1997). Such slow heating of topsoil is sometimes not the case in real fires and Albalasmeh et al. (2013) has shown that a slow rate of heating may underestimate the effect of fires on weakening aggregates stability of moist soils. To avoid possible moisture related effect, soils were oven dried at 60°C overnight prior to heating treatment.

Once the set temperature is reached, samples were exposed to the set temperatures for a period of 30 minutes. Thirty minutes is approximately equivalent to the time it takes to burn off small dry logs (Chandler et al., 1983; Stoof et al., 2010) and has become the standard in laboratory soil heating experiments (Fernandez et al., 2001; Giovannini, 1994; Varela et al., 2010). Although some studies use slightly longer time; for example, Zavala et al. (2010) used 40 minutes and Giovannini et al. (1988) used 60 min; many similar laboratory fire simulation experiments used 30 minutes of heating time (Albalasmeh et al., 2013; Badía & Martí, 2003a, 2003b).

3.4 Analysis of soil properties

3.4.1 Physical properties

Dry-aggregate size distribution of samples was measured by sieving. Samples were dry sieved into three aggregate size classes: 2–0.25 mm (macro-aggregates) ,0.25–0.053 mm (micro-aggregates) and <0.053 mm (silt and clay sized particles). Similar aggregate size classes have been used in soil organic matter stabilization related study by Six et al. (2000).

Water stable aggregate percent of soils was measured by wet-sieving following the methods of Nimmo and Perkins (2002). For this method, a wet-sieving apparatus (Eijkelkamp Agrisearch Equipment, Giesbeek, The Netherlands) with 0.25mm mesh size was used. In this procedure, a four grams of soil, was pre-wetted by capillary rise. The sieves are then shaken in a regular up-down motion with a vertical distance of 1.3 cm and a rate of 35 cycles per minute. Soil collected in the cans is weighed (M_1) after evaporating the supernatant water in oven. The samples remaining in the sieve are subjected to a second round of wet-sieving using another set of cans filled with dispersing solution (2 gL^{-1} of sodium hexametaphosphate for the soils with pH >7 and 2 gL^{-1} NaOH for the soils with pH <7). Samples are sieved until all particles smaller than the screen opening have gone through and mass of soil collected in the second set of cans (M_2) is determined by evaporating supernatant solution in oven and subtracting the weight of the dispersing-agent. The stable aggregate fraction is calculated as:

$$S = \frac{M_2}{M_1 + M_2} \times 100\%$$

Specific surface area was measured by an automated N_2-BET analyzer (Micromeritics Tri-Star 3000, Micromeritics Instrument Corporation, Norcross, GA, USA). The instrument measures specific surface areas by evaluating the amount of nitrogen adsorbed, at liquid nitrogen temperature, by sample in conjunction with the Brunauer, Emmett, and Teller (BET) equation (Pennell, 2002). Soil samples were oven dried at 60°C for over 36 hours prior to the analyses. Approximately 1 g of soil was out-gassed for half hour using flow of N_2 gas, the outgassing station (Micromeritics Analyzer FlowPrep) mantle was set to a temperature of 105°C. Measurement was done using ultra-high purity N_2 gas and the instrument was set to seven point measurement. The isotherm is analyzed using Micromeritics software.

3.4.2 Chemical properties

Soil pH was measured 1:2 suspension:solution ratio mixtures in a deionized water and 0.01 M $CaCl_2$. Five grams of soil was mixed by shaking with 10 ml of solution and allowed to stand for 30 minutes with stirring every 10 minutes. The pH reading was taken by placing electrodes directly in the sediment soil immediately after stirring (Thomas, 1996).

XRD analysis was done using an X-ray diffractometer (PANalytical Xpert Pro diffractometer, PANalytical Inc., Westborough, MA, USA). I used XRD analytical technique for identification of mineral phases and crystal structures (Schulze & Dixon, 2002). Soil samples were ground to fine powder consistency using ball-mill (8000M MiXer/Mill, with a 55 ml tungsten Carbide Vial, SPEX SamplePrep, LLC, Metuchen, NJ, USA) and oven dried at 60°C for over 36 hours. Samples were scanned at generator setting of 45 mA by 40 kV. Scan start position was set to 5°2θ and end position was set to 120°2θ. Scan step time was set to 10 seconds at step interval size of 0.0170 °2θ. Two or three replicate measurements were run for each sample and samples were measured in random order.

Cation exchange capacity (CEC) was measured by the barium exchange method at the UC Davis Analytical Laboratory (University of California-Davis, College of Agriculture and Environmental Sciences, Davis, USA). Barium was used to quantitatively displace soil exchangeable cations, excess barium was removed by four deionized water rinses. A known quantity of calcium is then exchanged for barium and excess solution calcium is measured in order to determine CEC by the difference in the quantity of the calcium added and the amount left in the resulting solution. The method has a detection limit of approximately 2.0 $cmol_c/kg$ (UCDavis Analytical Lab, 2014).

Carbon (C) and nitrogen (N) concentrations and stable isotope ratios were measured using an elemental combustion system (Costech ECS 4010 CHNSO Analyzer, Costech Analytical Technologies, Valencia, CA, USA) that is interfaced with a mass spectrometer (DELTA V Plus Isotope Ratio Mass Spectrometer, Thermo Fisher Scientific, Inc, Waltham, MA, USA). For the analyses, air-dried < 2mm soil samples were ground to powder consistency on a ball-mill (8000M MiXer/Mill, with a 55ml tungsten Carbide Vial, SPEX SamplePrep, LLC, Metuchen, NJ, USA) and oven dried at 60°C for over 36 hours. The values for C and N concentration were corrected for oven dried weights by oven-drying subsamples at 105°C. The stable isotope ratios are presented using the δ notation (per mill, ‰) as $\delta\ ^{13}C$ and $\delta\ ^{15}N$ calculated as:

$$\delta‰ = \frac{R_{sample} - R_{standard}}{R_{standard}} \times 1000$$

Where R is ratio of ${}^{13}C/{}^{12}C$ for $\delta\ ^{13}C$, and ${}^{15}N/{}^{14}N$ for $\delta\ ^{15}N$

The standards used for analyses are atmospheric N_2 for $\delta\ ^{15}N$ and Vienna Pee Dee Belemnite (VPDB) $\delta\ ^{13}C$.

Soil organic matter composition was analyzed using Fourier-transform infrared (FTIR) spectroscopy on a Bruker IFS 66v/S vacuum FT-IR spectrometer (Bruker Biosciences Corporation, Billerica, MA, USA). I used diffuse reflectance infrared Fourier-transform (DRIFT) technique (Ellerbrock & Gerke, 2013; Parikh et al., 2014). Powder samples were dried overnight at 60°C and scanned in mid-IR from 4000 to 400 cm^{-1}. Non-KBr diluted samples were used after preliminary analyses revealed that dilution is not necessary for soils with low (<10%) organic matter concentrations (Ellerbrock & Gerke, 2013; Reeves III, 2003). Furthermore, using non-diluted samples was also favored because, even though dilution has the advantage of increased spectral quality, non-KBr diluted DRIFT has advantage in that it reduces sample preparation to a minimum, reduces possible interference by absorbed matrix hydration, maintains higher sensitivity, and the use of relatively larger samples provide better representation of sample heterogeneity (Janik et al., 1998).

3.5 Statistical analysis

All data tests with numerical output were reported as mean ± standard error. I used Analysis of Variance (ANOVA) to test for statistically significant differences in measurement means among samples. Pairwise comparisons between temperatures (treatment) was made using Tukey's HSD test at $p<0.05$ significance level. All statistical analysis was conducted using R statistical software (r-project.org).

4 Results

Summary of all the data that was produced as part of my master's thesis work is presented in Appendix I: Summary of analysis data). The results section is organized in sections based on the specific analysis that I performed according to the procedures described in Chapter 3.

4.1 Physical properties

4.1.1 Soil color

I observed a marked difference in soil color change with increasing heating temperature. Table 4-1 shows Munsell colors across heating temperatures. Initially, dry soils became darker at mid temperatures ranges (150 – 250°C), losing Munsell value. At higher temperatures soils became increasingly redder with increase in chroma. At temperatures above 550°C (650°C for Shaver soils) soils become increasingly redder and lighter, with higher Munsell value and hue change from 10YR to 7.5YR. Moist soils followed a similar pattern with lower Munsell value and chroma.

Table 4-1 Soil color change across heating temperatures.

Soil series and elevation (m)		Munsell color at Temperature (°C)						
		unburnt	150	250	350	450	550	650
Vista (210)	Dry	10YR 6/3	10YR 5/3	10YR 4/3	10YR 4/3	10YR 5/8	7.5YR 5/6	7.5YR 5/6
	Moist	10YR 3/2	10YR 3/2	10YR 3/2	10YR 2/2	10YR 2/2	7.5YR 3/4	7.5YR 3/4
Musick (1384)	Dry	10YR 3/3	10YR 3/3	10YR 2/1	10YR 2/2	10YR 5/6	7.5YR 5/8	7.5YR 6/6
	Moist	10YR 2/1	10YR 2/2	10YR 2/1	10YR 2/1	10YR 2/2	7.5YR 5/6	7.5YR 5/6
Shaver (1737)	Dry	10YR 5/2	10YR 4/2	10YR 3/3	10YR 3/3	10YR 5/8	10YR 5/6	7.5YR 6/6
	Moist	10YR 2/2	10YR 2/2	10YR 2/1	10YR 2/1	10YR 2/1	7.5YR 3/4	7.5YR 4/6
Sirretta (2317)	Dry	10YR 5/4	10YR 4/3	10YR 2/2	10YR 3/4	10YR 4/4	7.5YR 6/6	7.5YR 6/6
	Moist	10YR 3/2	10YR 2/2	10YR 2/1	10YR 2/2	10YR 2/2	7.5YR 4/6	7.5YR 5/6
Chiquito (2865)	Dry	10YR 6/3	10YR 4/2	10YR 3/2	10YR 3/3	10YR 6/3	7.5YR 6/4	10YR 6/6
	Moist	10YR 2/2	10YR 2/2	10YR 2/1	10YR 2/1	10YR 2/2	7.5YR 4/4	10YR 6/6

4.1.2 Mass loss

For all soils, I observed a consistent pattern of continuous mass loss with increases in temperature of combustion until 450ºC. The rate of mass loss started to level off after 450ºC. In each case, between 250 and 450°C all soils lost 5 to 15% of their initial dry mass (Figure 4-1). I observed the lowest mass loss for the soils from the lowest elevation site (Vista) compared to the highest mass loss from the Musick soils from the 1384 m.a.s.l. site, while the maximum mass loss remained at about 10% for all other soils. For all the samples, rapid mass loss due to combustion occurred between 150 and 450ºC. For all soils, there was no statistically significant difference in mass loss, compared to the unburnt samples, at 150°C. On the other end of the temperature spectrum, for all samples, there was no statistically significant difference in mass loss after 450ºC.

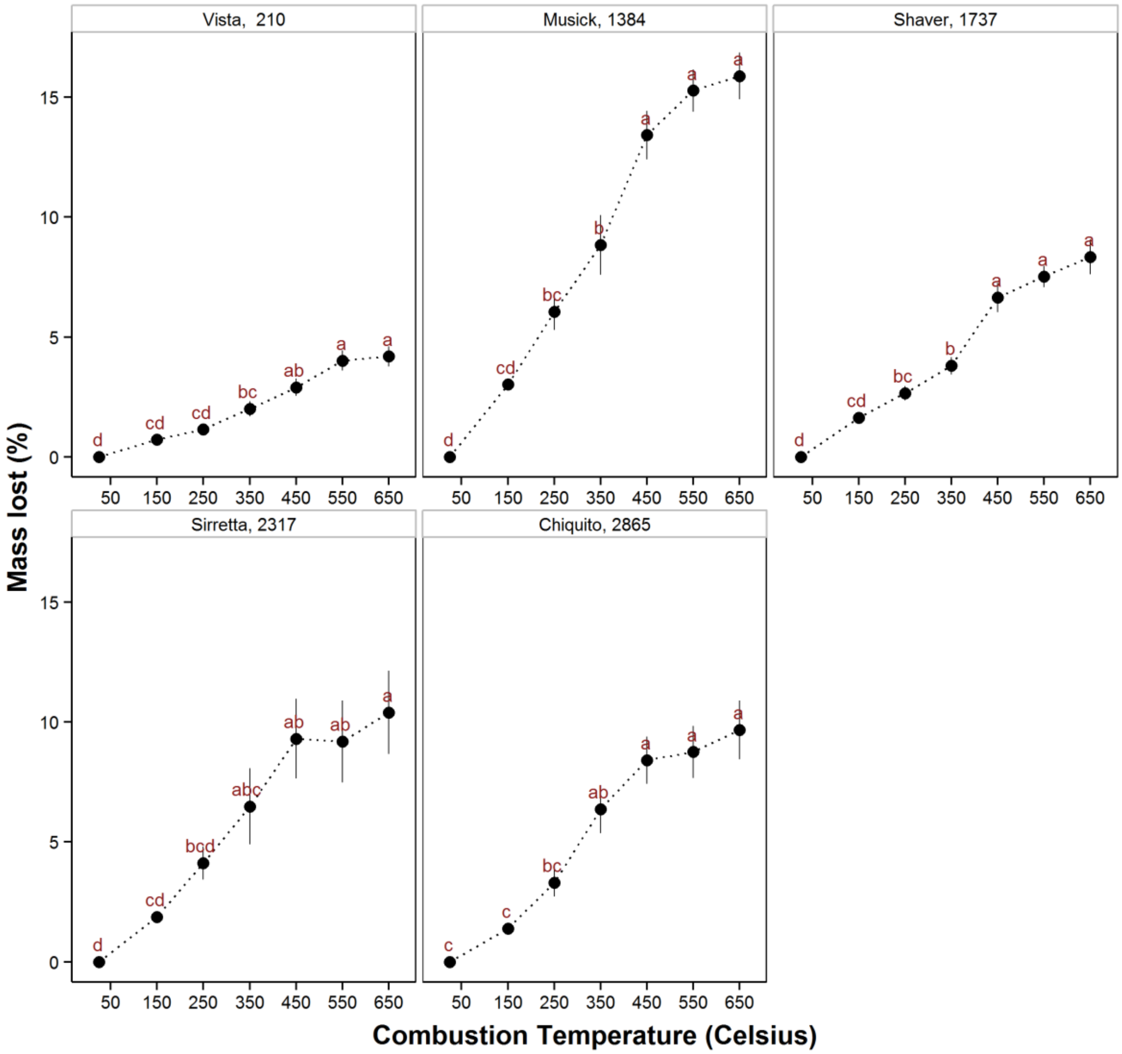

Figure 4-1 Percent mass lost with heating (error bars represent standard error where n=3). Different letters represent significantly different means (p<0.05) at each temperature after Tukey's HSD testing.

4.1.3 Soil aggregate stability

Aggregate stability showed a stepwise response to increase in combustion temperature (Figure 4-2). Initial mean water stable aggregate percent for Vista (210 m) and Shaver (1800 m) soils was in the range 30 – 35% while it was 45 – 55% for the rest of our soils. All soils showed statistically insignificant change in aggregate stability upon combustion to up to 250ºC, but heating at higher temperatures led to decrease in aggregate strength. Upon heating at temperatures greater than 450°C mean water stable aggregate percent dropped to 15 – 20% for all soils. A statistically significant decrease ($p < 0.05$) was observed in the temperature range 350 – 550°C except for Vista (210 m) and Sirretta (2317 m). The lowest elevation, Vista soil showed an increase in aggregate stability up to 350ºC (statistically insignificant compared to initial), but aggregate stability decreased after combustion at higher temperatures (statistically significant). Sirretta also showed a similar pattern to Vista, but the increase in aggregate stability only occurred up to 150ºC, with a marked decrease at higher temperatures.

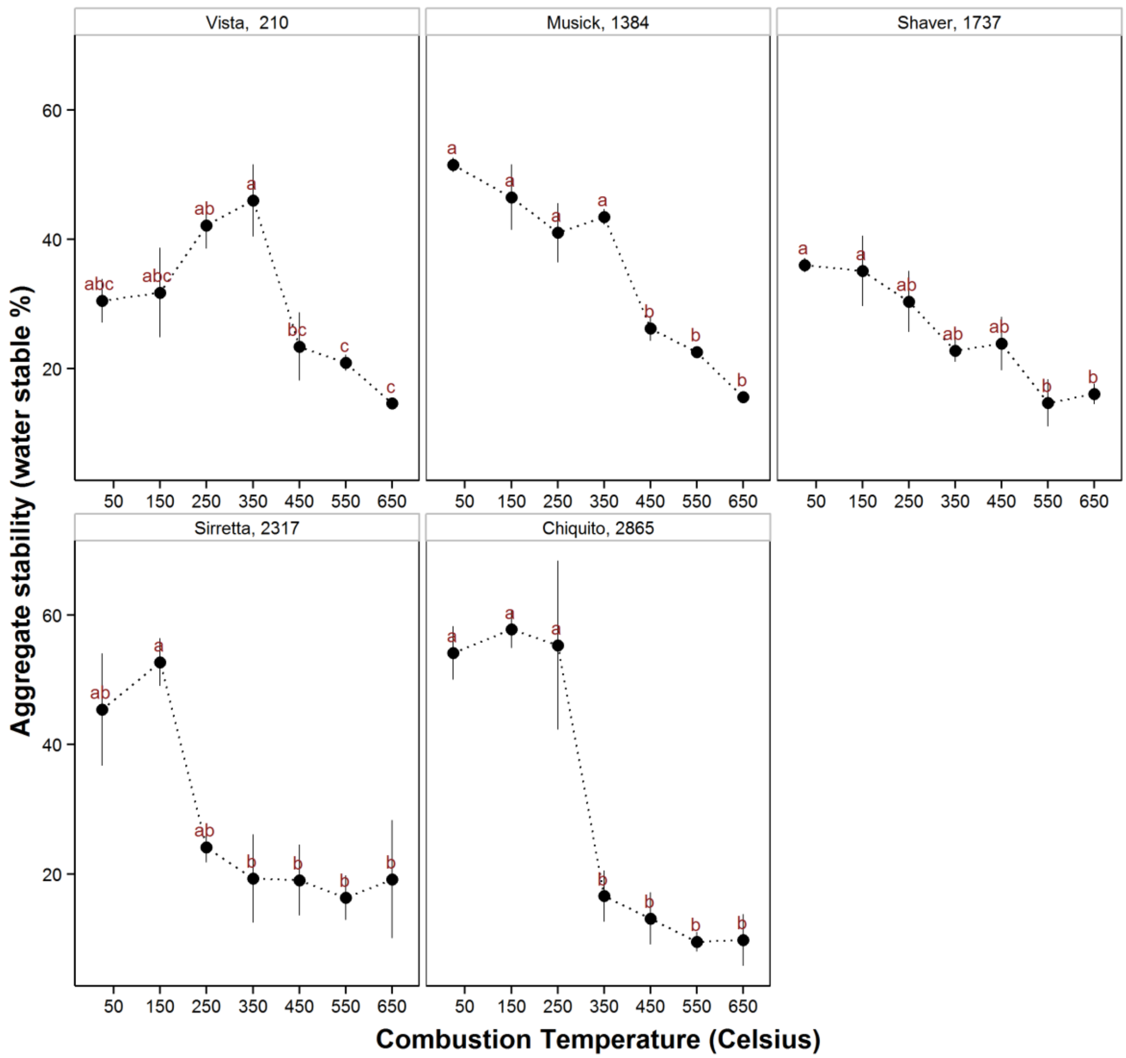

Figure 4-2 Water stable aggregate percent with heating (error bars represent standard error where n=3). Different letters represent significantly different means ($p<0.05$) at each temperature after Tukey's HSD testing.

4.1.4 Aggregate size distribution

With increase in heating temperature, all soils showed a decrease in macro-aggregate fraction accompanied by increase in micro-aggregate and silt-clay sized fractions (Figure 4-3). For the two lower elevation soils (Vista and Musick) the decrease in macro-aggregate fraction was over 10% while the rest of the soils only experienced less than 5% change. The decrease was not statistically significant for all the soils except for Musick soils (1390 m) which showed a statistically significant decrease in macro-aggregate between 150 and 350°C.

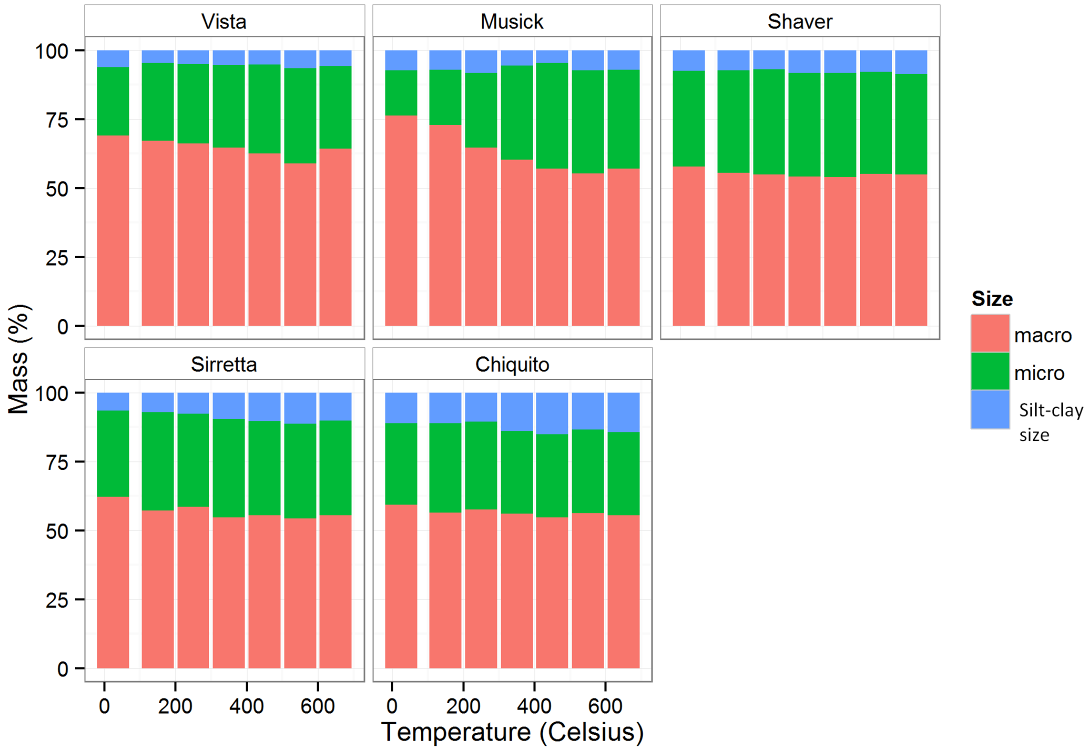

Figure 4-3 Weight fraction of aggregate sizes: macro (2-0.25 mm), micro (0.25-0.053 mm) and silt-clay (<0.053 mm) sizes.

4.1.5 Specific surface area

For all soils, I observed a step-wise increase in specific surface area (SSA) when the samples were combusted to between 250 to 450°C (Figure 4-4). The mass loss adjusted changes in SSA between 250 and 450°C were statically significant at $p<0.05$ for all soils, except the high elevation soils Sirretta (2317 m) and Chiquito (2865 m), Sirretta soils showed a lot of variability and did not show any significant change in SSA throughout the temperature range while the Chiquito soil showed statistically significant increase between low temperature 150 – 250°C and higher temperature 350 – 550°C range. The pattern of change in SSA was similar for all soils with the lowest SSA being observed at 250°C. The soils showed highest SSA at either 350°C (for Musick and Chiquito soils) or 450°C (Vista and Shaver soils). I observed a slightly decreasing trend of SSA at temperature > 550ºC.

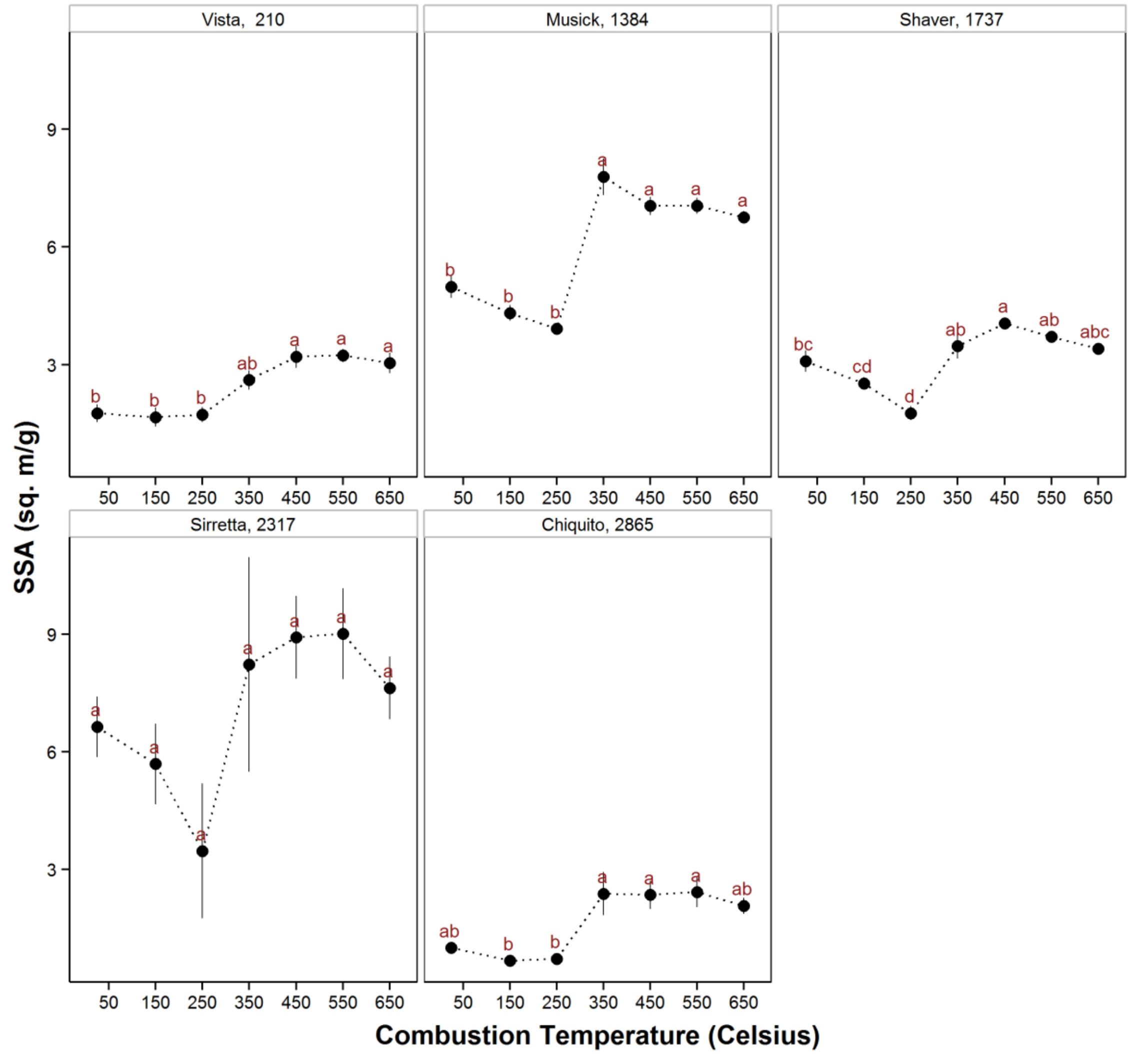

Figure 4-4 Mass lost adjusted specific surface area with combustion temperature (error bars represent standard error where n=3). Different letters represent significantly different means ($p<0.05$) at each temperature after Tukey's HSD testing.

4.2 Chemical properties

4.2.1 Soil pH

Initially, all the soils I investigated were from slight to moderately acidic. All soils showed a consistent pattern of increasing pH with increase in heating temperature (Figure 4-5). All soils showed a sharp increase in pH (2.5 – 5 units) when heated between 250 and 450°C. The largest change in soil pH with increasing temperature was observed for the Musick soil (1384 m) that reached the largest pH of 10 after heating of >550ºC. The lowest final pH after heating was observed for the highest elevation soil, Chiquito (2865 m), that reached pH of 7.5 after heating at >550ºC.

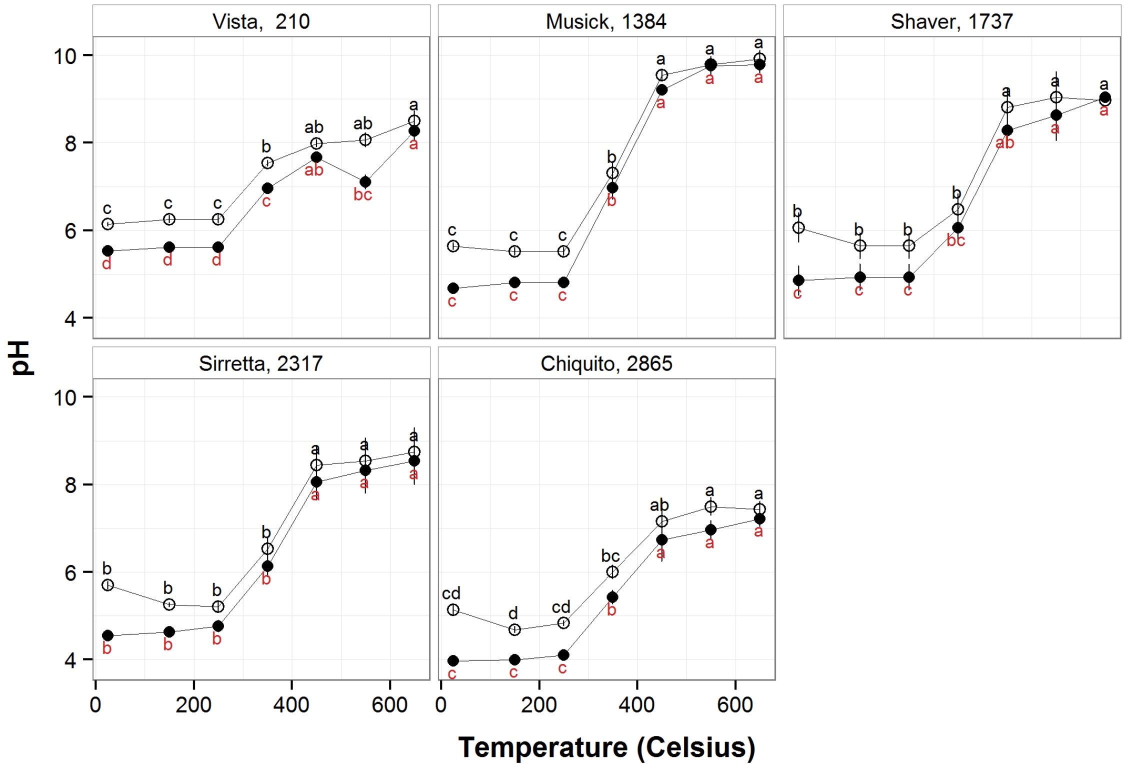

Figure 4-5 Change in soil pH (measured on 2:1 solution:soil ratio) with heating (geometric means, error bars represent standard error where n=3). Open circles measured in water and closed circles measured in $CaCl_2$ solution. Different letters represent significantly different means ($p<0.05$) at each temperature after Tukey's HSD testing.

4.2.2 X-ray diffraction spectroscopy

The results of changes in soil mineralogy in response to heating are presented for basic mineral groups as: feldspar (microcline and orthoclase); plagioclase (albite and oligoclase); amphibole; mica/ illite (biotite); kaolinite; smectite; gibbsite; and other phyllosilicate (montmorillonite and vermiculite). We identified vermiculite with low confidence, since we did not correct with oriented clay treatments, hence it is not certain if the identified peaks are indeed representative of vermiculite, chlorite, or both.

The XRD analysis was done on bulk soil samples and therefore the resolution, especially the quantitative analysis using retveld, is low. The study soils showed significant transformations in soil mineralogy with heating due to dehydration and de-hydroxylation of clay minerals. Layer silicates tended to collapse structurally from the removal of H_2O and –OH groups resulting in the shifted peaks as shown in the XRD diagrams (Figure 4-6 to Figure 4-10). A summary of the main constituent mineral groups that were identified with XRD is shown in Figure 4-11. Across the entire elevation transect, the biggest changes in distribution of mineral groups in response to heating temperatures were observed for mica/illite, kaolinite, plagioclases, and amphibole.

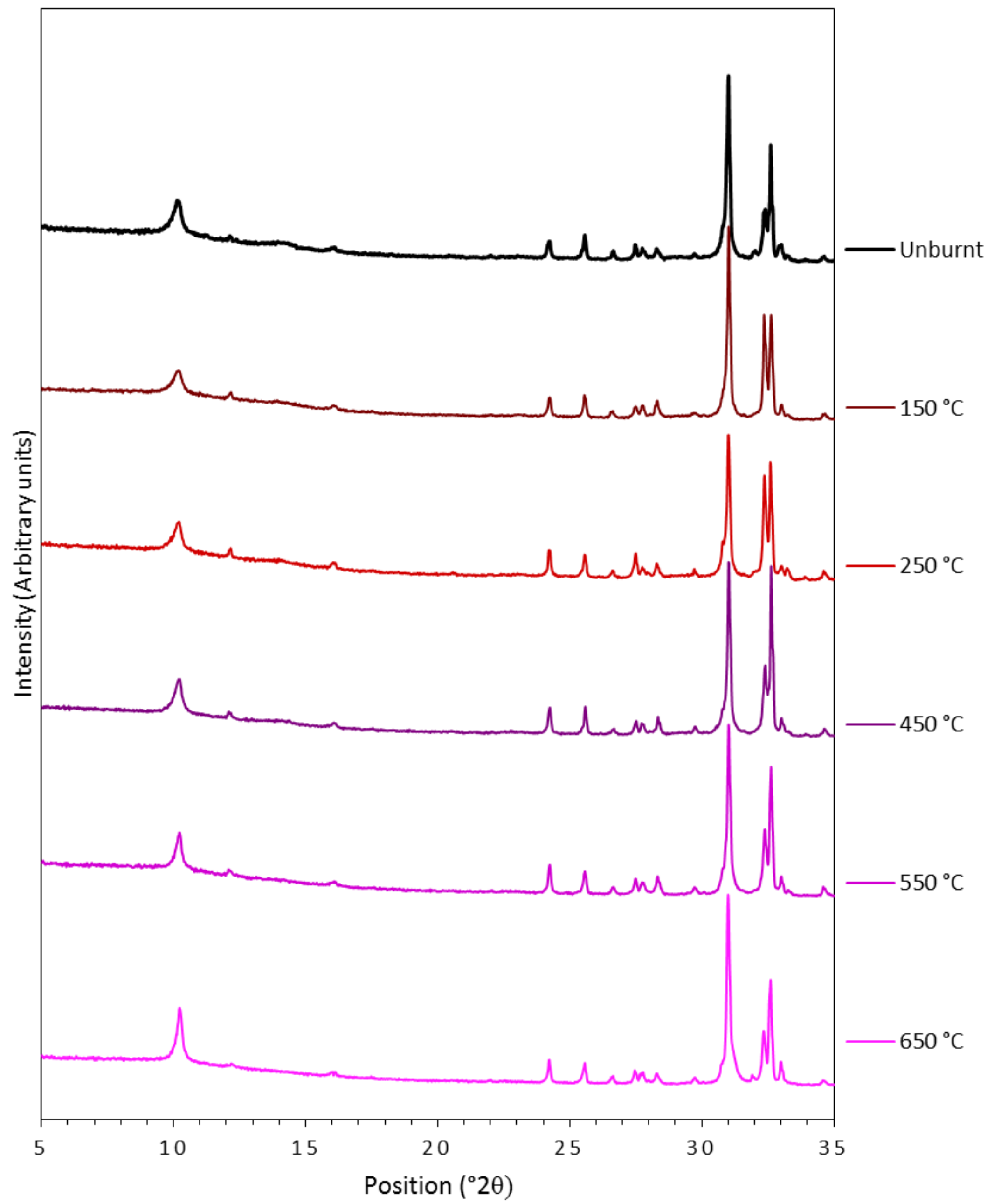

Figure 4-6 XRD diagram across combustion temperature: Vista soils

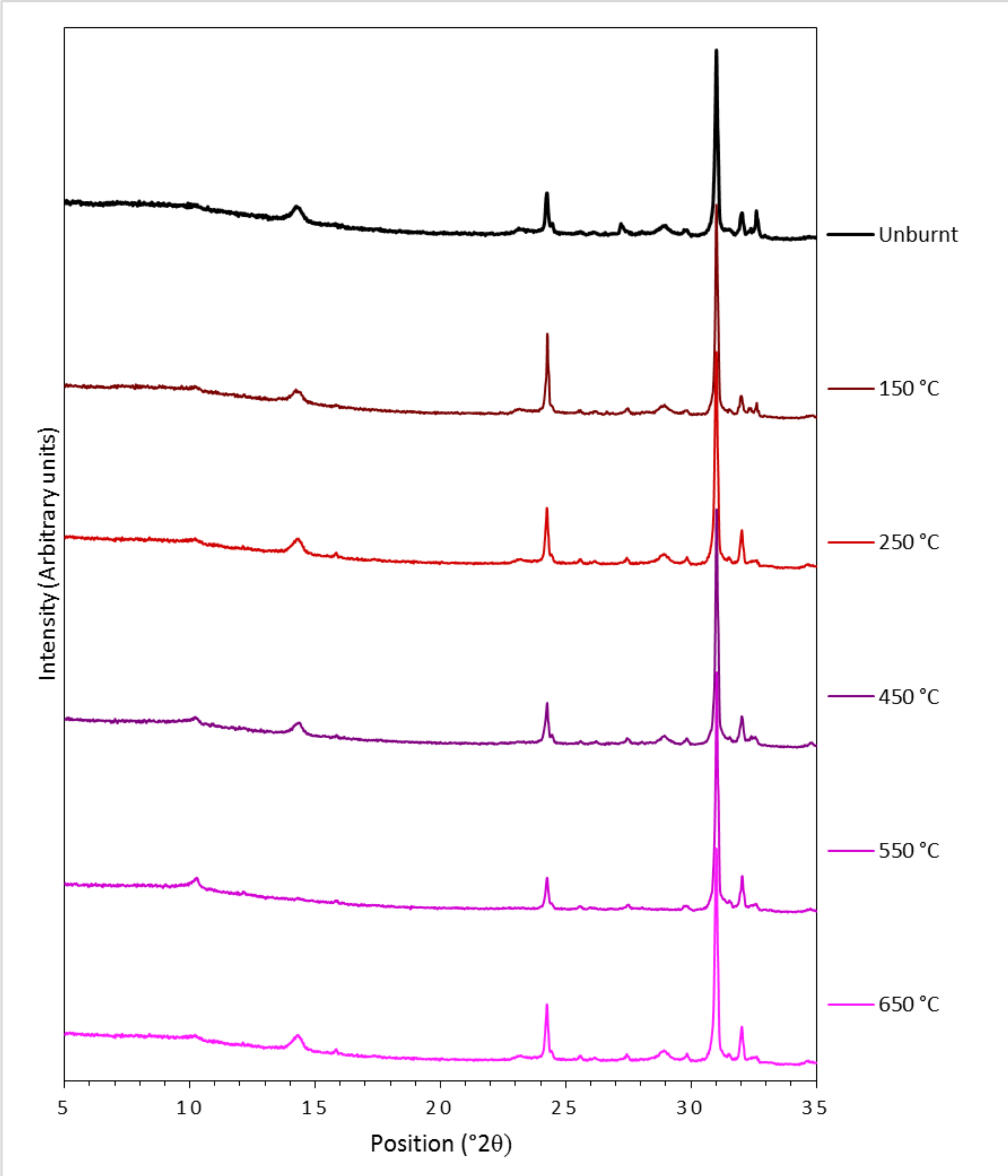

Figure 4-7 XRD diagram across combustion temperature: Musick soils

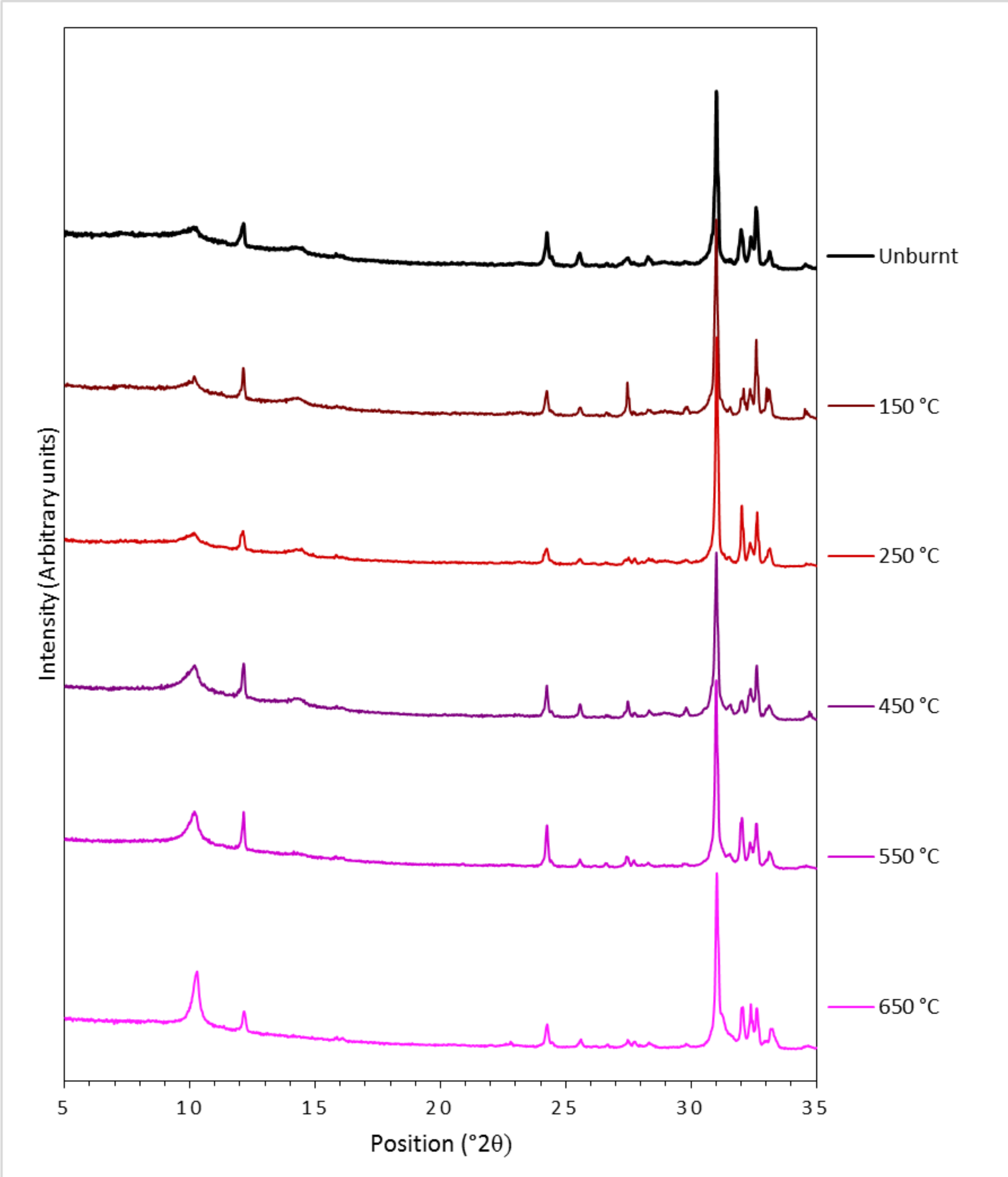

Figure 4-8 XRD diagram across combustion temperature: Shaver soils

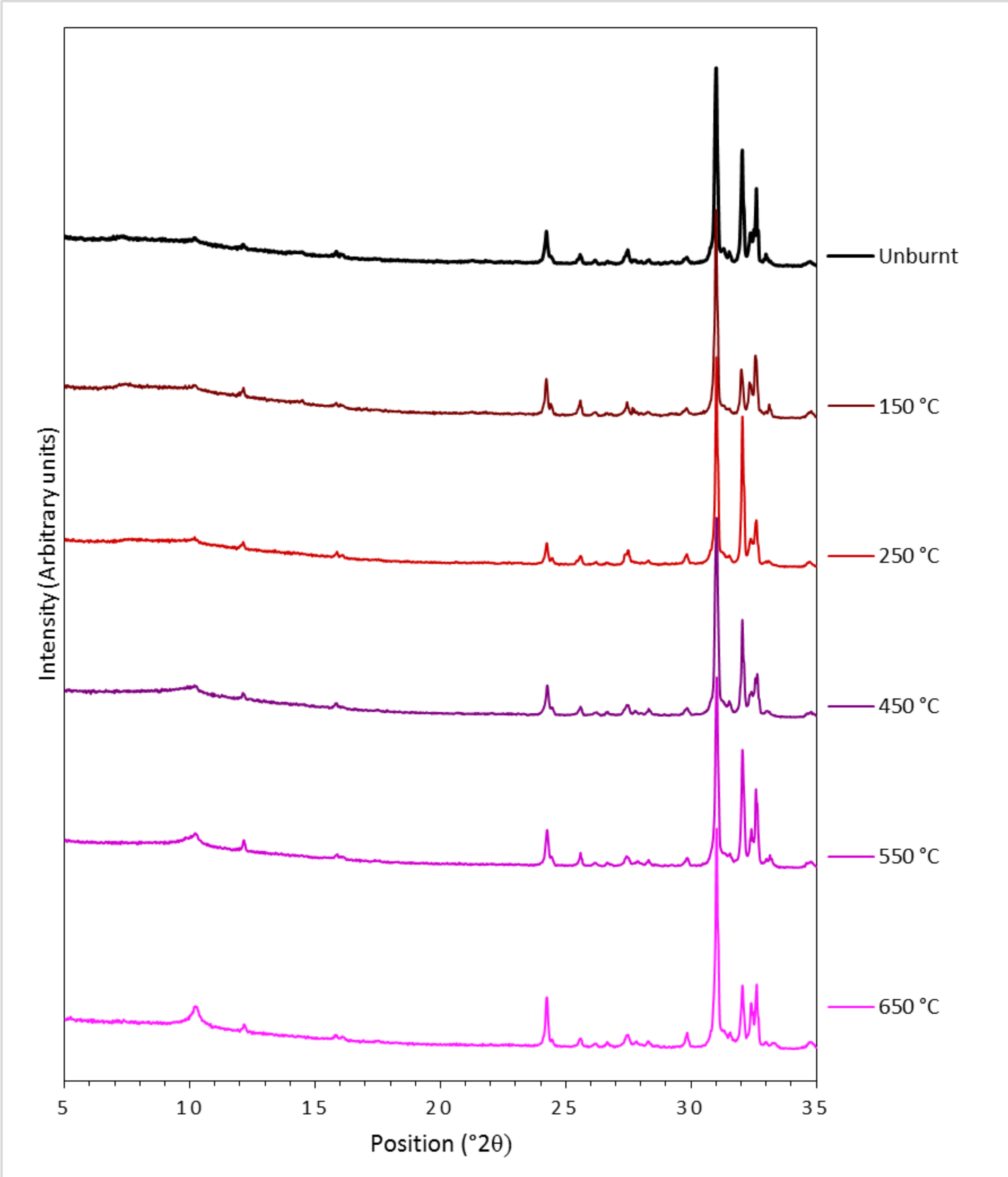

Figure 4-9 XRD diagram across combustion temperature: Sirretta soils

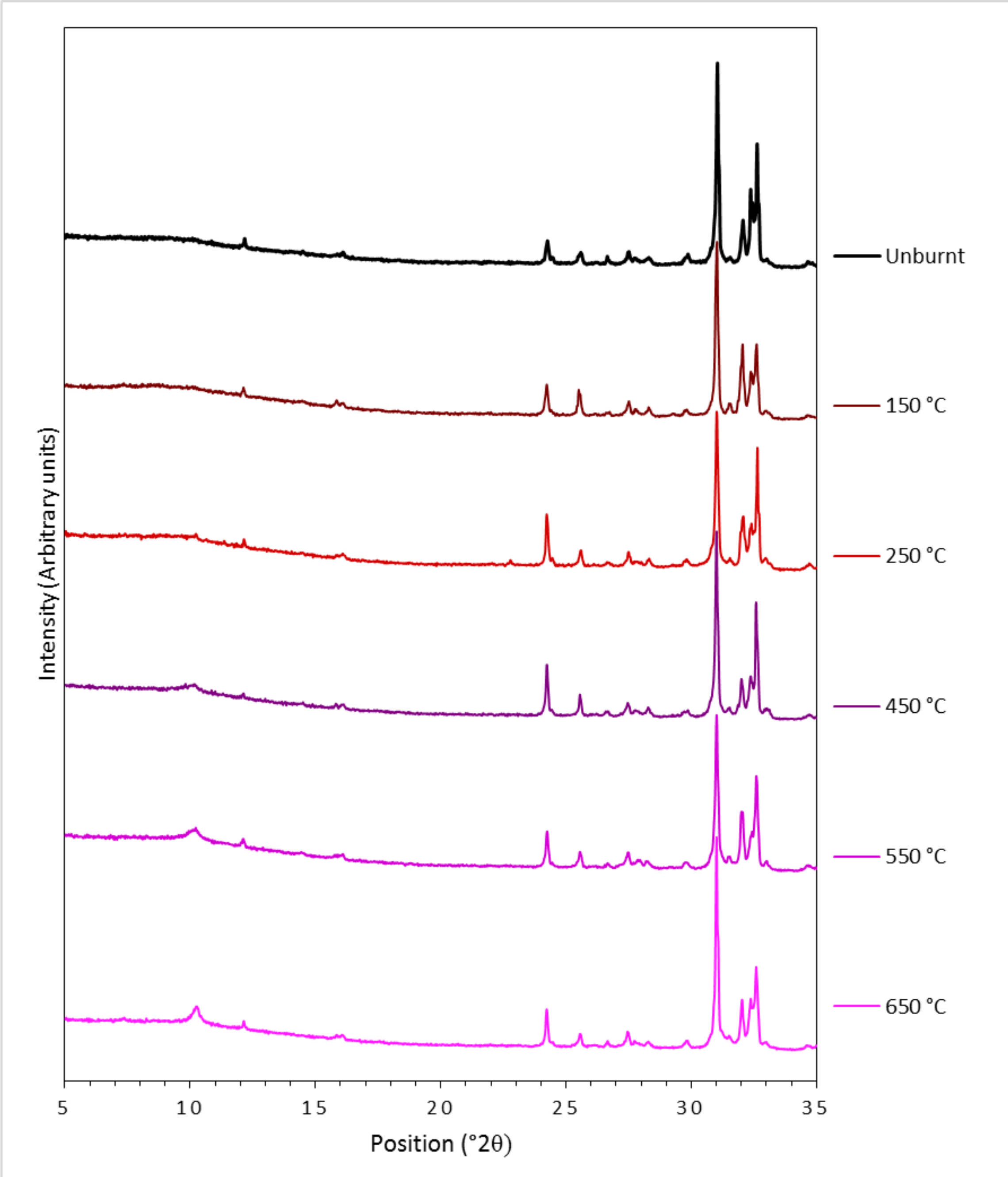

Figure 4-10 XRD diagram across combustion temperature: Chiquito soils

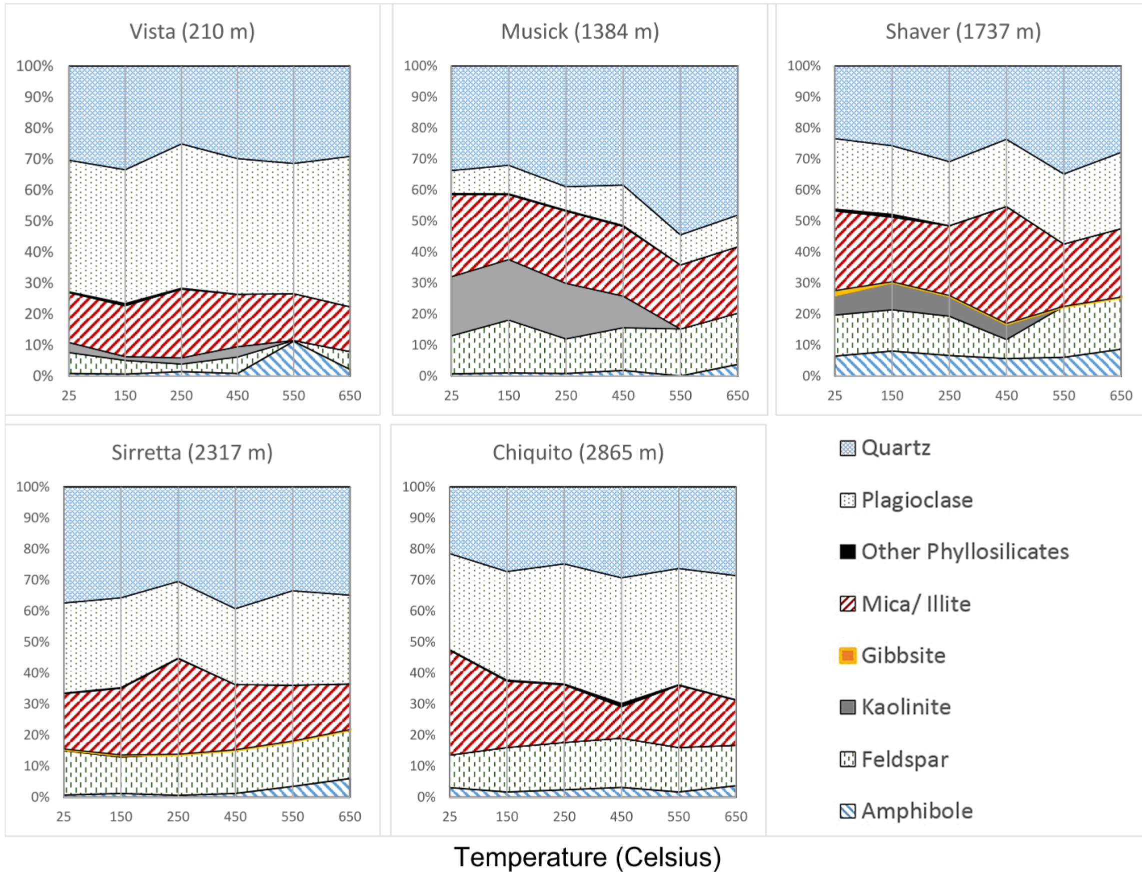

Figure 4-11 Relative amounts of minerals identified from powder XRD

4.2.3 Cation exchange capacity

Initial Cation exchange capacity (CEC) of the soils in our study Climosequence varied from 6 to 25 $cmol_c$/kg soil. Heating of the top soils had a consistent effect of decreasing CEC (Figure 4-12). However, the only statistically significant drop ($p<0.05$) occurred between 350 and 450ºC except for Musick (1384 m) that had the highest initial CEC of 25 $cmol_c$/kg and significant CEC change occurred at the lowest heating temperature of 250ºC and Chiquito (2865 m) where the significant change in CEC occurred after heating at 450ºC. For the Chiquito (2865 m), that had a very low starting CEC (6 $cmol_c$/kg), the CEC dropped below our minimum detection limit after 150°C. Furthermore, although not statistically significant, CEC spiked by a few units from 250 to 350°C breaking the pattern of continuous decrease with temperature. This small spike was not observed for Musick (1384 m) soils.

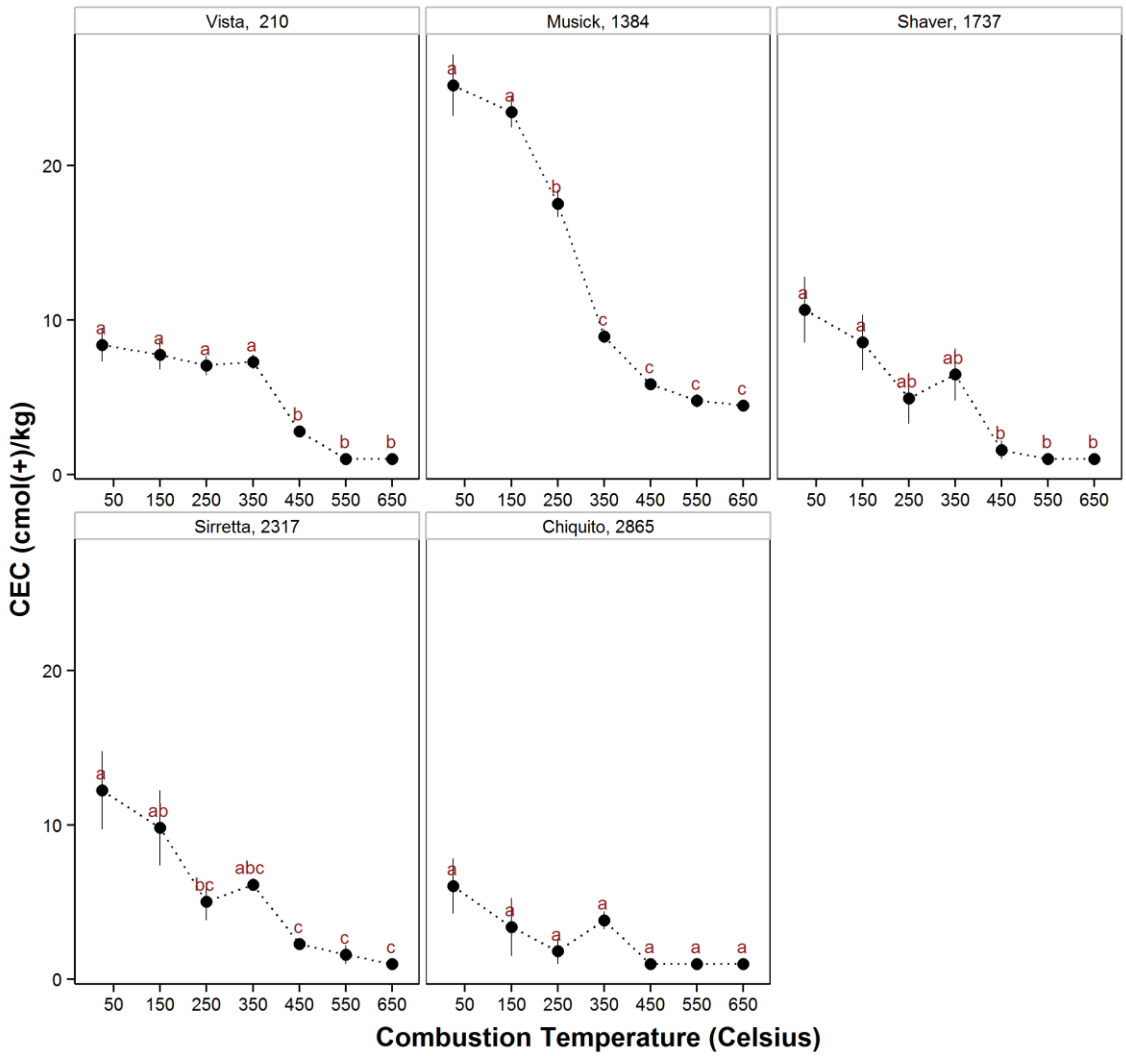

Figure 4-12 Cation exchange capacity adjusted for mass lost, with combustion temperature. Values below the 2 $cmol_c$/kg minimum detection limit are assigned a value of 1 $cmol_c$/kg for ease of calculation (error bars represent standard error where n=3). Different letters represent significantly different means ($p<0.05$) at each temperature after Tukey's HSD testing.

4.2.4 Carbon and nitrogen concentration

The initial concentration of C in topsoil range from <2% (for the Vista soil, 210 m site) to >7 % (for the Musick soils, 1384 m site). Soil C concentration decreased with increase in temperature (Figure 4-13). For all soils a sharp decrease occurred between temperatures 250 and 450°C. At 450°C all soils had lost more than 95% of their initial C. The decrease above that temperature was small and statistically insignificant ($p<0.05$).

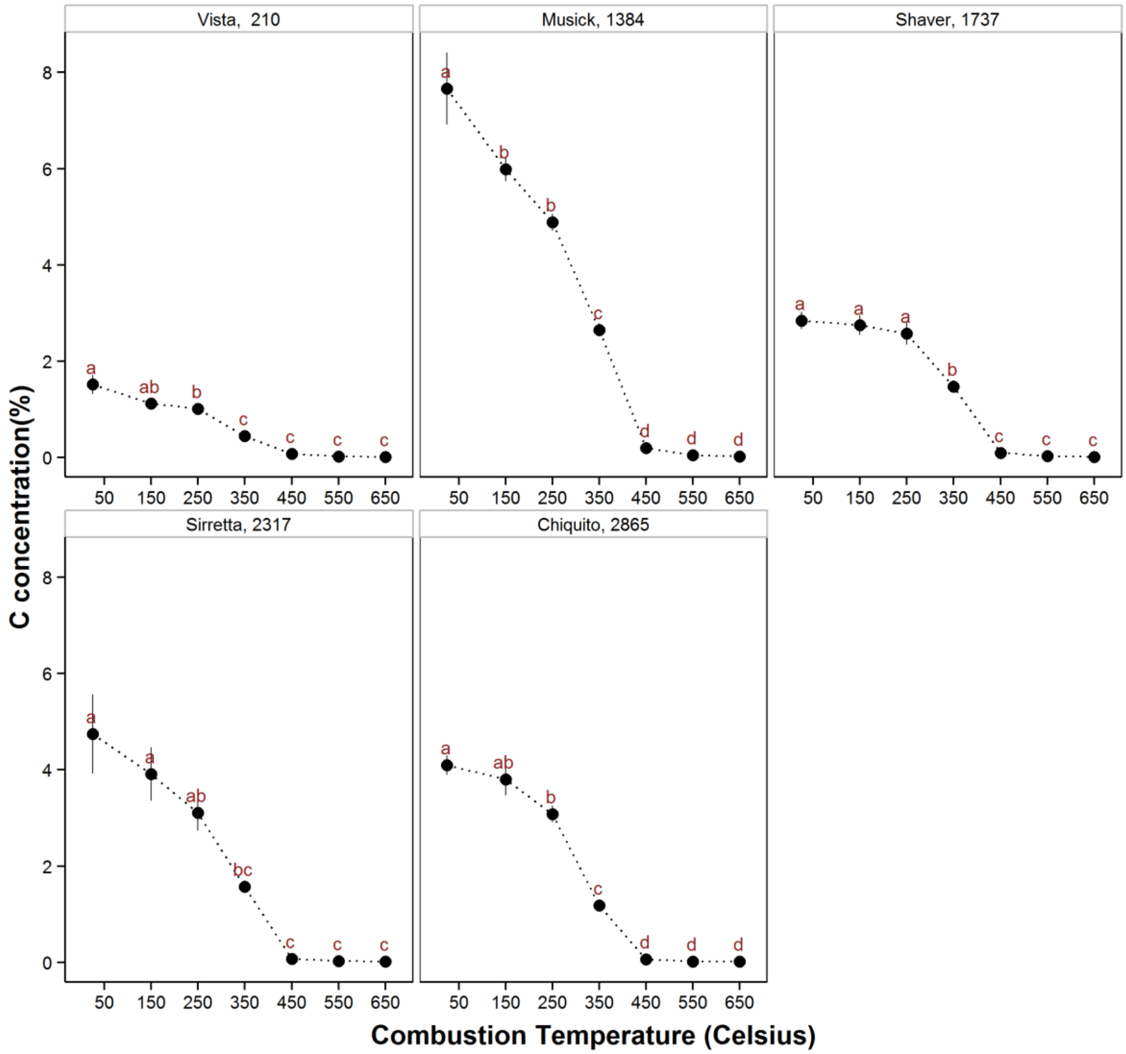

Figure 4-13 Carbon concentration (mass) versus heating temperature (error bars represent standard error where n=3). Different letters represent significantly different means ($p<0.05$) at each temperature after Tukey's HSD testing.

The loss of C concentration as a percentage of original concentration shows a closely similar pattern of loss among all five soils, starting from 100% for unburned to 0% at 650°C (Figure 4-14). After 250°C all the soils lost more than 25% of their initial C (except Shaver soils that lost only about 10%). At 350°C all soils lost 50 to 70% of C. Combustion at 450°C led to loss of more than 95% of their initial C for all soils in this study.

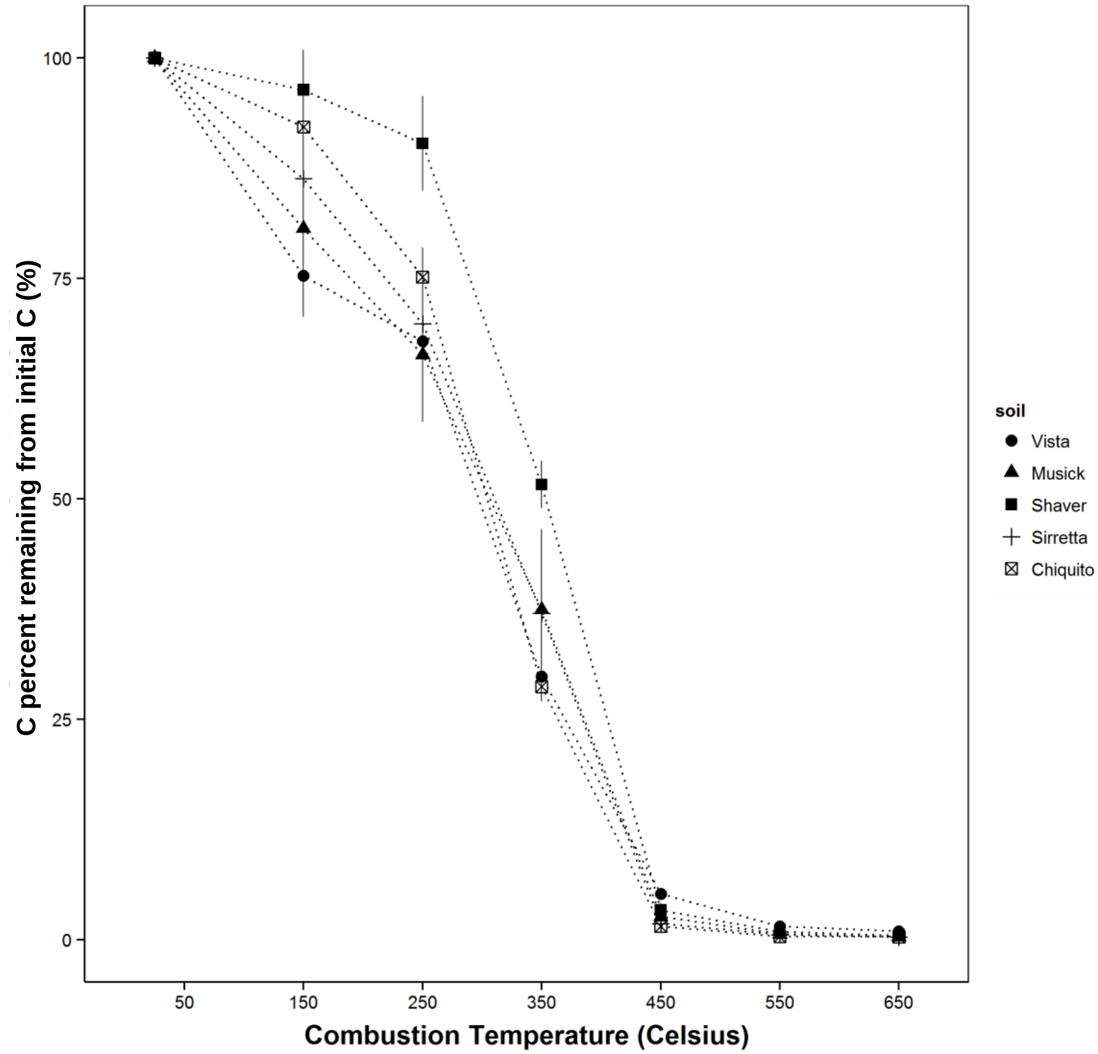

Figure 4-14 Carbon loss as percentage of original concentration in topsoil (error bars represent standard error where n=3).

Initial concentration of N in topsoil showed a much smaller change than concentration of C in soil along the elevational transect. However, the pattern of change in soil N concentration for all soils was very similar to change in soil C concentration (Figure 4-15), with a notable difference in that the range of sharp decrease was off-set by a +100°C and occurred between 350 and 550°C for N. In addition, with the exception of Sirretta soils, all soils showed a statistically significant drop in N between 450 and 550°C temperatures. For all soils there was no statistically significant decrease above 550°C.

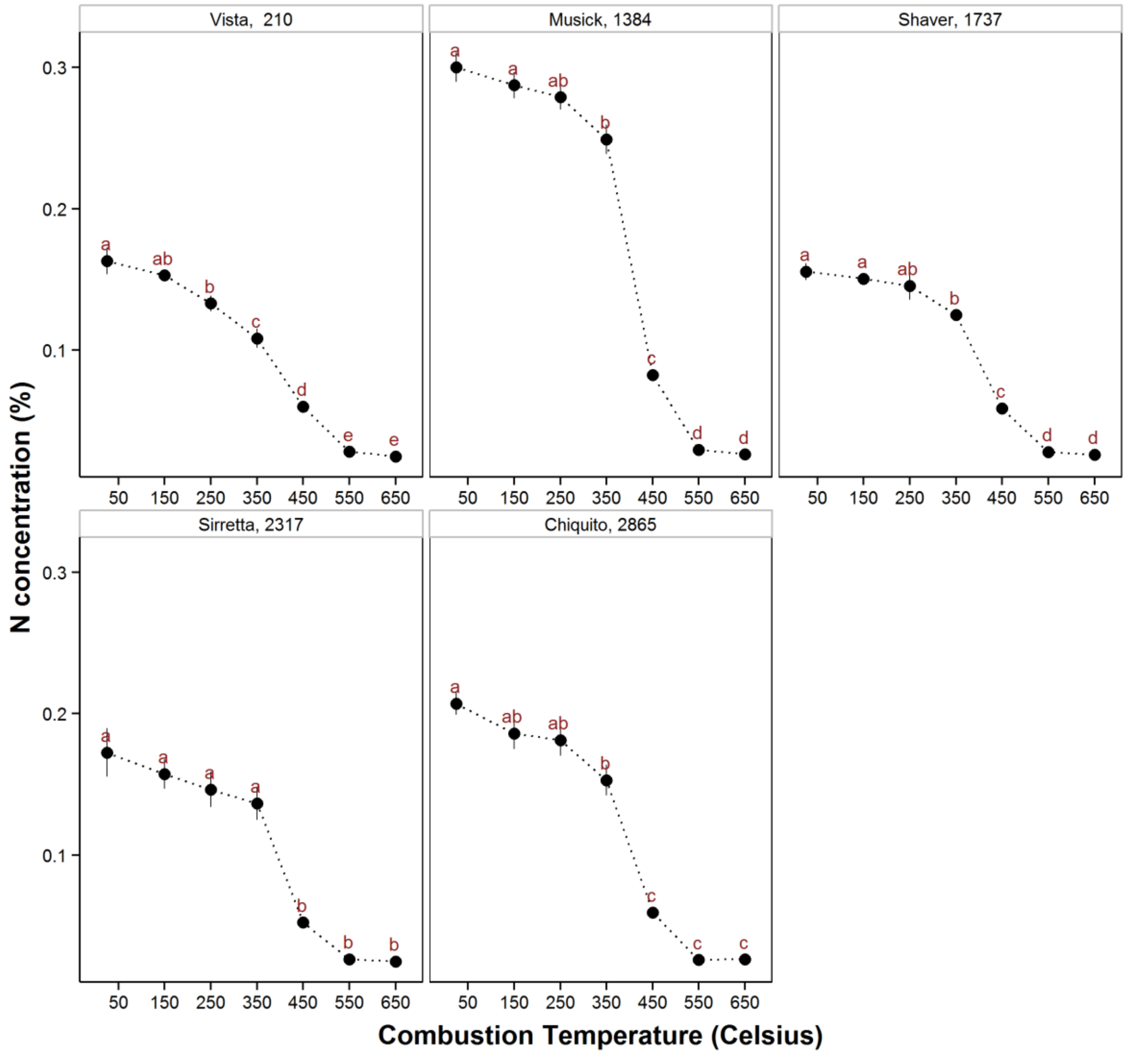

Figure 4-15 Nitrogen concentration (mass) percent versus heating temperature (error bars represent standard error where n=3). Different letters represent significantly different means ($p<0.05$) at each temperature after Tukey's HSD testing.

Loss of N was lower than that of C, even at temperatures greater than 550ºC there was 5 to 15% of soil N still left in soil. Consequently I observed a decrease of C:N ratio with increase in heating temperature. All soils continued to loose about 15% soil N for every 100°C increase and maintained more than 60% of their N at heating temperatures up to 350ºC. After heating at 450°C, all soils lost more than 60% of the initial soil N and by 550°C all soils lost about 85% N. Figure 4-16 plots N loss as a percentage of original N concentration and shows that all soils followed a very similar pattern of N loss among all soils.

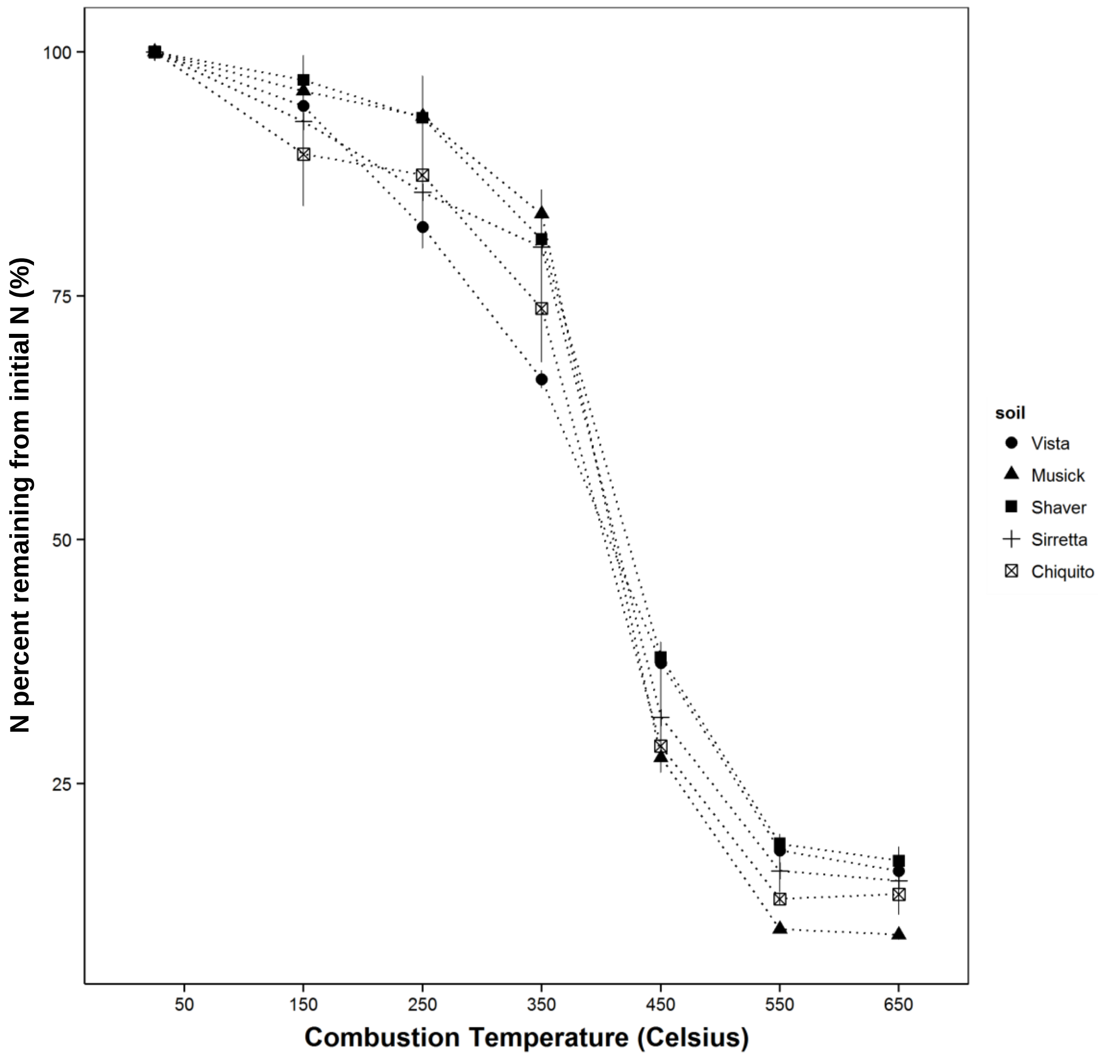

Figure 4-16 Nitrogen loss as percentage of original concentration in topsoil (error bars represent standard error where n=3).

Initially, the topsoil C:N ratio ranged from 10 (at the lowest elevation Vista site at 210 m) to 29 (at the Musick site at 1384 m). The change in C:N ratio with increasing heating temperature was very consistent among the study soils and followed a similar decreasing pattern with temperature as C change (Figure 4-17). The sharpest change in C:N ratio of topsoil was observed between 250 and 450°C. The change in C:N ratio from 450 to 650°C was very small for all soils and not statistically significant at the 95% confidence level.

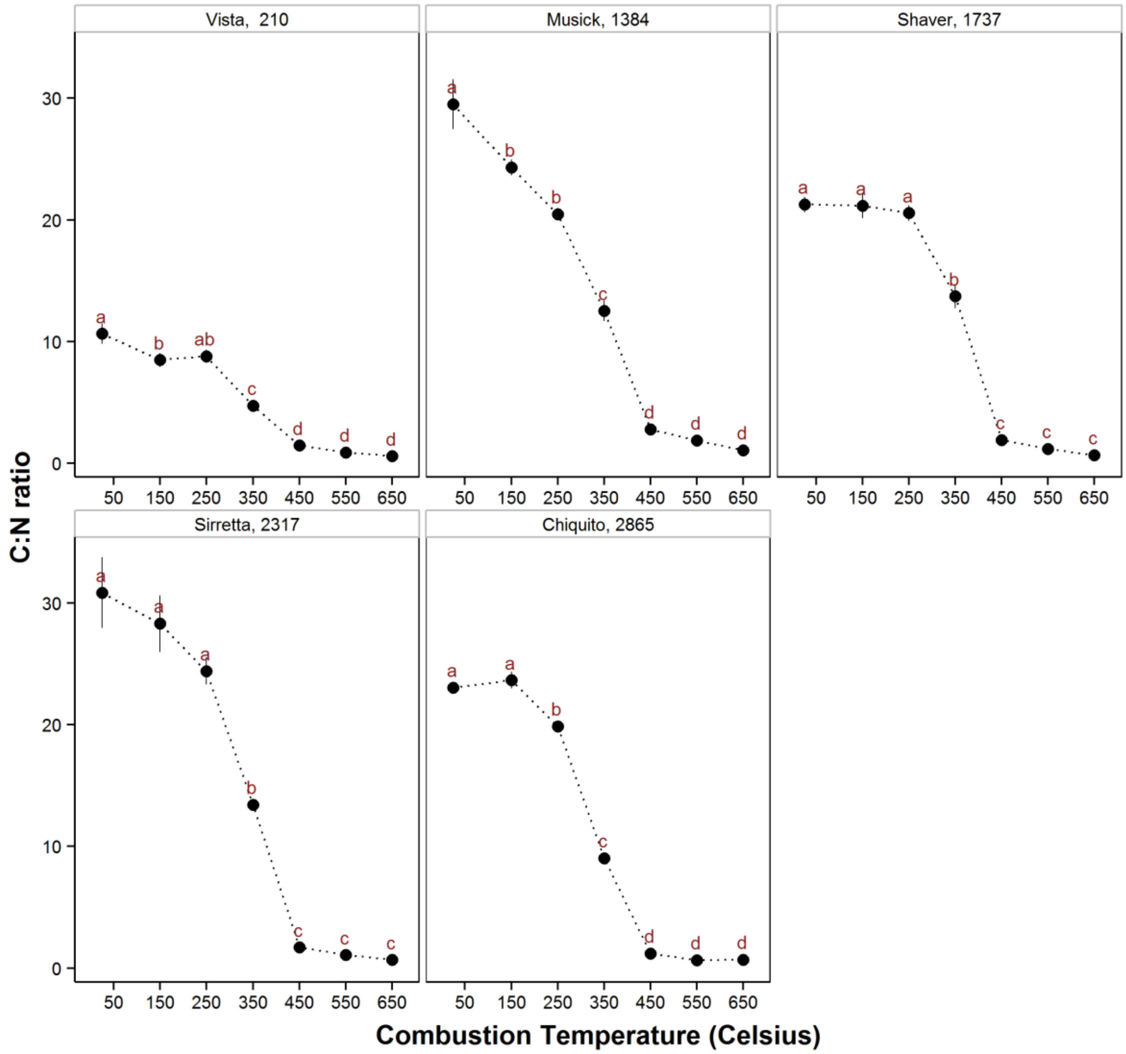

Figure 4-17 Carbon to nitrogen ratio versus heating temperature. Different letters represent significantly different means ($p<0.05$) at each temperature after Tukey's HSD testing. Error bars represent standard error where n=3. In some cases the errors bars are smaller than the symbols and not noticeable in the figure.

4.2.5 Carbon and nitrogen stable isotopes

The $\delta^{13}C$ composition of topsoil was consistently indicative of C-3 vegetation. Soil $\delta^{13}C$ composition was most negative at about -28‰ for the lowest elevation Vista site (210 m) and consistently gets less negative going up the elevation transect reaching about -24‰ in the top two sites in the climosequence (i.e. >2317 m elevation). There was an overall trend of $\delta^{13}C$ enrichment with temperature (Figure 4-18). Soils below Shaver (1737 m) elevation showed a steep change of 2.5 –2.9‰ between 250 and 450°C. While for the two higher elevation soils (Sirretta and Chiquito) a steep change of 2.8 –3.0 ‰ occurred between 150 and 450°C; and for these two soils there was a significant (p

<0.05) depletion above that temperature. For all soils, except Musick (1384 m) and Shaver (1737 m), the maximum enrichment occurred at 450°C.

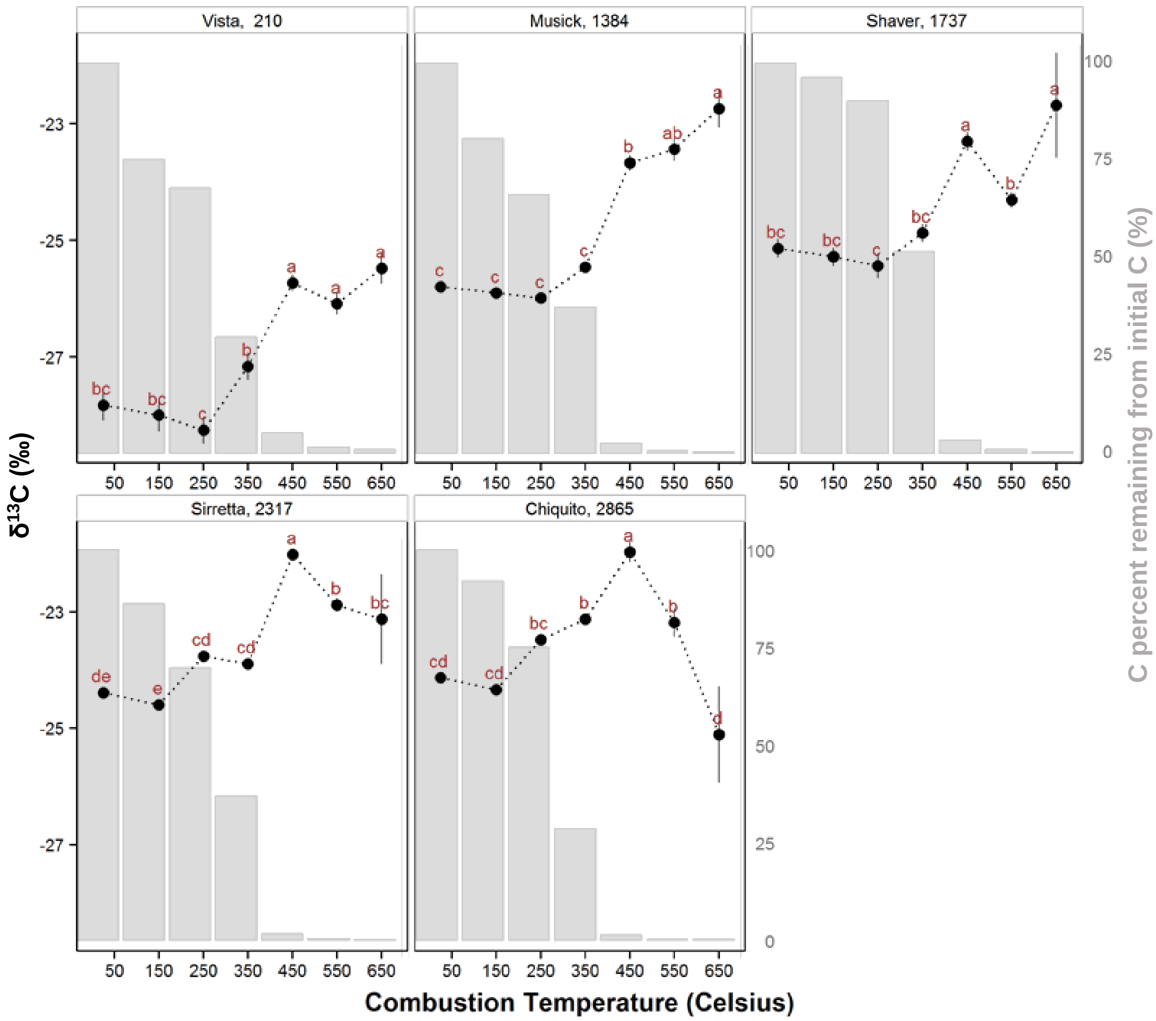

Figure 4-18 $\delta^{13}C$ isotope (‰) versus heating temperature (error bars represent standard error where n=3). Different letters represent significantly different means ($p<0.05$) at each temperature after Tukey's HSD testing. Back ground bars show C percent remaining from initial C.

The continued enrichment of $\delta^{13}C$ stops only at higher temperature (>450°C). The changes in $\delta^{13}C$ is perhaps more clear when we consider this change with that of bulk C (Figure 4-19). The $\delta^{13}C$ of the topsoil continues to get less negative until about 95% of the initial soil C has been lost due to combustion, and reverses course and gets more negative beyond this point. The reverse in pattern of $\delta^{13}C$ of topsoil with topsoil C loss is likely a result of complete combustion C in SOM, with little isotopic discrimination.

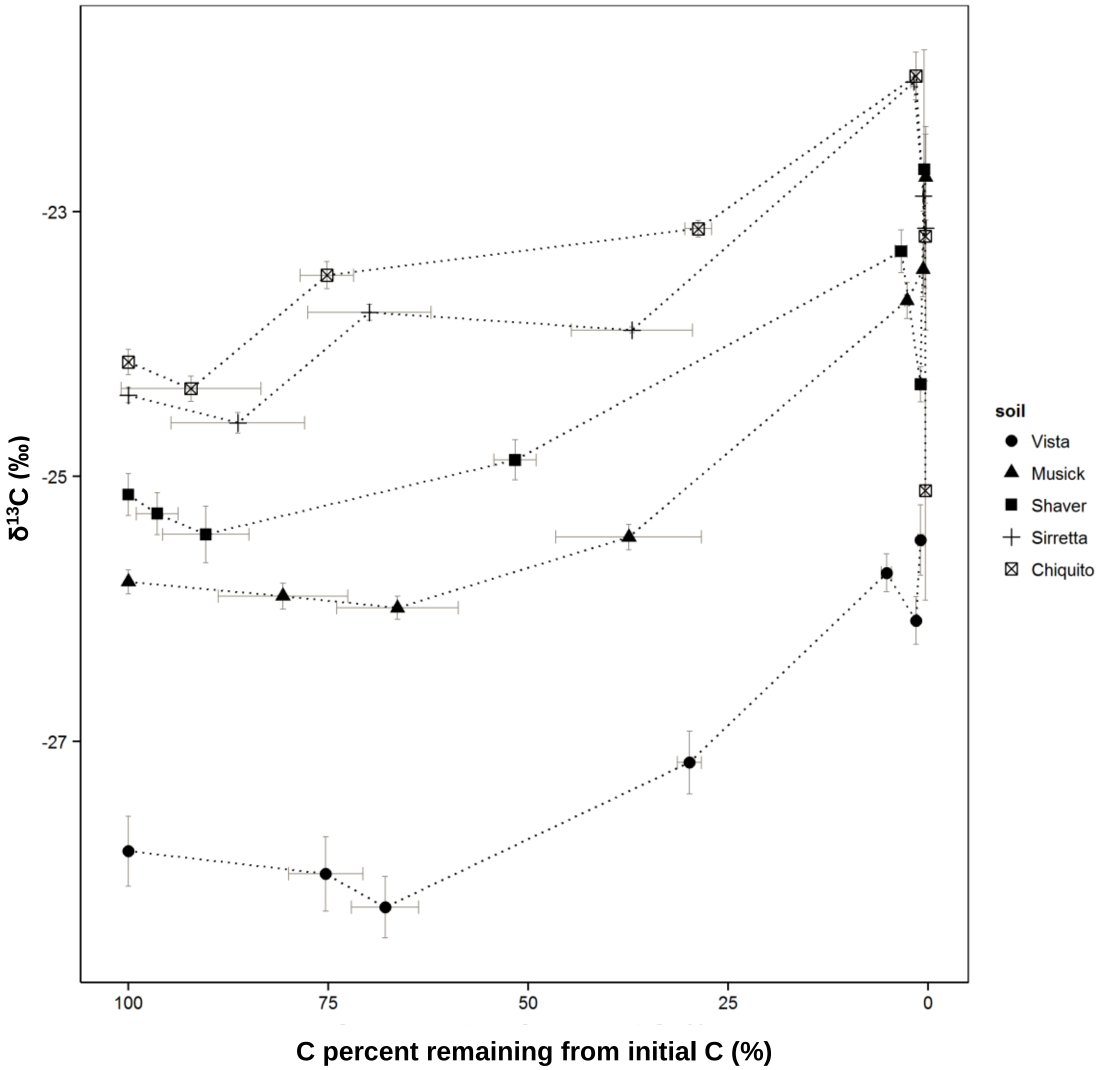

Figure 4-19 $\delta^{13}C$ change with percent of total C lost from soils. (error bars represent standard error where n=3).

The change in initial $\delta^{15}N$ composition of topsoil along the elevation transect was considerably smaller than initial $\delta^{13}C$ composition. All our soils followed a very similar pattern of change for $\delta^{15}N$ with increase in heating temperature. There was a >2‰ enrichment in $\delta^{15}N$ with heating at temperatures up to 350°C; after that temperature there was a significant depletion (>3‰) up to 650°C (Figure 4-20).

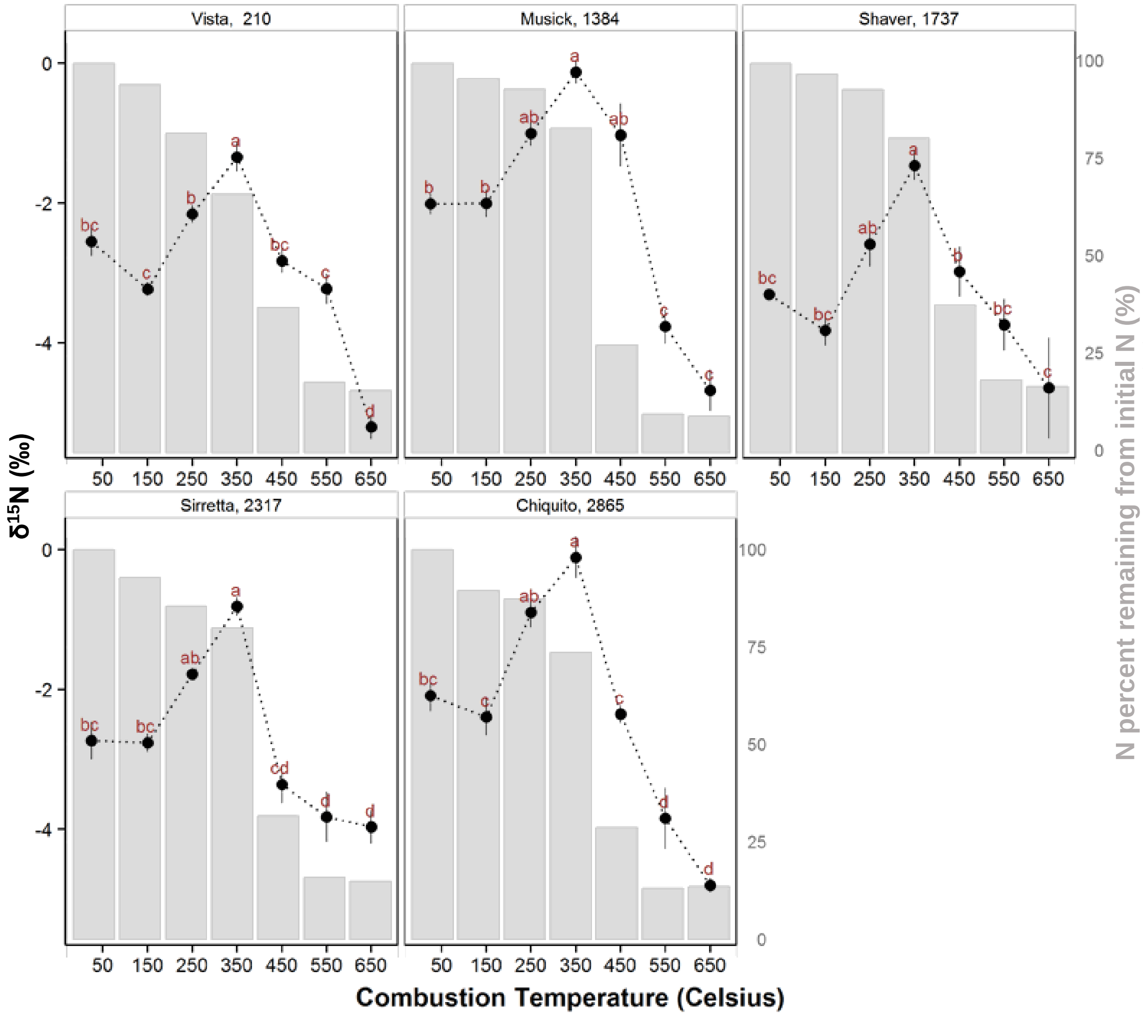

Figure 4-20 15-N isotope (‰) versus heating temperature (error bars represent standard error where n=3). Different letters represent significantly different means (p<0.05) at each temperature after Tukey's HSD testing. Background bars show N percent remaining from initial N.

$\delta^{15}N$ change with the change in concentration of total N in the soils shows a more consistent pattern (Figure 4-21) than the pattern that was observed for changes in $\delta^{13}C$ with changes in total soil C as a result of heating. All soils show enrichment up until about 25% of N has been lost and then it is a continuous decrease which the decline getting even sharper at concentration below 25% of remaining N.

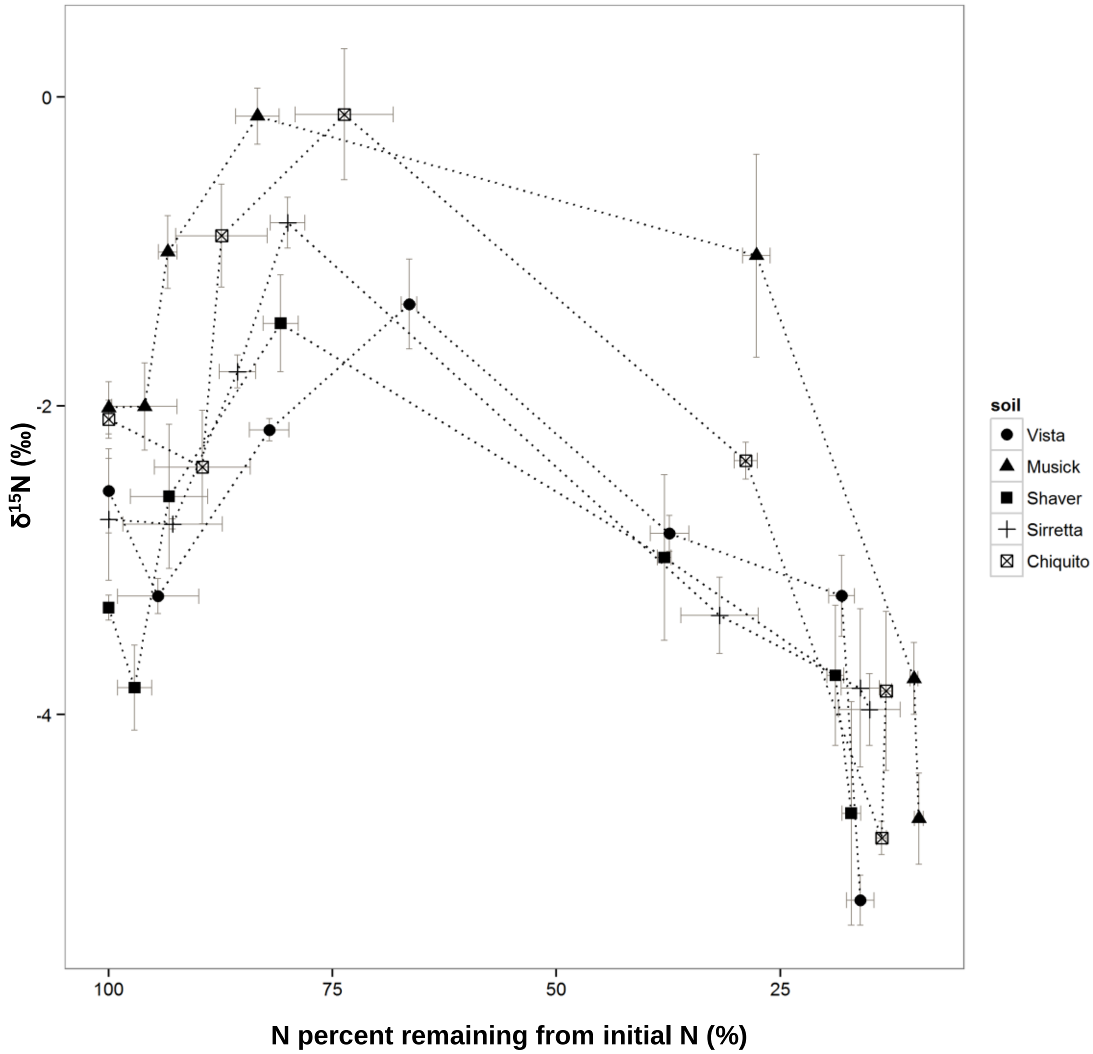

Figure 4-21 $\delta^{15}N$ change with percent of total N lost from soils (error bars represent standard error where n=3).

4.2.6 Carbon and nitrogen distribution in aggregate size fractions

I measured C and N concentration and stable isotope ratio for all the soils. I analyzed only ranges from unburnt to 450°C because the concentration of C and N above 450°C was close to zero and the change in C and N concentration as well as isotopic composition above that temperature was not significant at a 95% confidence level. Measurement for Chiquito soils (2865 m) at 350°C is missing.

The distribution of C in the three aggregate sizes fractions more or less stayed the same through combustion temperatures. The macro aggregate size fraction (2-0.25 mm) had less C concentration than the micro aggregate sizes (0.25-0.053 mm), and silt-clay size particles (<0.053 mm) had the largest concentration of C (Figure 4-22).

N concentration for the macro size aggregates was low beyond detection limit at 450°C for Chiquito and Sirretta. The change in C and N concentration across combustion temperature was similar for all. The distribution of C and N in different size aggregates did not change until 450°C where concentration in all three fractions converged to zero.

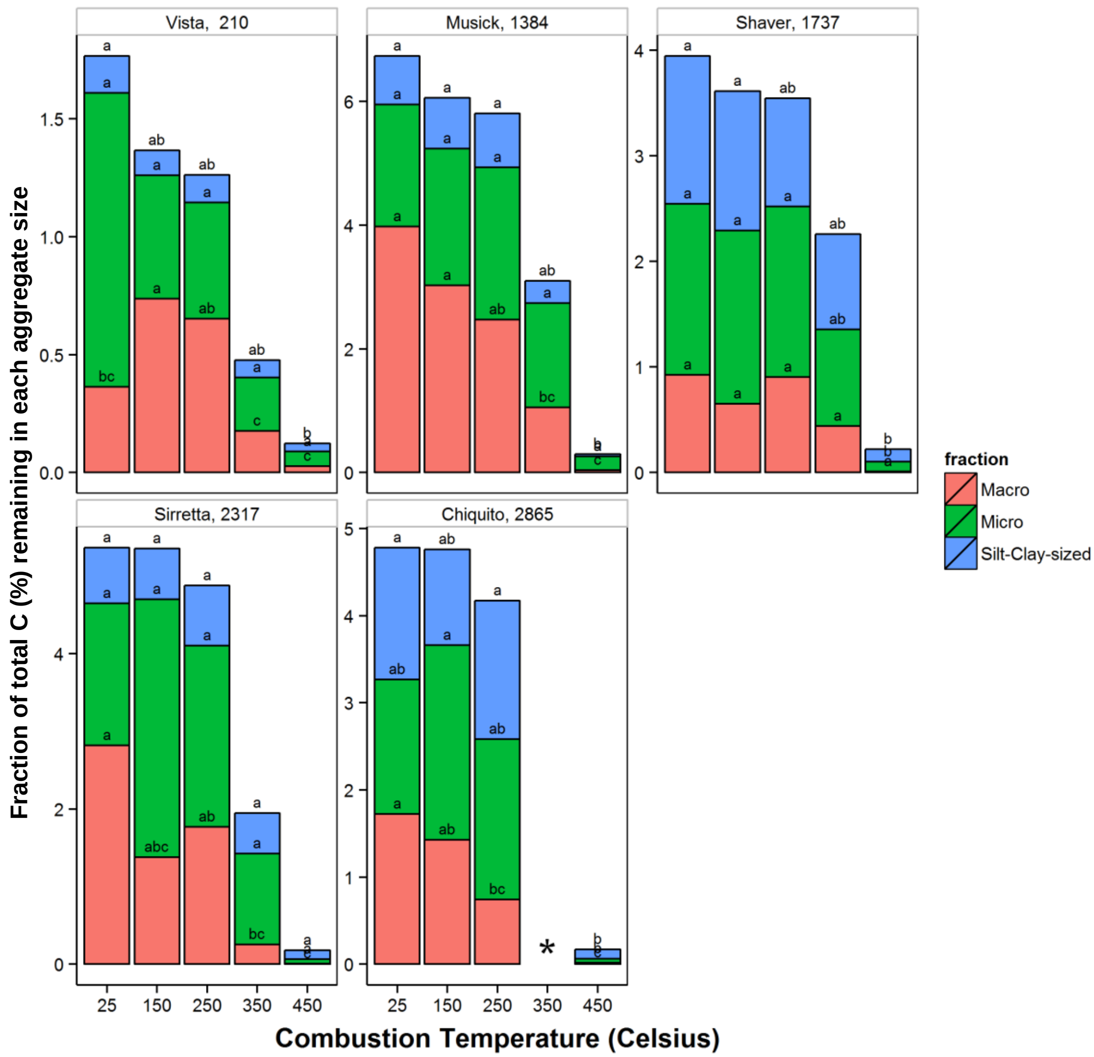

Figure 4-22 C concentration in soils and C distribution among macro (2-0.25 mm), micro (0.25-0.053 mm) and silt-clay sized (<0.053 mm) aggregates. Different letters represent significantly different means ($p<0.05$) at each temperature after Tukey's HSD testing. "*" indicates missing measurement.

The distribution of N in the three aggregate sizes fractions was similar to that of C and more or less stayed the same through combustion temperatures. The macro aggregate size fraction (2-0.25 mm) had less N concentration than the micro aggregate sizes (0.25-0.053 mm), and silt-clay size particles (<0.053 mm) had the largest concentration of N (Figure 4-23). For Shaver (1737 m), Sirretta (2317 m) and Chiquito

(2865 m) soils, the macro size aggregate N concentration was too low and could not be detected.

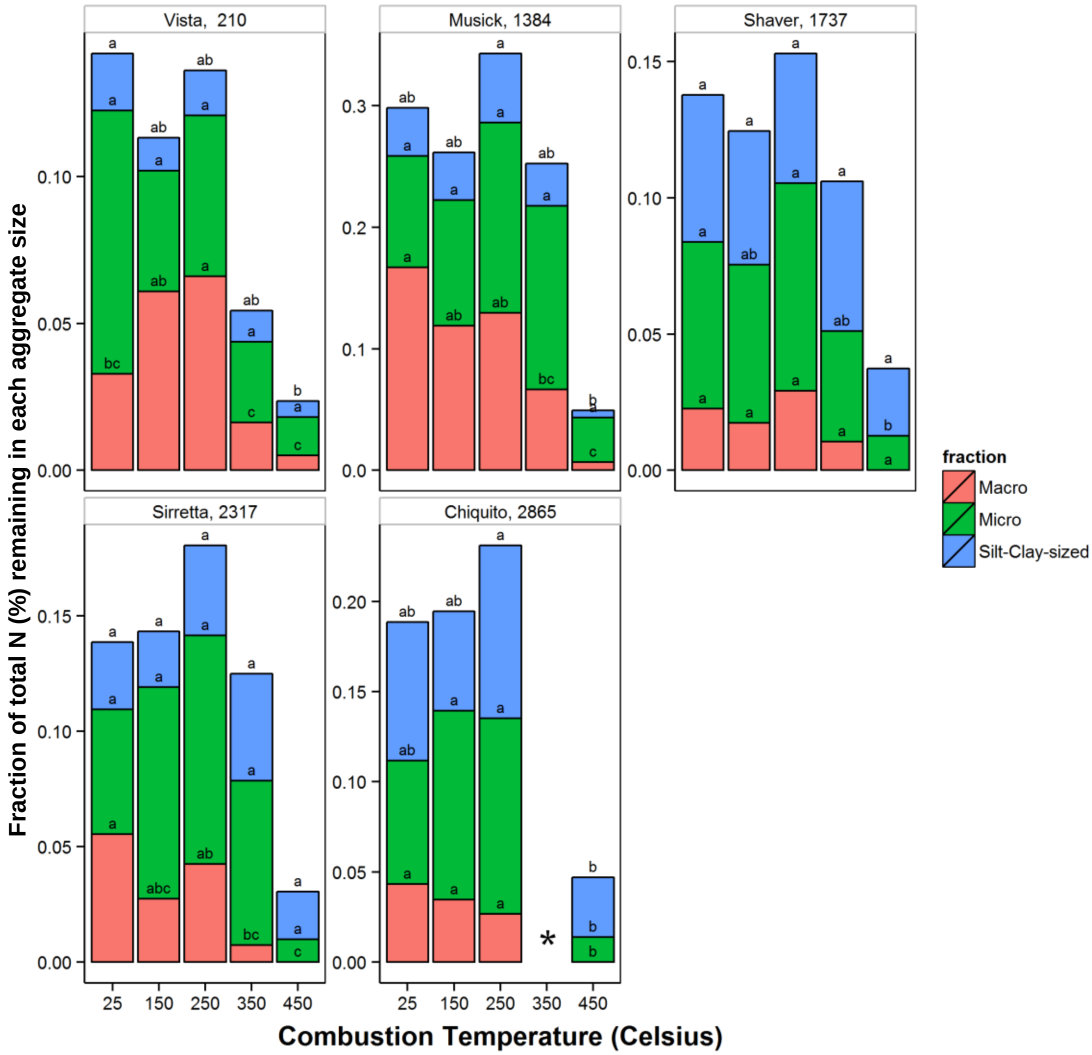

Figure 4-23 N concentration in soils and N distribution among macro (2-0.25 mm), micro (0.25-0.053 mm) and silt-clay sized (<0.053 mm) aggregates. Different letters represent significantly different means ($p<0.05$) at each temperature after Tukey's HSD testing. "*" indicates missing measurement.

The atomic C:N ratio generally stayed the same for all soils through the temperatures. C:N ratio was highest in macro size aggregates, which had lowest C and N concentration, followed by micro and by silt-clay sizes for all soils (Figure 4-24).

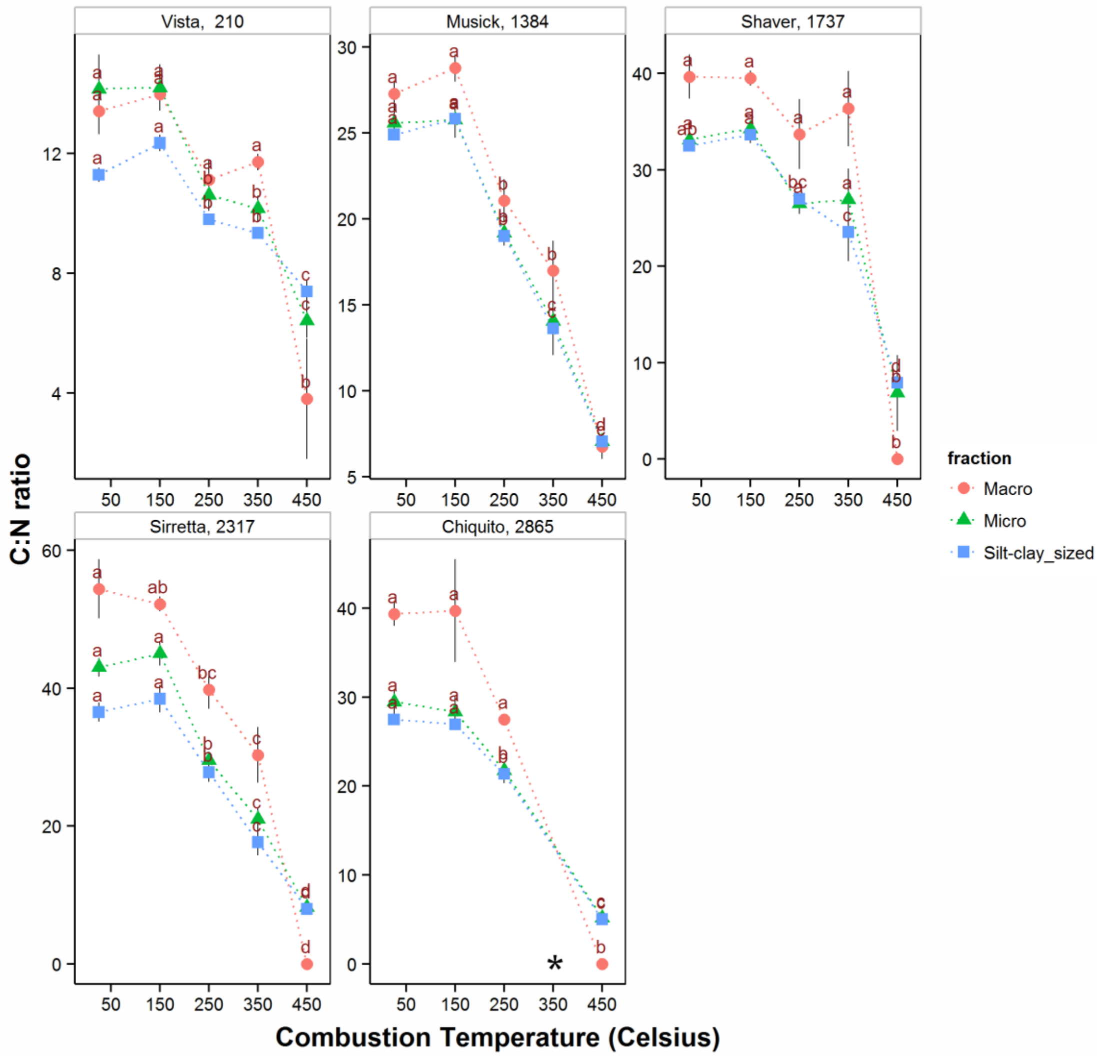

Figure 4-24 C:N atomic ratio in macro (2-0.25 mm), micro (0.25-0.053 mm) and silt-clay (<0.053 mm) aggregate sizes (error bars represent standard error where n=3). Different letters represent significantly different means ($p<0.05$) at temperature after Tukey's HSD testing. "*" indicates missing measurement.

The stable isotope fraction of ^{13}C was very similar between aggregate sizes with silt-clay size aggregates being slightly more enriched except for Shaver (1737 m), which had slightly more enriched macro aggregates. The $\delta^{13}C$ values only showed slight changes with combustion temperatures, notably Vista (210 m) and Musick (1384 m) macro aggregates showed more enrichment and had more positive $\delta^{13}C$ value at 450°C. The small differences in $\delta^{13}C$ are better illustrated as a scatter plot than a barograph. Figure 4-25 shows $\delta^{13}C$ value among aggregate sizes across combustion temperatures.

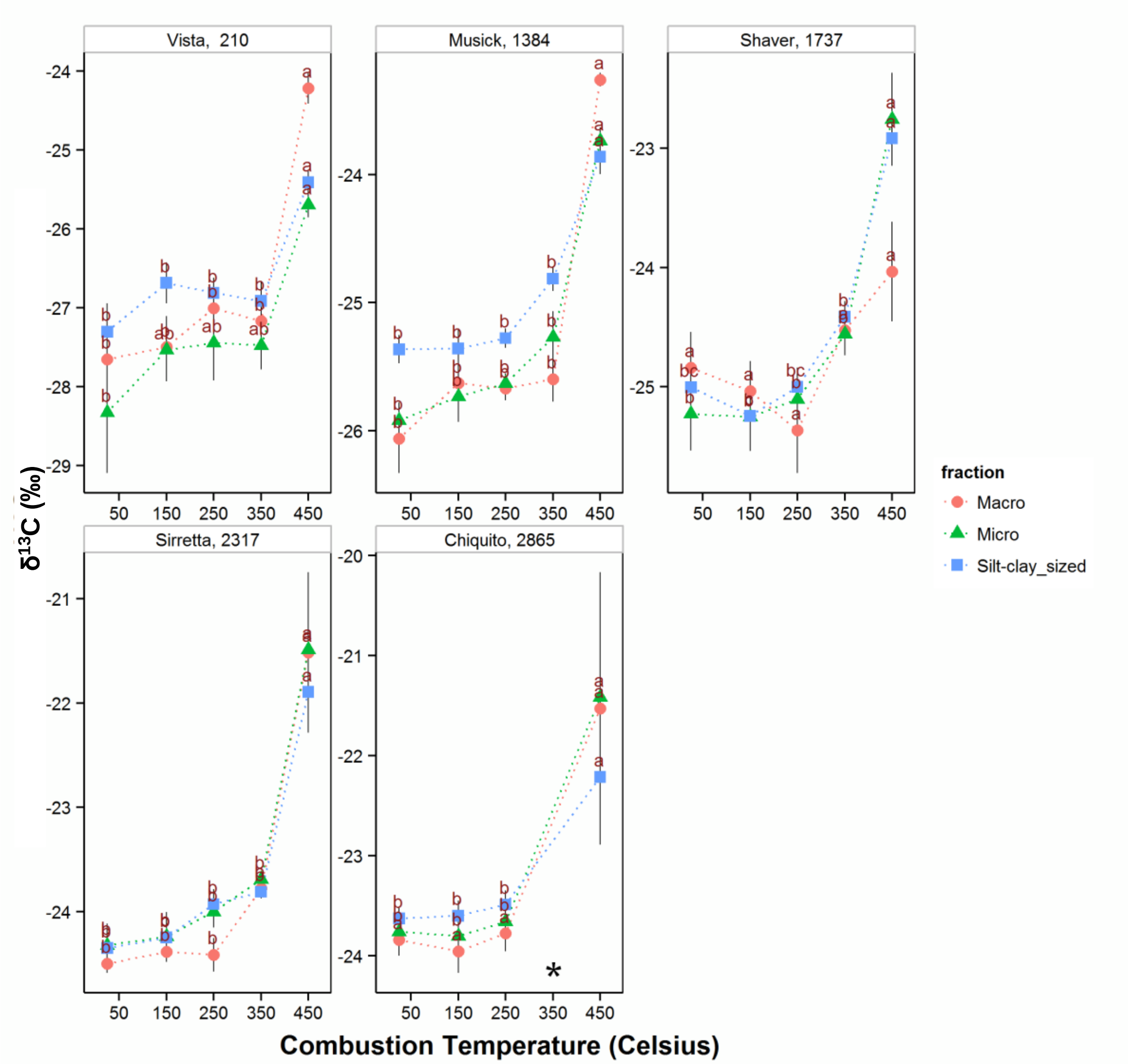

Figure 4-25 $\delta^{13}C$ value in macro (2-0.25 mm), micro (0.25-0.053 mm) and clay (<0.053 mm) aggregate sizes (error bars represent standard error where n=3). Different letters represent significantly different means ($p<0.05$) at temperature after Tukey's HSD testing. "*" indicates missing measurement.

The $\delta^{15}N$ values were clearly different among aggregate fractions even though this difference did not change notably with combustion temperatures. $\delta^{15}N$ was highest in silt-clay size particles and lowest in macro size aggregates with the micro size aggregates showing intermediate values. The pattern of change in $\delta^{15}N$ across combustion temperatures did not affect this order of $\delta^{15}N$ values among aggregate fractions. Figure 4-26 shows $\delta^{15}N$ values among aggregate sizes across combustion temperatures.

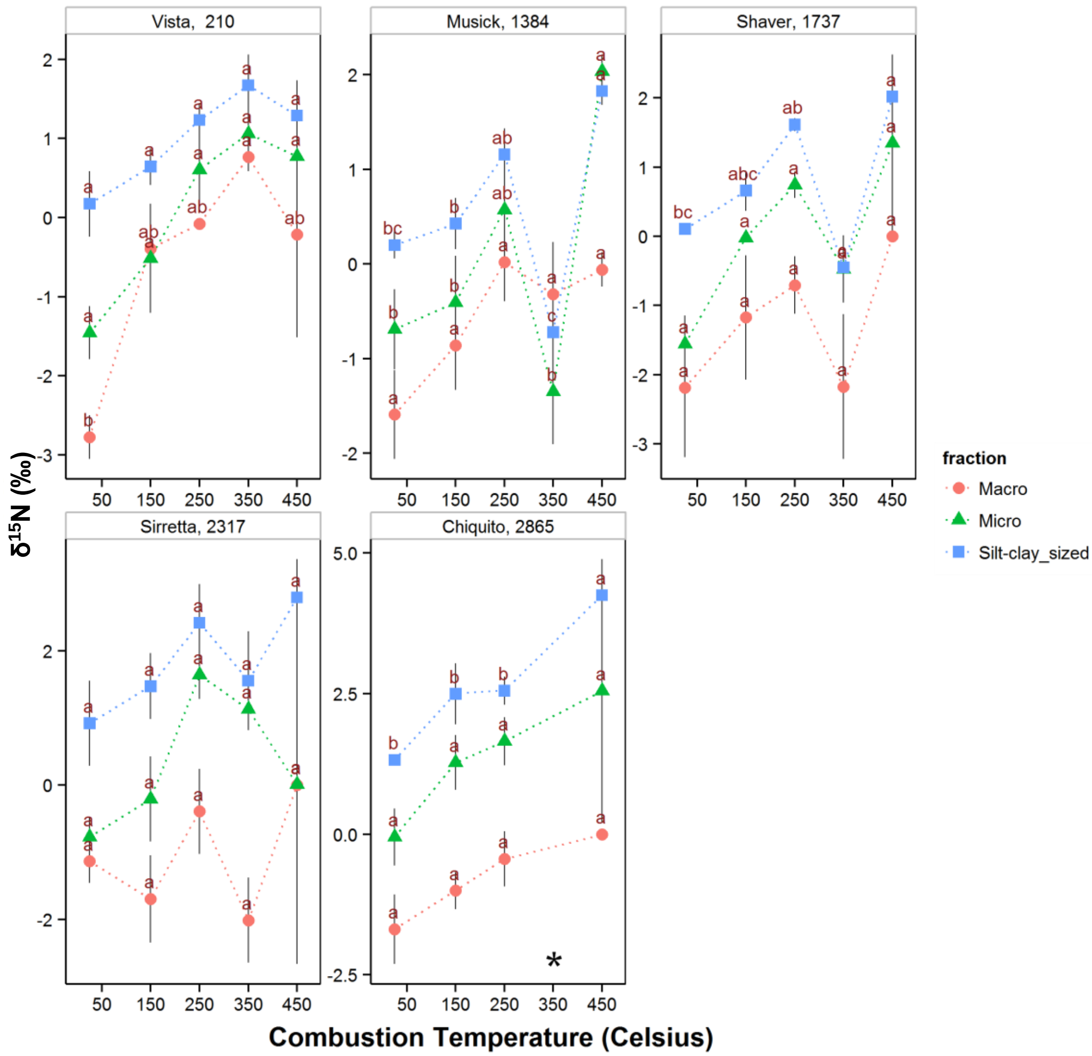

Figure 4-26 $\delta^{15}N$ value in macro (2-0.25 mm), micro (0.25-0.053 mm) and silt-clay (<0.053 mm) aggregate sizes (error bars represent standard error where n=3). Different letters represent significantly different means ($p<0.05$) at temperature after Tukey's HSD testing. "*" indicates missing measurement.

4.2.7 FTIR spectroscopy

Changes in quality of SOM due to heating were analyzed by infrared spectroscopy using Diffuse reflectance infrared fourier transform (DRIFT) technique. FTIR spectra for the five soils are shown in Figure 4-27 to Figure 4-31. Absorption band functional group assignments that were used in this study are given in Table 4-2. The spectra and peaks after combustion at different temperatures exhibited qualitative similarities among the different soils I analyzed. One of the most prominent changes that occurred in the functional group composition of SOM with heating is the lowered absorbance intensity of aliphatic methylene groups (as represented by the aliphatic C–H stretching peak that appear at bands between 2950 – 2850 cm^{-1}) at >250°C in all soils. When comparing intensity of peaks at 2910 – 2930 and 2853 cm^{-1} wave numbers (from aliphatic methyl and methylene groups, band A) with those at 1653 and 1400 cm^{-1} (oxygen containing carboxyl and carbonyl groups, band B), the decrease in prominence in the aliphatic C-H peak occurs early in the heating sequence while the C=O band shows little relative change. In addition, after heating at a temperature of 550°C all soils lost the O–H stretching peaks (between 3700 – 3200 cm^{-1}). In a pattern that is more prominent for the Musick soil that had the highest concentration of OM, the aromatic C=C stretch around 1600 cm^{-1} gets more resolved with increase in heating temperature. This pattern in the C=C is visible, but less well resolved in the rest of the soils, especially the Vista soil that showed the least resolved aromatic C=C stretch peak at this region.

Table 4-2 FTIR absorption band assignment of organic functional groups (Ellerbrock & Gerke, 2013; Madari et al., 2006; Parikh et al., 2014)

Absorption band (cm^{-1})	**Assignment**
3700—3200 [a]	O—H and N—H stretch
3450—3300 [a]	H bonded O—H, N—H stretch; greater N—H contribution at lower range
3000—2800 [a]	Alipahtic C—H stretch
2300—2200 [b]	Nitriles, Methanenitrile; C≡N stretch
1850 & 1780 [c]	Ketone, acyclic stretch
1650—1600 [a]	Aromatic C=C stretch and/or carboxylate C-O asymmetric stretch and/or conjugated ketone C=O stretch
1300 [a]	C-H overtone
1160—1000 [a]	Ester, phenol C—O—C, C—OH stretch attributed to polysaccharides or polysaccharide-like compounds
975—700 [a]	Aromatic C—H out-of-plane bend; increasing wave numbers with increasing degree of substitution

[a] Parikh et al. (2014)

[b] Doe (2014)

[c] Hanson (2014)

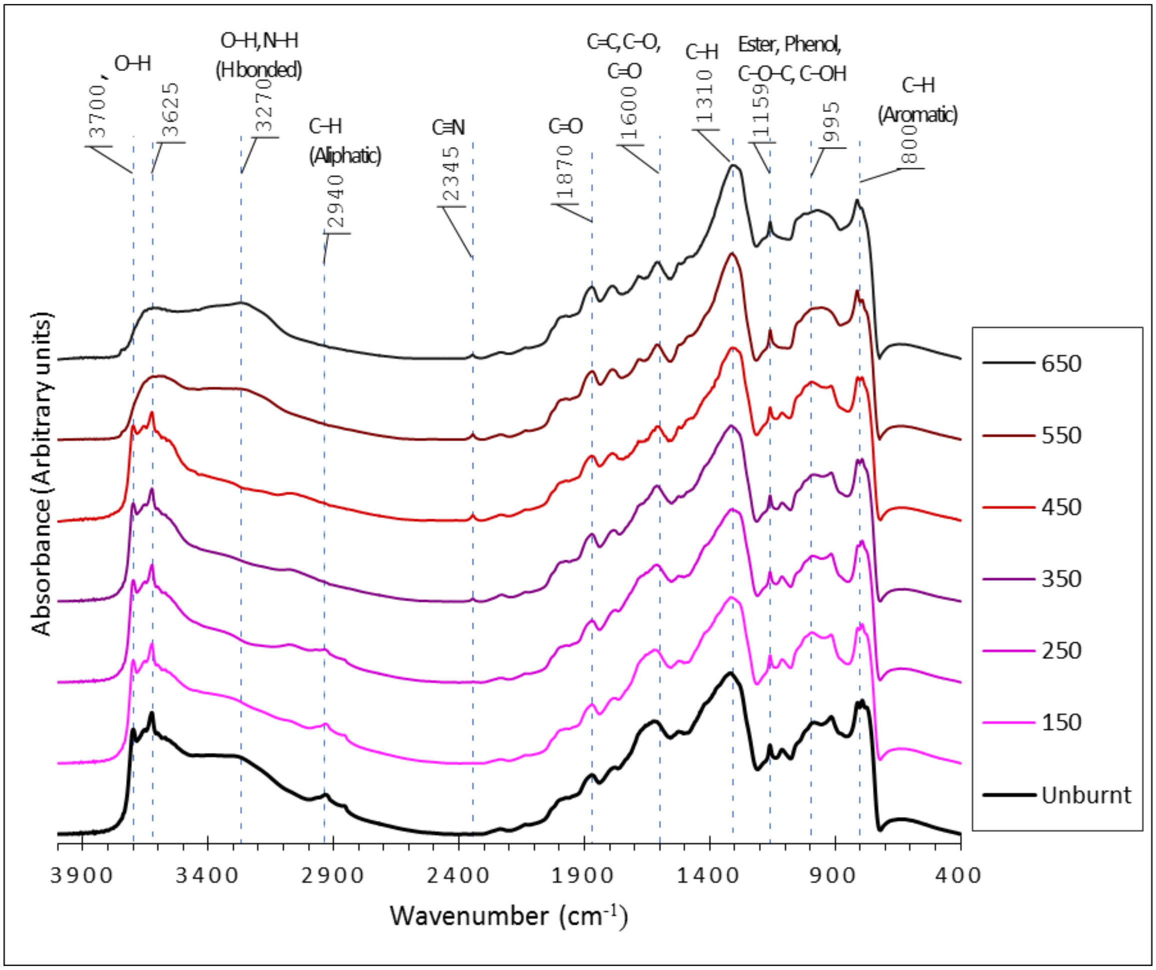

Figure 4-27 FTIR spectra for Vista soils at the different combustion temperatures.

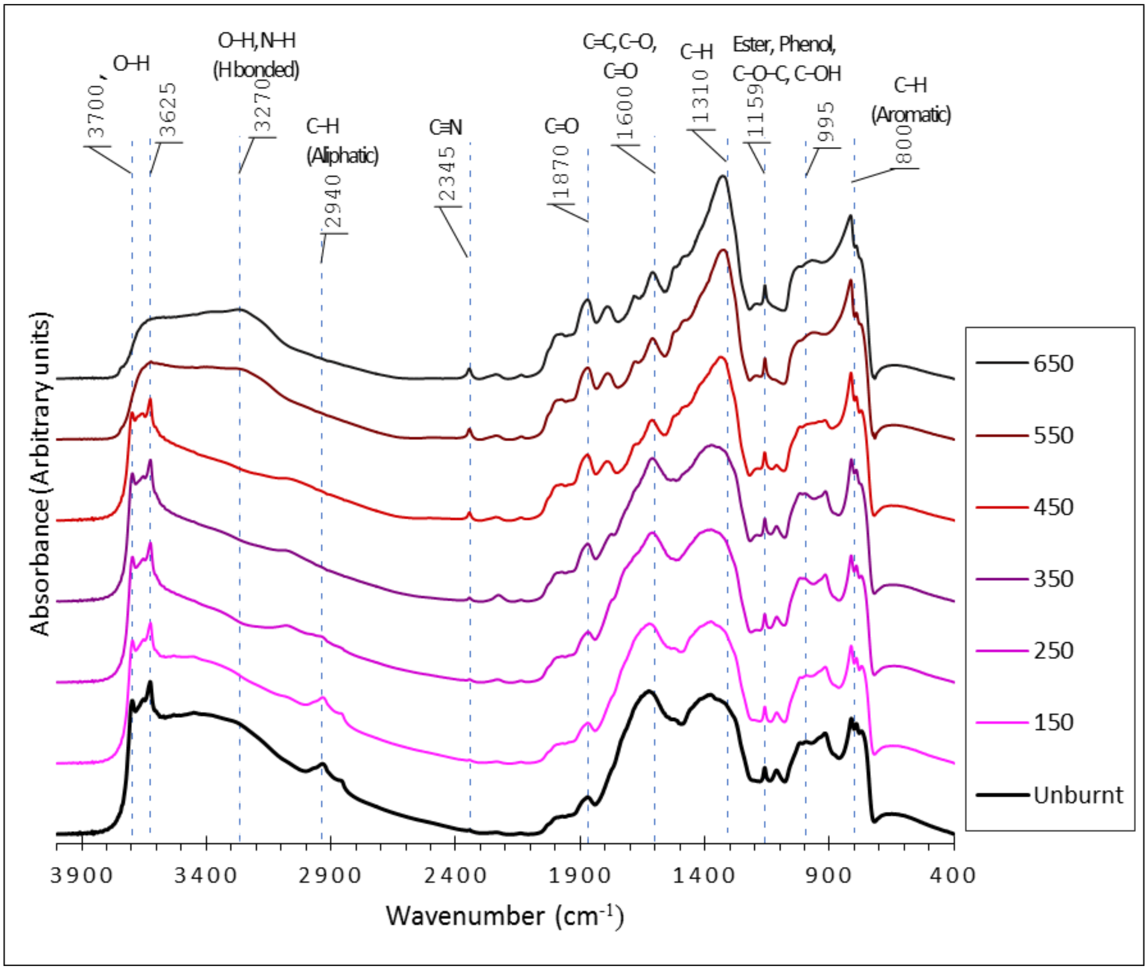

Figure 4-28 FTIR spectra for Musick soils at the different combustion temperatures.

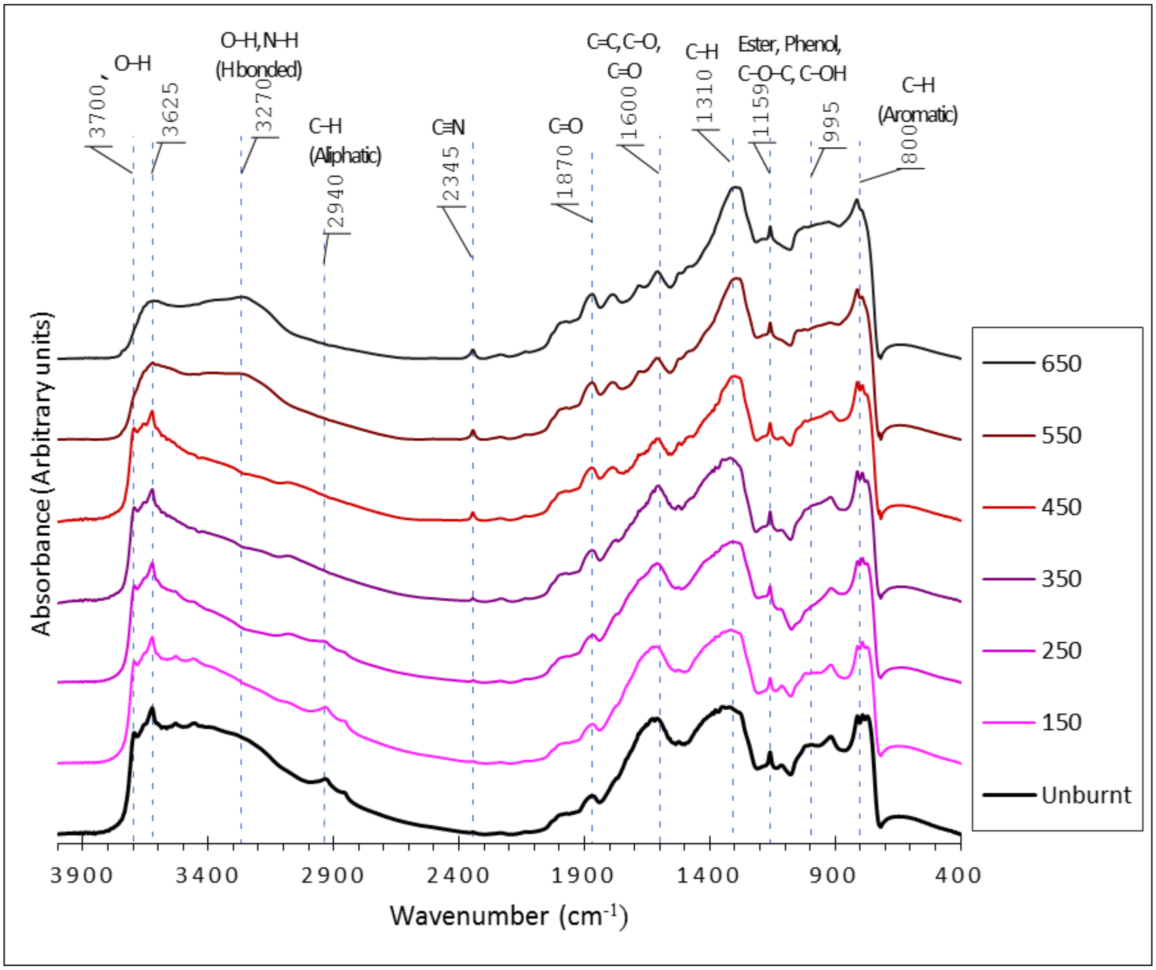

Figure 4-29 FTIR spectra for Shaver soils at the different combustion temperatures.

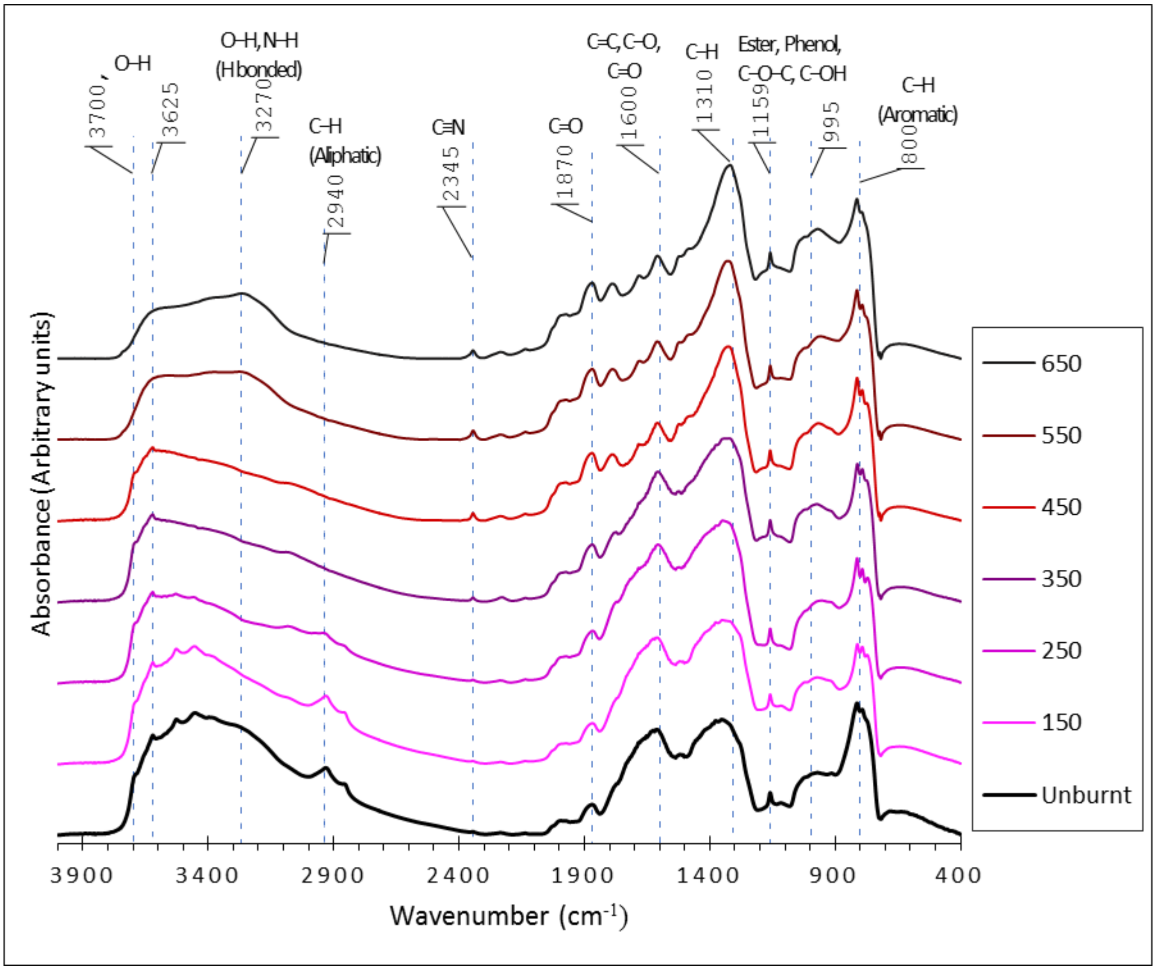

Figure 4-30 FTIR spectra for Sirretta soils at the different combustion temperatures.

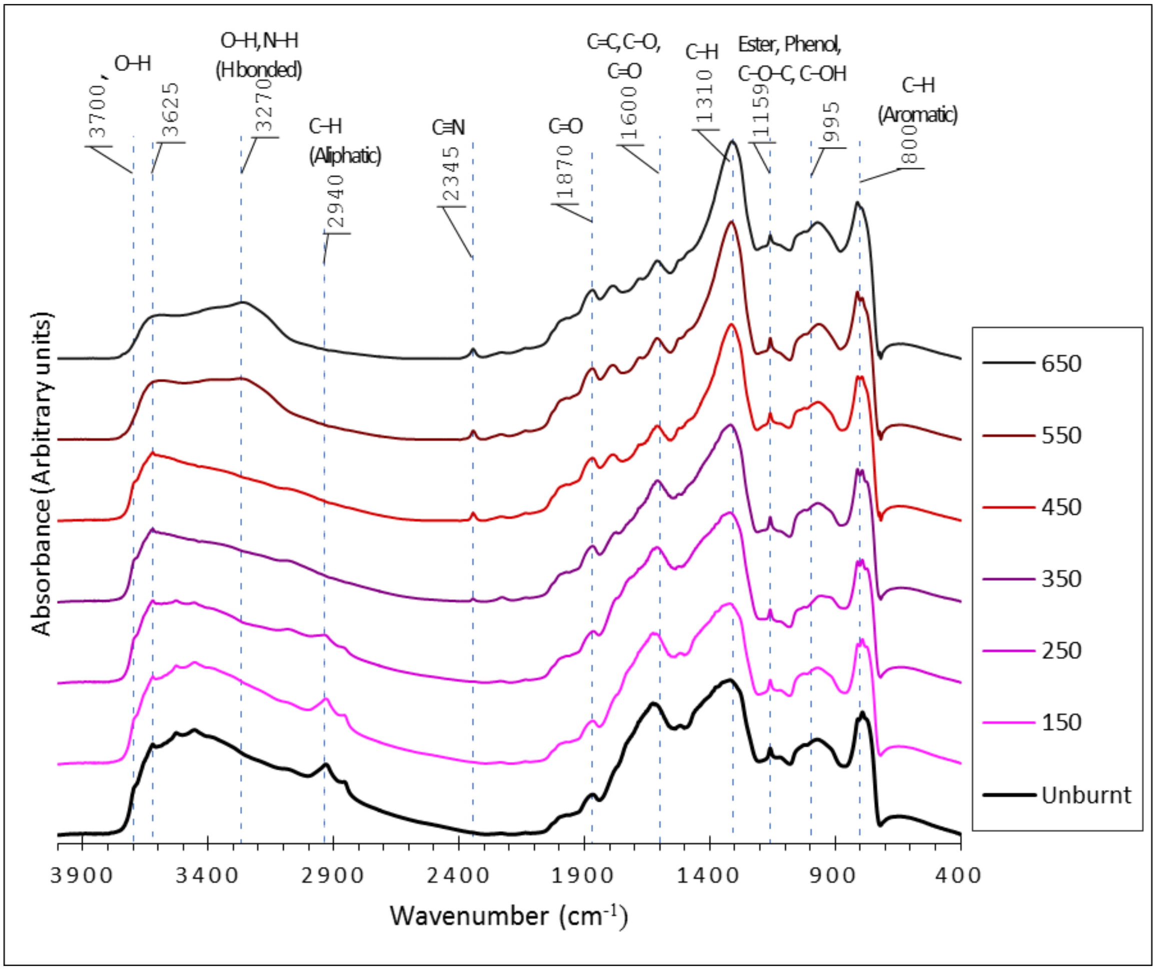

Figure 4-31 FTIR spectra for Chiquito soils at the different combustion temperatures.

5 Discussion

Findings of my thesis research showed that increase in heating temperature leads to discernable changes in soil physical and chemical properties, including amount and composition of SOM. Most of the important heating-induced changes I observed were mediated by loss and transformations of SOM in topsoil that increased progressively along the temperature spectrum that I used in my experiments. To minimize the effect of water on heating and transformations associated with combustion, all the samples in my thesis research were dried prior to all the analyses. Results presented above demonstrate the type and magnitude of changes in important soil physico-chemical conditions that can be expected when topsoil is burned at low, medium and high intensity fires.

Soil color changed with heating with two main changes that were readily observable. In the mid temperature ranges, soils got darker (lower Munsell value) compared to initial color due to charring of OM and production of black or pyrogenic C. At higher temperature soils got redder and with higher Munsell chromas and values than unburnt soils. In pedology, reddening of soils at higher temperature is attributed to oxidation and transformation of Fe-oxides (in a manner analogous to aging of soils and transformations of mineral soil after intense weathering) while increase in Munsell values is attributed to removal of OM (Giovannini et al., 1988; Ketterings & Bigham, 2000; Ulery & Graham, 1993).

The main effect of fire on soil physical structure is attributed to combustion of SOM rather than to changes in minerals. OM plays most prominent roles in fire-induced changes of topsoil properties since minerals are not significantly altered at temperatures <500°C, and the concentration of minerals in top soils is often relatively low so that their contribution to soil properties is limited (Neary et al., 1999; Ubeda & Outeiro, 2009). Loss of mass with increased combustion temperature is mainly due to loss of OM. The statistically significant change ($p<0.05$) in mass occurred within the temperature ranges of SOM combustion; mass loss showed good linear correlation with C content (first figure in Appendix III). To a lesser extent (especially at <250 and >450°C) mass loss occurs due to other processes such as dehydration and removal of volatile compounds.

The two most affected soil physical properties are water repellency and aggregate stability (Arcenegui et al., 2008; Zavala et al., 2010). Most studies find fire reduces aggregate stability, however contrasting findings are also reported. Mataix-Solera et al. (2011) conducted a comprehensive literature review and concluded on the existence of three different patterns of aggregate stability change during fire that depend on soil properties and burn factors. In the first case, in soils with high clay content where the main cementing substances are calcium carbonate, Fe and Al oxides, aggregate strength may simply increase with heating temperature. In the second case where

SOM is the principal binding agent and is low in water repellency aggregate stability increases up to medium severity fires (due to increase in hydrophobicity) but decrease afterwards due to loss of its cementing material. In the third case where soil is sandy and the principal binding agent is SOM, that has properties of water-repellency, aggregate stability would simply decline with temperature increase. The soils from this study fall into the second and third cases; the temperatures of significant aggregate stability decline for our soils correspond to temperatures of significant SOM transformation (> 250°C) where the Vista (210 m), Sirretta (2317 m) and Chiquito (2865 m) soils initially showed a slight increase in aggregation before declining at higher temperatures. The increase in hydrophobicity, and hence more resistance to slaking, was especially evident with Chiquito (2865 m) soils heated at 250°C which presented a challenge for the aggregate stability test—it was impossible to wet some of the samples.

Soil specific surface area (SSA) is a critical soil property that regulated many essential chemical and physical properties in soil including: adsorption, ion exchange capacity, reactivity, aggregation and porosity (Feller et al., 1992). SSA of soil is largely dictated by clay-size particles and organic matter (Carter et al., 1986). The increase in SSA with heating that I observed in my work is most likely the result of changes in OM especially at temperatures below 500ºC. Soil minerals were only significantly affected after 500˚C, in our soils where I observed kaolinite spectra disappear at temperatures above 550˚C. Similarly the small proportion of other phyllosilicates in the study soils appears to have disappeared at 450 – 550ºC. Because of combustion and heat induced dehydration, larger organic matter particles are likely to have fragmented and reduced in size with increase in heating temperature creating larger surface area per given mass. In addition, breakup of larger OM particles with combustion might increase surfaces. Furthermore, removal of organic matter from mineral surfaces may also increase surface area by reducing overall size of particles. At higher temperatures, XRD spectra showed some collapse of mineral complexes through dehydration and de-hydroxylation of clay minerals that may reduce mineral particle size and increase surface area. The changes in mineralogy I observed using XRD spectroscopy might have a significant effect on SOM. After finding HF treated soils released more organic compounds during pyrolysis compared to untreated soils, Rosa et al. (2013) suggested that mineral complexes may protect release of compounds during pyrolysis. Hence the collapse of the mineral complexes, as seen on XRD and decrease of aggregate strength, may have significant effects on making organic C more vulnerable to further thermal oxidation and loss.

Increase in pH with fire heating is universally observed in all fire studies (Badía & Martí, 2003b; Chandler et al., 1983; Ubeda & Outeiro, 2009). In a similar heating experiment, Fernandez et al. (1997) observed a pH (water) increase of 1.7 at 350ºC and 2.35 at 490ºC. Increase in pH with fire heating is attributed to the denaturation of organic acids, the release of base cations from combustion (K- and Na-hydroxides, Mg- and Ca- carbonates), the deposition of ashes and loss of hydroxyl groups from clays (Badía & Martí, 2003b; Certini, 2005). Given there was no deposition in our experiment; the increase in pH represents changes in the soil. In our soils, the higher elevation soils (Shaver, Sirretta and Chiquito) showed a decrease of 0.3 to 0.5 pH units (measured in water) at 250ºC although this change was not statistically significant; Badía and Martí (2003b); Terefe et al. (2008) have reported similar initial decrease. Terefe et al. (2008) hypothesized that this may be due to the combined effect of desiccation and heating effect which favor proton-reducing oxidation reactions. And the fact it is below the temperature for start of combustion of organic acids means contribution of SOM to pH increase (organic acid denaturation and ash liming effect) was absent at this temperature. In a similar heating experiment Badía and Martí (2003b) found an increase in electric conductivity and soluble Ca along with decrease in pH at 250°C. Such increase in soluble cations might explain my findings since there was no decrease in pH observed when measured in $CaCl_2$ solution hence suggesting that the decrease in pH might have to do with increase in soluble salt with heating up to 250°C.

Capacity of soil to exchange positively charged ions between soil and soil solution decreased with increasing temperature since CEC is dependent on secondary clay minerals and OM (Sparks, 2005). The threshold type loss of CEC is closely associated with loss of SOM. Different authors have attributed loss of CEC in heating mainly with loss of SOM (Fernandez et al., 1997; Ubeda & Outeiro, 2009) since OM loss start at temperatures above 200°C with little or no decrease at lower temperatures where SOM is not affected (Nishita & Haug, 1972; Soto & Diazfierros, 1993). The slight increase of CEC at 350°C may be due to the threshold increase of specific surface area at that temperature (Figure 4-12). The additional surface for cation adsorption might have to an extent compensated for the loss of SOM at that temperature. Furthermore, the contribution of surface oxidation of char products has been shown to increase CEC per unit C (Liang et al., 2006), because of the almost complete loss of C at > 450°C and little effect of heating at < 250°C, the 350°C temperature was most likely when the soils had highest concentration of charred SOM.

5.1 Soil organic matter

Top soils have relatively high OM and low clay content. The sensitivity of the top soil layer to fire and the fact that properties in top layers are often dominated by SOM means changes in SOM to heating drive many other changes. Analyses of associations between C concentration and several soil properties showed linear association between: C and N (R^2 >0.8), mass loss (R^2 >0.8, except for Vista and Sirretta soils), pH (R^2 >0.8, except for Shaver and Sirretta), CEC (R^2 >0.7, except for Chiquito). Linear association between C concentration and aggregate strength (R^2 >0.7, except for Musick and Chiquito which had R^2 ~0.7). Specific surface area showed relation with C (R^2 >0.7 except for Vista and Musick). Linear regression equations and plots are shown in Appendix III.

The C and N concentrations were highest in silt-clay size particles followed by larger micro and macro aggregates, however since 55 to 70% of our soils consisted of macro aggregates (by weight) the macro-aggregate size fraction had more relevance to SOM changes.

Effect of fire heating on OM ranged from slight distillation (volatilization of minor constituents) typically at temperatures below 150°C, to charring which typically starts at temperatures above 350°C and complete combustion (Badía & Martí, 2003b; Certini, 2005). Following wild fires, soil total C may decrease (for example Badía et al. (2013); Knicker et al. (2005))or, remain unchanged or may even increase (for example Dennis et al. (2013); Kavdır et al. (2005)) due to incorporation of necromass from surface biomass (Almendros et al., 1990). Without addition from above ground biomass the effect of fire heating is to decrease soil organic matter (Certini, 2005).

During heating we found significant changes in quantity and quality of SOM. The steep decline in concentration of C in soil that I observed between 250 – 450ºC in the soils from this study is consistent with loss of soil organic carbon. The decrease of about 25% C at 250°C and an almost 99% loss at 450°C is similar to the pattern observed by previous studies (Terefe et al., 2008; Ulery & Graham, 1993) that investigated changes in soil C using artificial heating experiment. Giovannini et al. (1988) found OM decrease started at 220°C with about 15% loss of OM and about 90% OM loss at 460°C. Fernandez et al. (1997), in a heating experiment of the top 5 cm depth soils, reported 37% of SOM loss at 220°C and 90% at 350°C.

Furthermore, along with the change in C concentration; between 150°C and before almost total loss of C above 450°C, the SOM went through significant qualitative changes that included decrease in C:N ratio, enrichment in $\delta^{13}C$ isotope, changes in $\delta^{15}N$ isotope, and changes in FTIR spectra.

The C:N ratio is an important property in soils that controls rates of SOM decomposition and nutrient cycling, including N (Leonard F. DeBano, 1991). Loss in N after fire heating is the result of combustion and volatilization (Fisher & Binkley, 2000). Moderate to high intensity fires convert most organic-N into inorganic Ammonium (NH_4^+) (Certini, 2005; Huber et al., 2013). Ammonium is the immediate combustion product that contributes to formation of nitrate (NO_3^-) by nitrification reactions in weeks or months after fire. Decrease in C:N ratio with fire heating is typically reported in fire studies (Badía & Martí, 2003a; Certini, 2005; Fernandez et al., 1997; González-Pérez et al., 2004) . Decrease of C:N ratio is as a result of slower loss of N with heating, compared to C. In this study, I observed that N is not as significantly reduced until 350°C with about 75% N remaining as opposed to greater than 50% loss of C concentration at the same temperature (Figure 4-16).

SOM has a C isotopic composition that reflects the $\delta^{13}C$ signature of native vegetation. Plants are depleted in $\delta^{13}C$ relative to atmosphere. The $\delta^{13}C$ composition for our soils indicated that the dominant source of OM in all soils is C3 plant biomass that had average $\delta^{13}C$ of -27%, with the higher elevation soils having more positive $\delta^{13}C$ than the low elevation (Golchin et al., 1995). Enrichment of ^{13}C with heating is consistent with the loss of plant derived C. The continued enrichment of $\delta^{13}C$ with heating is also likely enhanced because the relatively more $\delta^{13}C$ depleted lipids are combusted at lower temperatures relative to woody materials (cellulose, lignin) which are also lost at higher temperatures (>300°C) (C. I. Czimczik et al., 2002).

The stable C and N isotope composition of our soils showed significant fractionation with temperature. $\delta^{13}C$ values became more positive (enriched in $\delta^{13}C$) up to 450°C where up to 99% of C was lost (Figure 4-19). At higher temperature there was a less uniform pattern among the soils. For the last <1% C, Sirretta and Chiquito soils continued to be more negative (depleted in $\delta^{13}C$) at higher temperature while for the rest of the soils there was a slight depletion at 550°C followed by a slight enrichment at 650°C (Figure 4-18). The depletion of $\delta^{13}C$ at 550 and 650°C found in this study might be the result of SOM charring as there was little or no decrease in C concentration between these temperatures. In a wood charring experiment (non-oxygen atmosphere) at 150, 340 and 480°C, C. I. Czimczik et al. (2002), observed an enrichment of $\delta^{13}C$ at 150°C where there was no C concentration change but a depletion of $\delta^{13}C$ at 340 and 480°C with charring where the C concentration increased over 50% due to charring.

Enrichment of ^{15}N was observed in soils immediately after fires (Boeckx et al., 2005; Grogan et al., 2000; Herman & Rundel, 1989; Huber et al., 2013). Enrichment of ^{15}N up to 350°C and depletion after 350°C for all soils (Figure 4-20) happened most likely because the isotopic fractionation of ^{15}N during combustion and volatilization is dependent on duration and intensity of heating as Huber et al. (2013) have suggested. In a post fire-analysis of $\delta^{15}N$ on a sub-alpine ecosystem in Australia,Huber et al. (2013) found that bulk soil (0 – 5 cm) was enriched in ^{15}N (approximately 3.3‰) while charred OM was enriched to a lesser extent (approximately 0.5‰) and ash to an even lesser extent (approximately -0.6‰). They attributed this difference in enrichment to be the result of heating intensity, that is, lower heat intensity provided slower processes for greater fractionation (observed in bulk soil), while higher intensity fires result in full combustion of plant material providing little opportunity for isotopic discrimination (observed in ash). The depletion of ^{15}N observed after 350°C corresponds with my findings of steep decline in N concentration (Figure 4-14) further supporting the explanation that the enrichment prior to 350°C is likely due to fractionation during combustion and volatilization whereas at higher temperatures reversal of pattern towards depletion is likely a result of the indiscriminate removal of N.

Within SOM, lipids are combusted at lower temperatures and lipids are relatively more depleted in $\delta\, ^{13}C$ relative to other more thermally resistant, woody materials (cellulose, lignin) which are also lost at temperatures above 300°C (C. I. Czimczik et al., 2002). Incomplete combustion of OM results in transformation and production of charred products. For example degradation of lignin and hemicellulose begin at 130 and 190°C, respectively.

In Table 5-1 I have summarizes common char products from SOM as reviewed by Knicker (2007).

Table 5-1 Common char products from SOM (from Knicker (2007))

Original compound	**Char product at <300°C**	**Char product at 300°C - 400°C**
Cellulose and pectin (account for 20 – 50% of plant dry mass)	Aliphatic C, phenol and/or furan C, aromatic C, and carbonyl C	Polycyclic aromatic hydrocarbons (PAHs)
d-glucose and sucrose	Furans, pyranones, anhydrosugars and 5-hydroxymethylfurfural	
Carbohydrate	Phenols, furans and aromatic hydrocarbons	Furan-like compounds
Lignin (accounts for 20–40% of wood and about 4% of grasses)	Methoxyphenols	At 400°C: phenolic C and alcoholic C yields diminish. Methoxyl C removed
Proteins and amino acids	cyclic dipeptides (diketopiperazines), or dipeptides, or loss of water or ammonium to give cyclic products	>500°C: polynuclear aromatic structures containing nitrogen (N-PACs) are also produced

Knicker (2007) notes a SOM and plant residue heating experiment in which 350°C completely removes carbohydrate signal from ^{13}C NMR spectra, furthermore stable alkyl C and also carboxyl C also removed at 350°C and there is an increase in aromatic-C content. FTIR spectra from this work showed that the aliphatic O—H stretch peak (bands 3700 – 3200 cm^{-1}) disappeared at temperatures above 550°C for all soils accompanied by nitriles or methanenitrile C≡N stretch (2300—2200 cm^{-1}) at temperature above 450 suggesting condensation of C.

5.2 Importance of the 250 – 450°C range

Based on maximum surface temperature, fires are often classified as low, medium or high intensity. Low intensity fires reach surface temperatures of up to 250°C, medium intensity fires reach surface temperatures of 400°C, and high intensity fires reach surface temperatures above 675°C (Janzen & Tobin-Janzen, 2008). In this study, the most significant changes of soil chemical properties occurred between 250 and 450°C. Table 5-2 shows the changes between unburned and 650°C burned soils along with 250 to 450°C heating changes. In many properties, the 250 – 450°C range accounts for more than half the total value change.

Table 5-2 Difference between means of unburned and 650°C heated soils; and difference of means within the 250 to 450°C range inside square-brackets.

Soil series and elevation (m)	pH (water)	pH ($CaCl_2$)	CEC ($cmol_c$/kg)	C (%)	N (%)	C:N ratio
Vista, 210	-2.37 [-1.73]	-2.74 [-2.06]	7.4 [4.27]	1.5 [0.93]	0.14 [0.07]	10.05 [7.33]
Musick, 1384	-4.28 [-4.04]	-5.11 [-4.4]	20.74 [11.68]	7.64 [4.69]	0.27 [0.2]	28.42 [17.67]
Shaver, 1737	-2.91 [-3.17]	-4.19 [-3.36]	9.67 [3.33]	2.83 [2.48]	0.13 [0.09]	20.57 [18.64]
Sirretta, 2317	-3.05 [-3.23]	-4 [-3.3]	11.23 [2.75]	4.73 [3.03]	0.15 [0.09]	30.16 [22.7]
Chiquito, 2865	-2.29 [-2.33]	-3.26 [-2.63]	5.03 [0.81]	4.08 [3.02]	0.18 [0.12]	22.34 [18.65]

Temperatures below 250°C are very critical for many processes, water is lost at 95°C and this has a significant effect on soil heat conduction and soil biota (Janzen & Tobin-Janzen, 2008). However temperatures below 200°C have very little effect on SOM. This means low intensity fires, such as typical prescribed fires, contribute little to soil C loss. Similarly temperatures above 500°C do little change to SOM, which already has been lost or transformed into a pyrogenic product. The effect on soil inorganic particles starts at high temperature but the significance of change on minerals is not as large. Hence we found that the most important soil changes occur the 250 – 450°C range.

6 Summary and Conclusions

This thesis investigated the immediate effects of combustion at different temperatures on physical and chemical properties of top soils from an elevational transect along the Western slope of the Sierra Nevada Mountains in California.

Findings of this study showed that changes in soil properties during heating are closely related to changes in SOM. The temperatures most critical to SOM alteration were found to be 250ºC, where charring of OM starts and 450ºC where most of the SOM is combusted. Most soil properties exhibited a steep change in this temperature range. Soil aggregate stability, CEC, and C and N concentrations significantly decreased with increased combustion temperature while soil pH and SSA significantly increased. SOM exhibited significant changes: soil was enriched in ^{13}C and ^{15}N isotopic composition until approximately 90% of C and N was lost, at higher temperatures, slight depletion of ^{13}C and steep depletion of ^{15}N was observed as a result of total OM combustion. FTIR spectroscopy showed the reduction and disappearance of aliphatic OH functional groups with temperature increase and accumulation of aromatic carbon groups. The most important effect of combustion on soil mineralogy as observed by XRD analysis was the reduction of kaolinite, which was undetectable at temperatures over 500ºC.

This study presented the effect of heat input on top soil properties which are necessary to understand changes in fires that result in heating of soil, without the additional variables of charred plant material and ash addition, influence of soil moisture, etc. Findings from this study will contribute towards estimating the amount and rate of change in carbon and nitrogen loss, and other essential soil properties that can be expected from topsoil exposure to different intensity fires.

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Appendix I: Summary of analysis data

Mean values of analysis and standard errors in brackets (where n=3). pH values are geometric means. SSA and CEC values have been adjusted for mass lost by combustion.

Elevation (m)	*Soil series*	*Combustion Temp. (°C)*	*Mass lost (%)*	*Water stable aggregate (%)*	*SSA (m^2/g)*	*pH (water)*	*pH ($CaCl_2$)*	*CEC ($cmol_c/kg$)*	*C concentration (%)*	*N concentration (%)*	*$\delta^{13}C$ (‰)*	*$\delta^{15}N$ (‰)*	*C:N ratio*
210	Vista	25	0 (0)	30.5 (3.39)	1.75 (0.22)	6.14 (0.06)	5.53 (0.04)	8.4 (1.07)	1.51 (0.2)	0.16 (0.01)	-27.83 (0.26)	-2.55 (0.21)	10.64 (0.84)
210	Vista	150	0.72 (0.04)	31.75 (6.95)	1.66 (0.24)	6.25 (0.08)	5.61 (0.09)	7.74 (0.95)	1.12 (0.1)	0.15 (0)	-28 (0.28)	-3.23 (0.1)	8.49 (0.58)
210	Vista	250	1.15 (0.2)	42.15 (3.61)	1.72 (0.19)	6.25 (0.08)	5.61 (0.09)	7.05 (0.61)	1.01 (0.09)	0.13 (0.01)	-28.25 (0.23)	-2.16 (0.13)	8.78 (0.54)
210	Vista	350	2.01 (0.32)	45.99 (5.57)	2.6 (0.24)	7.53 (0.07)	6.96 (0.07)	7.28 (0.46)	0.45 (0.05)	0.11 (0.01)	-27.16 (0.24)	-1.34 (0.21)	4.75 (0.22)
210	Vista	450	2.91 (0.37)	23.39 (5.28)	3.2 (0.28)	7.99 (0.22)	7.67 (0.09)	2.78 (0.28)	0.08 (0)	0.06 (0)	-25.73 (0.14)	-2.83 (0.17)	1.46 (0.05)
210	Vista	550	4.02 (0.42)	20.91 (1.23)	3.23 (0.16)	8.07 (0.1)	7.1 (0.17)	1 (0)	0.02 (0)	0.03 (0)	-26.09 (0.18)	-3.23 (0.22)	0.9 (0.07)
210	Vista	650	4.19 (0.42)	14.59 (0.85)	3.04 (0.27)	8.5 (0.25)	8.27 (0.22)	1 (0)	0.01 (0)	0.03 (0)	-25.48 (0.27)	-5.21 (0.17)	0.59 (0.06)
1384	Musick	25	0 (0)	51.53 (1.11)	4.98 (0.29)	5.64 (0.08)	4.67 (0.08)	25.2 (2)	7.66 (0.75)	0.3 (0.01)	-25.8 (0.09)	-2.01 (0.15)	29.49 (2.05)
1384	Musick	150	3.02 (0.2)	46.49 (5.06)	4.32 (0.2)	5.51 (0.08)	4.81 (0.1)	23.46 (0.99)	5.98 (0.25)	0.29 (0.01)	-25.9 (0.1)	-2 (0.2)	24.3 (0.66)
1384	Musick	250	6.06 (0.76)	41.01 (4.59)	3.91 (0.15)	5.51 (0.08)	4.81 (0.1)	17.54 (0.89)	4.89 (0.17)	0.28 (0.01)	-25.99 (0.09)	-1 (0.18)	20.45 (0.51)
1384	Musick	350	8.84 (1.24)	43.47 (1.21)	7.78 (0.46)	7.3 (0.27)	6.97 (0.27)	8.94 (0.44)	2.65 (0.13)	0.25 (0.01)	-25.46 (0.1)	-0.12 (0.17)	12.53 (0.84)
1384	Musick	450	13.42 (1.01)	26.21 (1.94)	7.04 (0.23)	9.55 (0.11)	9.21 (0.11)	5.86 (0.14)	0.2 (0.02)	0.08 (0)	-23.67 (0.14)	-1.03 (0.45)	2.78 (0.09)
1384	Musick	550	15.27 (0.89)	22.56 (0.5)	7.05 (0.2)	9.78 (0.1)	9.76 (0.2)	4.78 (0.44)	0.05 (0.01)	0.03 (0)	-23.44 (0.21)	-3.77 (0.24)	1.88 (0.26)

Elevation (m)	*Soil series*	*Combustion Temp. (°C)*	*Mass lost (%)*	*Water stable aggregate (%)*	*SSA (m^2/g)*	*pH (water)*	*pH ($CaCl_2$)*	*CEC ($cmol_c/kg$)*	*C concentration (%)*	*N concentration (%)*	*$\delta^{13}C$ (‰)*	*$\delta^{15}N$ (‰)*	*C:N ratio*
1384	Musick	650	15.88 (0.98)	15.61 (0.71)	6.75 (0.16)	9.92 (0.19)	9.78 (0.19)	4.46 (0.23)	0.02 (0)	0.03 (0)	-22.74 (0.33)	-4.68 (0.29)	1.07 (0.06)
1737	Shaver	25	0 (0)	35.99 (1.13)	3.08 (0.27)	6.06 (0.22)	4.85 (0.34)	10.67 (2.13)	2.84 (0.18)	0.16 (0.01)	-25.14 (0.16)	-3.31 (0.06)	21.25 (0.65)
1737	Shaver	150	1.63 (0.16)	35.1 (5.44)	2.52 (0.16)	5.64 (0.25)	4.93 (0.3)	8.55 (1.8)	2.75 (0.2)	0.15 (0)	-25.28 (0.16)	-3.83 (0.22)	21.16 (1.04)
1737	Shaver	250	2.66 (0.3)	30.36 (4.73)	1.76 (0.17)	5.64 (0.25)	4.93 (0.3)	4.92 (1.64)	2.58 (0.23)	0.15 (0.01)	-25.44 (0.21)	-2.59 (0.32)	20.55 (0.63)
1737	Shaver	350	3.8 (0.36)	22.77 (1.77)	3.47 (0.31)	6.48 (0.35)	6.06 (0.36)	6.47 (1.69)	1.48 (0.13)	0.12 (0)	-24.88 (0.15)	-1.47 (0.21)	13.72 (0.98)
1737	Shaver	450	6.64 (0.61)	23.86 (4.17)	4.05 (0.02)	8.81 (0.38)	8.29 (0.41)	1.59 (0.59)	0.1 (0.02)	0.06 (0)	-23.3 (0.16)	-2.98 (0.36)	1.91 (0.3)
1737	Shaver	550	7.52 (0.44)	14.72 (3.66)	3.71 (0.14)	9.04 (0.49)	8.63 (0.59)	1 (0)	0.03 (0)	0.03 (0)	-24.3 (0.13)	-3.74 (0.37)	1.18 (0.17)
1737	Shaver	650	8.34 (0.73)	16.07 (1.57)	3.41 (0.09)	8.97 (0.68)	9.04 (0.84)	1 (0)	0.02 (0)	0.03 (0)	-22.68 (0.9)	-4.65 (0.72)	0.68 (0.14)
2317	Sirretta	25	0 (0)	45.41 (8.66)	6.63 (0.78)	5.7 (0.07)	4.54 (0.09)	12.23 (2.55)	4.74 (0.82)	0.17 (0.02)	-24.39 (0.06)	-2.74 (0.27)	30.83 (2.91)
2317	Sirretta	150	1.86 (0.16)	52.74 (3.69)	5.69 (1.02)	5.25 (0.06)	4.63 (0.06)	9.81 (2.44)	3.91 (0.56)	0.16 (0.01)	-24.6 (0.08)	-2.77 (0.13)	28.3 (2.32)
2317	Sirretta	250	4.12 (0.69)	24.11 (2.38)	3.47 (1.72)	5.21 (0.11)	4.76 (0.13)	5.03 (1.22)	3.11 (0.37)	0.15 (0.01)	-23.76 (0.06)	-1.78 (0.08)	24.4 (1.11)
2317	Sirretta	350	6.48 (1.59)	19.29 (6.81)	8.22 (2.74)	6.53 (0.24)	6.13 (0.24)	6.13 (0.39)	1.57 (0.13)	0.14 (0.01)	-23.9 (0.02)	-0.81 (0.13)	13.42 (0.11)
2317	Sirretta	450	9.3 (1.66)	19.03 (5.5)	8.91 (1.06)	8.44 (0.39)	8.06 (0.42)	2.29 (0.28)	0.08 (0.01)	0.05 (0)	-22.02 (0.04)	-3.36 (0.27)	1.7 (0.1)
2317	Sirretta	550	9.19 (1.7)	16.3 (3.44)	9 (1.16)	8.54 (0.52)	8.33 (0.53)	1.61 (0.61)	0.02 (0)	0.03 (0)	-22.88 (0.11)	-3.82 (0.36)	1.07 (0.09)
2317	Sirretta	650	10.4 (1.73)	19.17 (9.16)	7.63 (0.8)	8.75 (0.54)	8.54 (0.55)	1 (0)	0.01 (0)	0.02 (0)	-23.13 (0.77)	-3.97 (0.24)	0.68 (0.08)
2865	Chiquito	25	0 (0)	54.15 (4.16)	1 (0.04)	5.13 (0.16)	3.96 (0.13)	6.03 (1.79)	4.1 (0.2)	0.21 (0.01)	-24.14 (0.1)	-2.09 (0.23)	23.03 (0.33)

Elevation (m)	Soil series	Combustion Temp. (°C)	Mass lost (%)	Water stable aggregate (%)	SSA (m²/g)	pH (water)	pH ($CaCl_2$)	CEC ($cmol_c$/kg)	C concentration (%)	N concentration (%)	$\delta^{13}C$ (‰)	$\delta^{15}N$ (‰)	C:N ratio
2865	Chiquito	150	1.39 (0.16)	57.78 (2.88)	0.67 (0.03)	4.68 (0.11)	4 (0.08)	3.38 (1.87)	3.8 (0.33)	0.19 (0.01)	-24.34 (0.1)	-2.4 (0.26)	23.64 (0.7)
2865	Chiquito	250	3.3 (0.58)	55.34 (13.05)	0.72 (0.05)	4.83 (0.36)	4.1 (0.07)	1.81 (0.81)	3.08 (0.17)	0.18 (0.01)	-23.48 (0.1)	-0.9 (0.21)	19.87 (0.17)
2865	Chiquito	350	6.36 (0.99)	16.57 (3.95)	2.38 (0.55)	6 (0.17)	5.42 (0.16)	3.81 (0.57)	1.18 (0.08)	0.15 (0.01)	-23.13 (0.06)	-0.11 (0.29)	9.04 (0.29)
2865	Chiquito	450	8.4 (0.99)	13.09 (4.01)	2.35 (0.36)	7.16 (0.46)	6.73 (0.49)	1 (0)	0.06 (0)	0.06 (0)	-21.98 (0.18)	-2.36 (0.13)	1.22 (0.06)
2865	Chiquito	550	8.75 (1.09)	9.5 (1.54)	2.42 (0.38)	7.5 (0.24)	6.96 (0.21)	1 (0)	0.01 (0)	0.03 (0)	-23.19 (0.25)	-3.85 (0.44)	0.66 (0.04)
2865	Chiquito	650	9.67 (1.23)	9.77 (3.97)	2.07 (0.2)	7.43 (0.16)	7.22 (0.19)	1 (0)	0.02 (0)	0.03 (0)	-25.11 (0.83)	-4.8 (0.1)	0.69 (0.11)

Analysis data for aggregate size fractions.

Elevation (m)	*Soil series*	*Combustion Temperature (°C)*	*Aggregate size fraction§*	*Mass (%)*	*C concentration (%)*	*N concentration (%)*	*δ¹³C (‰)*	*δ¹⁵N (‰)*	*C:N ratio*
210	Vista	25	Macro	69.06 (0.92)	0.8 (0.14)	0.07 (0.01)	-27.66 (0.53)	-2.77 (0.28)	13.41 (0.78)
210	Vista	25	Micro	24.77 (0.67)	2.46 (1.09)	0.19 (0.07)	-28.33 (0.77)	-1.46 (0.33)	14.15 (1.15)
210	Vista	25	Silt-clay size	6.17 (0.95)	1.76 (0.2)	0.18 (0.02)	-27.3 (0.36)	0.17 (0.41)	11.28 (0.23)
210	Vista	150	Macro	67.18 (1.14)	1.21 (0.21)	0.1 (0.01)	-27.5 (0.4)	-0.39 (0.52)	13.97 (0.47)
210	Vista	150	Micro	28.09 (1.32)	1.59 (0.44)	0.13 (0.03)	-27.54 (0.4)	-0.51 (0.69)	14.19 (0.77)
210	Vista	150	Silt-clay size	4.73 (0.19)	1.7 (0.21)	0.16 (0.02)	-26.69 (0.26)	0.64 (0.23)	12.34 (0.27)
210	Vista	250	Macro	66.24 (1.85)	1.1 (0.2)	0.11 (0.01)	-27.01 (0.39)	-0.08 (0.06)	11.12 (0.66)
210	Vista	250	Micro	28.81 (0.88)	1.44 (0.39)	0.16 (0.04)	-27.45 (0.48)	0.61 (0.41)	10.61 (0.54)
210	Vista	250	Silt-clay size	4.95 (0.99)	1.65 (0.13)	0.2 (0.01)	-26.81 (0.14)	1.23 (0.21)	9.8 (0.16)
210	Vista	350	Macro	64.56 (3)	0.35 (0.05)	0.03 (0.01)	-27.17 (0.2)	0.77 (0.16)	11.71 (0.28)
210	Vista	350	Micro	29.99 (2.08)	0.57 (0.07)	0.07 (0.01)	-27.48 (0.31)	1.06 (0.48)	10.16 (0.44)
210	Vista	350	Silt-clay size	5.45 (0.93)	0.76 (0.05)	0.1 (0.01)	-26.92 (0.26)	1.67 (0.39)	9.34 (0.14)
210	Vista	450	Macro	62.61 (2.97)	0.06 (0.01)	0.01 (0)	-24.22 (0.2)	-0.22 (1.3)	3.81 (2.01)
210	Vista	450	Micro	32.1 (2.24)	0.13 (0.02)	0.02 (0)	-25.7 (0.16)	0.77 (0.96)	6.42 (0.57)
210	Vista	450	Silt-clay size	5.3 (0.74)	0.24 (0.02)	0.04 (0)	-25.41 (0.15)	1.29 (0.41)	7.39 (0.39)
1384	Musick	25	Macro	76.3 (1.02)	5.79 (0.25)	0.25 (0.02)	-26.06 (0.27)	-1.59 (0.47)	27.28 (0.75)
1384	Musick	25	Micro	16.36 (0.62)	8.66 (1.5)	0.39 (0.06)	-25.92 (0.14)	-0.69 (0.42)	25.57 (0.94)
1384	Musick	25	Silt-clay size	7.34 (0.49)	8.26 (0.45)	0.39 (0.02)	-25.37 (0.11)	0.2 (0.14)	24.91 (0.34)
1384	Musick	150	Macro	72.83 (3.05)	4.79 (0.34)	0.19 (0.02)	-25.63 (0.25)	-0.86 (0.47)	28.78 (0.78)
1384	Musick	150	Micro	20.14 (2.41)	7.54 (1.21)	0.34 (0.04)	-25.73 (0.2)	-0.41 (0.5)	25.76 (1.04)
1384	Musick	150	Silt-clay size	7.03 (0.71)	8.04 (0.36)	0.36 (0.01)	-25.36 (0.16)	0.43 (0.27)	25.83 (0.29)
1384	Musick	250	Macro	64.6 (3.12)	4.49 (0.29)	0.25 (0.01)	-25.67 (0.09)	0.02 (0.41)	21.06 (1.25)
1384	Musick	250	Micro	27.2 (2.06)	6.88 (1.22)	0.42 (0.08)	-25.63 (0.08)	0.57 (0.36)	19.19 (0.31)
1384	Musick	250	Silt-clay size	8.2 (2.37)	7.57 (0.53)	0.46 (0.03)	-25.28 (0.07)	1.16 (0.27)	19.01 (0.56)
1384	Musick	350	Macro	60.2 (1.5)	2.25 (0.29)	0.16 (0.02)	-25.6 (0.18)	-0.32 (0.55)	16.99 (1.75)

Elevation (m)	Soil series	Combustion Temperature (°C)	Aggregate size fraction[§]	Mass (%)	C concentration (%)	N concentration (%)	δ13C (‰)	δ15N (‰)	C:N ratio
1384	Musick	350	Micro	34.17 (1.18)	3.77 (0.47)	0.31 (0.01)	-25.27 (0.2)	-1.35 (0.56)	14.06 (1.31)
1384	Musick	350	Silt-clay size	5.62 (1.37)	4.21 (0.49)	0.36 (0.03)	-24.81 (0.1)	-0.72 (0.3)	13.63 (1.55)
1384	Musick	450	Macro	57.02 (1.58)	0.12 (0.02)	0.02 (0)	-23.26 (0.05)	-0.06 (0.18)	6.78 (0.74)
1384	Musick	450	Micro	38.27 (1.8)	0.37 (0.03)	0.06 (0.01)	-23.74 (0.11)	2.03 (0.18)	7.05 (0.32)
1384	Musick	450	Silt-clay size	4.71 (1)	0.41 (0.04)	0.07 (0.01)	-23.86 (0.14)	1.83 (0.15)	7.06 (0.22)
1737	Shaver	25	Macro	57.81 (2.13)	2.16 (0.91)	0.06 (0.02)	-24.84 (0.3)	-2.19 (1)	39.66 (2.3)
1737	Shaver	25	Micro	34.63 (1.18)	3.86 (1.02)	0.13 (0.03)	-25.23 (0.31)	-1.56 (0.41)	33.11 (0.77)
1737	Shaver	25	Silt-clay size	7.56 (0.94)	7.22 (0.38)	0.26 (0.01)	-25.01 (0.24)	0.11 (0.07)	32.5 (0.26)
1737	Shaver	150	Macro	55.54 (1.26)	1.76 (0.54)	0.05 (0.01)	-25.04 (0.25)	-1.17 (0.9)	39.51 (0.79)
1737	Shaver	150	Micro	37.24 (1.07)	3.49 (0.36)	0.12 (0.01)	-25.26 (0.29)	-0.02 (0.04)	34.27 (0.78)
1737	Shaver	150	Silt-clay size	7.22 (0.58)	6.93 (0.34)	0.24 (0.01)	-25.25 (0.15)	0.66 (0.29)	33.64 (0.86)
1737	Shaver	250	Macro	54.93 (0.28)	2.23 (0.27)	0.08 (0.02)	-25.37 (0.36)	-0.71 (0.42)	33.7 (3.62)
1737	Shaver	250	Micro	38.05 (0.31)	3.58 (0.6)	0.16 (0.02)	-25.11 (0.17)	0.74 (0.19)	26.5 (1.09)
1737	Shaver	250	Silt-clay size	7.02 (0.09)	6.57 (0.2)	0.28 (0.01)	-25 (0.16)	1.61 (0.09)	26.99 (0.25)
1737	Shaver	350	Macro	54.09 (0.5)	1.16 (0.42)	0.04 (0.01)	-24.53 (0.18)	-2.17 (1.05)	36.36 (3.91)
1737	Shaver	350	Micro	37.56 (0.96)	2.04 (0.47)	0.09 (0.01)	-24.56 (0.18)	-0.48 (0.48)	26.91 (3.21)
1737	Shaver	350	Silt-clay size	8.35 (1.44)	4.37 (0.84)	0.21 (0.02)	-24.41 (0.13)	-0.45 (0.46)	23.53 (3.04)
1737	Shaver	450	Macro	53.92 (1.08)	0.05 (0.02)	0 (0)	-24.04 (0.42)	0 (0)	0 (0)
1737	Shaver	450	Micro	37.79 (0.68)	0.18 (0.07)	0.02 (0.01)	-22.76 (0.39)	1.34 (1.28)	6.84 (3.92)
1737	Shaver	450	Silt-clay size	8.29 (1.67)	0.33 (0.07)	0.05 (0.01)	-22.92 (0.16)	2.02 (0.42)	7.91 (0.79)
2317	Sirretta	25	Macro	62.1 (2.87)	4.88 (0.99)	0.11 (0.03)	-24.5 (0.09)	-1.14 (0.32)	54.43 (4.28)
2317	Sirretta	25	Micro	31.47 (2.37)	5.41 (1.66)	0.15 (0.05)	-24.32 (0.18)	-0.77 (0.29)	43.02 (1.38)
2317	Sirretta	25	Silt-clay size	6.43 (0.53)	7.58 (2.14)	0.24 (0.07)	-24.35 (0.23)	0.92 (0.63)	36.54 (1.39)
2317	Sirretta	150	Macro	57.21 (1.68)	3.4 (1.03)	0.08 (0.02)	-24.38 (0.1)	-1.7 (0.65)	52.23 (1.07)
2317	Sirretta	150	Micro	35.67 (1.47)	6.64 (2.17)	0.17 (0.06)	-24.24 (0.24)	-0.21 (0.63)	45.05 (1.74)
2317	Sirretta	150	Silt-clay size	7.12 (0.43)	6.63 (1.59)	0.2 (0.05)	-24.25 (0.22)	1.47 (0.49)	38.46 (1.97)

Elevation (m)	*Soil series*	*Combustion Temperature (°C)*	*Aggregate size fraction*[§]	*Mass (%)*	*C concentration (%)*	*N concentration (%)*	*δ¹³C (‰)*	*δ¹⁵N (‰)*	*C:N ratio*
2317	Sirretta	250	Macro	58.62 (1.82)	3.52 (0.64)	0.1 (0.01)	-24.41 (0.16)	-0.39 (0.63)	39.78 (2.75)
2317	Sirretta	250	Micro	33.76 (2.18)	5.22 (1.75)	0.2 (0.06)	-24 (0.15)	1.64 (0.36)	29.51 (1)
2317	Sirretta	250	Silt-clay size	7.62 (0.38)	6.75 (1.35)	0.28 (0.05)	-23.93 (0.14)	2.42 (0.58)	27.82 (1.4)
2317	Sirretta	350	Macro	54.8 (1.04)	0.93 (0.03)	0.04 (0.01)	-23.77 (0.04)	-2.01 (0.63)	30.32 (4.04)
2317	Sirretta	350	Micro	35.61 (0.85)	1.95 (0.23)	0.11 (0.02)	-23.69 (0.09)	1.13 (0.26)	21.01 (1.6)
2317	Sirretta	350	Silt-clay size	9.59 (0.23)	3.24 (0.23)	0.22 (0.04)	-23.81 (0.06)	1.56 (0.74)	17.65 (1.91)
2317	Sirretta	450	Macro	55.46 (1.87)	0.03 (0)	0 (0)	-21.52 (0.77)	0 (0)	0 (0)
2317	Sirretta	450	Micro	34.14 (1.29)	0.13 (0.02)	0.02 (0)	-21.49 (0.19)	0.01 (2.67)	8.2 (0.63)
2317	Sirretta	450	Silt-clay size	10.4 (0.58)	0.32 (0.04)	0.05 (0.01)	-21.9 (0.16)	2.8 (0.57)	7.97 (0.59)
2865	Chiquito	25	Macro	59.42 (0.69)	3.57 (0.5)	0.11 (0.02)	-23.84 (0.16)	-1.69 (0.62)	39.37 (1.38)
2865	Chiquito	25	Micro	29.56 (0.86)	4.77 (0.73)	0.19 (0.03)	-23.76 (0.17)	-0.05 (0.51)	29.47 (1.36)
2865	Chiquito	25	Silt-clay size	11.02 (0.18)	7.77 (1.23)	0.33 (0.05)	-23.63 (0.12)	1.32 (0.08)	27.48 (0.57)
2865	Chiquito	150	Macro	56.45 (1.17)	3.15 (0.19)	0.1 (0.01)	-23.95 (0.22)	-1 (0.33)	39.74 (5.77)
2865	Chiquito	150	Micro	32.46 (0.75)	4.79 (0.98)	0.2 (0.04)	-23.8 (0.21)	1.28 (0.48)	28.36 (1.67)
2865	Chiquito	150	Silt-clay size	11.09 (0.52)	7.18 (0.84)	0.31 (0.04)	-23.6 (0.15)	2.49 (0.54)	26.95 (0.64)
2865	Chiquito	250	Macro	57.64 (1.4)	2.07 (0.09)	0.09 (0.01)	-23.78 (0.18)	-0.44 (0.49)	27.49 (0.63)
2865	Chiquito	250	Micro	31.79 (1.26)	4.38 (0.51)	0.24 (0.04)	-23.66 (0.14)	1.65 (0.43)	21.76 (0.96)
2865	Chiquito	250	Silt-clay size	10.57 (0.34)	7.08 (0.57)	0.39 (0.05)	-23.49 (0.14)	2.55 (0.25)	21.36 (1.06)
2865	Chiquito	450	Macro	54.84 (0.47)	0.05 (0.03)	0 (0)	-21.53 (1.36)	0 (0)	0 (0)
2865	Chiquito	450	Micro	29.98 (0.89)	0.13 (0.04)	0.03 (0.01)	-21.42 (0.34)	2.55 (2.34)	5.17 (0.12)
2865	Chiquito	450	Silt-clay size	15.18 (1.31)	0.26 (0.02)	0.06 (0.01)	-22.21 (0.13)	4.25 (0.31)	5.01 (0.28)

[§] Macro aggregates = 2 – 0.25 mm; micro aggregates = 0.25 – 0.053 mm; and silt-clay size particles = <0.053 mm.

Appendix II: Analysis of variance tables and Tukey's HSD comparison of means

A. Bulk Soil analysis

Vista series (210m)

One-way analysis of variance for **Aggregate stability (water stable %)**

```
            Df Sum Sq Mean Sq F value  Pr(>F)
Temp         6 2310.7   385.1   6.708 0.00165 **
Residuals   14  803.8    57.4
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	1.25	-19.8754	22.37544	0.999992
250-25	11.65667	-9.46877	32.78211	0.519828
350-25	15.49	-5.63544	36.61544	0.229212
450-25	-7.10667	-28.2321	14.01877	0.90182
550-25	-9.58333	-30.7088	11.54211	0.713636
650-25	-15.9067	-37.0321	5.218772	0.206827
250-150	10.40667	-10.7188	31.53211	0.637213
350-150	14.24	-6.88544	35.36544	0.307622
450-150	-8.35667	-29.4821	12.76877	0.817637
550-150	-10.8333	-31.9588	10.29211	0.596903
650-150	-17.1567	-38.2821	3.968772	0.150159
350-250	3.833333	-17.2921	24.95877	0.99495
450-250	-18.7633	-39.8888	2.362106	0.097394
550-250	-21.24	-42.3654	-0.11456	0.048378
650-250	-27.5633	-48.6888	-6.43789	0.007576
450-350	-22.5967	-43.7221	-1.47123	0.032635
550-350	-25.0733	-46.1988	-3.94789	0.015768
650-350	-31.3967	-52.5221	-10.2712	0.002488
550-450	-2.47667	-23.6021	18.64877	0.999554
650-450	-8.8	-29.9254	12.32544	0.781989
650-550	-6.32333	-27.4488	14.80211	0.940235

One-way analysis of variance for **pH (water)**

```
            Df Sum Sq Mean Sq F value   Pr(>F)    
Temp         6 18.277  3.0462   49.65 1.22e-08 ***
Residuals   14  0.859  0.0614                     
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	0.116667	-0.57393	0.807264	0.996564
250-25	0.116667	-0.57393	0.807264	0.996564
350-25	1.396667	0.706069	2.087264	0.000116
450-25	1.85	1.159402	2.540598	4.64E-06
550-25	1.933333	1.242736	2.623931	2.73E-06
650-25	2.366667	1.676069	3.057264	2.21E-07
250-150	0	-0.6906	0.690598	1
350-150	1.28	0.589402	1.970598	0.000292
450-150	1.733333	1.042736	2.423931	1.01E-05
550-150	1.816667	1.126069	2.507264	5.77E-06
650-150	2.25	1.559402	2.940598	4.17E-07
350-250	1.28	0.589402	1.970598	0.000292
450-250	1.733333	1.042736	2.423931	1.01E-05
550-250	1.816667	1.126069	2.507264	5.77E-06
650-250	2.25	1.559402	2.940598	4.17E-07
450-350	0.453333	-0.23726	1.143931	0.334286
550-350	0.536667	-0.15393	1.227264	0.181868
650-350	0.97	0.279402	1.660598	0.004092
550-450	0.083333	-0.60726	0.773931	0.999474
650-450	0.516667	-0.17393	1.207264	0.212127
650-550	0.433333	-0.25726	1.123931	0.38125

One-way analysis of variance for **pH (CaCl2)**

```
            Df Sum Sq Mean Sq F value   Pr(>F)    
Temp         6 22.074   3.679   79.43 5.28e-10 ***
Residuals   14  0.648   0.046                     
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	0.086667	-0.51336	0.686696	0.998549
250-25	0.086667	-0.51336	0.686696	0.998549
350-25	1.433333	0.833304	2.033362	1.79E-05
450-25	2.143333	1.543304	2.743362	1.30E-07
550-25	1.573333	0.973304	2.173362	6.00E-06
650-25	2.74	2.139971	3.340029	5.05E-09
250-150	0	-0.60003	0.600029	1
350-150	1.346667	0.746638	1.946696	3.66E-05
450-150	2.056667	1.456638	2.656696	2.20E-07
550-150	1.486667	0.886638	2.086696	1.17E-05
650-150	2.653333	2.053304	3.253362	7.82E-09
350-250	1.346667	0.746638	1.946696	3.66E-05
450-250	2.056667	1.456638	2.656696	2.20E-07
550-250	1.486667	0.886638	2.086696	1.17E-05
650-250	2.653333	2.053304	3.253362	7.82E-09
450-350	0.71	0.109971	1.310029	0.016126
550-350	0.14	-0.46003	0.740029	0.981485
650-350	1.306667	0.706638	1.906696	5.14E-05
550-450	-0.57	-1.17003	0.030029	0.067622
650-450	0.596667	-0.00336	1.196696	0.051731
650-550	1.166667	0.566638	1.766696	0.000177

One-way analysis of variance for **SSA (m^2/g)**

```
            Df  Sum Sq  Mean Sq  F value    Pr(>F)
Temp         6   9.560   1.5933    9.771  0.000246 ***
Residuals   14   2.283   0.1631
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	-0.09682	-1.22265	1.029012	0.999926
250-25	-0.03233	-1.15816	1.093494	1
350-25	0.84986	-0.27597	1.975689	0.204753
450-25	1.445717	0.319888	2.571546	0.00861
550-25	1.476909	0.35108	2.602738	0.00725
650-25	1.28598	0.160151	2.411808	0.020814

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
250-150	0.064482	-1.06135	1.190311	0.999993
350-150	0.946677	-0.17915	2.072506	0.127816
450-150	1.542534	0.416705	2.668363	0.005057
550-150	1.573726	0.447897	2.699555	0.004265
650-150	1.382797	0.256968	2.508625	0.012188
350-250	0.882195	-0.24363	2.008024	0.175599
450-250	1.478052	0.352223	2.60388	0.007205
550-250	1.509244	0.383415	2.635072	0.00607
650-250	1.318314	0.192486	2.444143	0.017409
450-350	0.595857	-0.52997	1.721685	0.564141
550-350	0.627049	-0.49878	1.752877	0.509769
650-350	0.436119	-0.68971	1.561948	0.830824
550-450	0.031192	-1.09464	1.157021	1
650-450	-0.15974	-1.28557	0.966091	0.998687
650-550	-0.19093	-1.31676	0.934899	0.996491

One-way analysis of variance for **CEC (cmol$_c$/kg)**

```
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         6 196.19   32.70   28.12 4.85e-07 ***
Residuals   14  16.28    1.16
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	-0.65665	-3.6628	2.349504	0.986705
250-25	-1.35089	-4.35704	1.655267	0.721776
350-25	-1.11856	-4.12471	1.887594	0.854183
450-25	-5.6173	-8.62345	-2.61115	0.000268
550-25	-7.4	-10.4062	-4.39385	1.26E-05
650-25	-7.4	-10.4062	-4.39385	1.26E-05
250-150	-0.69424	-3.70039	2.311917	0.982407
350-150	-0.46191	-3.46806	2.544244	0.997955
450-150	-4.96065	-7.9668	-1.9545	0.000936
550-150	-6.74335	-9.7495	-3.7372	3.68E-05
650-150	-6.74335	-9.7495	-3.7372	3.68E-05
350-250	0.232327	-2.77383	3.238481	0.99996
450-250	-4.26641	-7.27257	-1.26026	0.003741
550-250	-6.04911	-9.05527	-3.04296	0.000122
650-250	-6.04911	-9.05527	-3.04296	0.000122

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
450-350	-4.49874	-7.50489	-1.49259	0.002338
550-350	-6.28144	-9.28759	-3.27529	8.12E-05
650-350	-6.28144	-9.28759	-3.27529	8.12E-05
550-450	-1.7827	-4.78885	1.223454	0.441849
650-450	-1.7827	-4.78885	1.223454	0.441849
650-550	-2.66E-15	-3.00615	3.006154	1

One-way analysis of variance for **Macro aggregate weight (%)**

```
            Df  Sum Sq Mean Sq F value Pr(>F)
Temp         6  197.5   32.91   1.371  0.292
Residuals   14  336.1   24.01
```

One-way analysis of variance for **Micro aggregate weight (%)**

```
            Df  Sum Sq Mean Sq F value Pr(>F)
Temp         6  170.3   28.39   1.919  0.148
Residuals   14  207.2   14.80
```

One-way analysis of variance for **silt-Clay size particles weight (%)**

```
            Df  Sum Sq Mean Sq F value Pr(>F)
Temp         6   7.97   1.328   0.606  0.722
Residuals   14  30.68   2.191
```

One-way analysis of variance for **δ15N (‰)**

```
            Df  Sum Sq Mean Sq F value Pr(>F)
Temp         6  52.23   8.706    47.6 <2e-16 ***
Residuals   41   7.50   0.183
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Tukey’s HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	-0.68283	-1.44804	0.082373	0.107754
250-25	0.394333	-0.37087	1.15954	0.684788
350-25	1.209212	0.444006	1.974418	0.000294
450-25	-0.27662	-1.04183	0.488585	0.918142
550-25	-0.68032	-1.343	-0.01763	0.040852
650-25	-2.65308	-3.41828	-1.88787	4.40E-12
250-150	1.077167	0.31196	1.842373	0.001529
350-150	1.892045	1.126839	2.657252	3.97E-08
450-150	0.406212	-0.35899	1.171418	0.65472
550-150	0.002518	-0.66017	0.665206	1

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
650-150	-1.97024	-2.73545	-1.20504	1.45E-08
350-250	0.814879	0.049673	1.580085	0.030301
450-250	-0.67095	-1.43616	0.094252	0.119505
550-250	-1.07465	-1.73734	-0.41196	0.000197
650-250	-3.04741	-3.81262	-2.2822	8.74E-13
450-350	-1.48583	-2.25104	-0.72063	8.11E-06
550-350	-1.88953	-2.55222	-1.22684	1.00E-09
650-350	-3.86229	-4.6275	-3.09708	8.16E-13
550-450	-0.40369	-1.06638	0.258994	0.499444
650-450	-2.37646	-3.14166	-1.61125	9.30E-11
650-550	-1.97276	-2.63545	-1.31007	3.06E-10

One-way analysis of variance for **δ13C (‰)**

```
            Df  Sum Sq Mean Sq F value   Pr(>F)    
Temp         6  41.23   6.872   22.51 3.37e-10 ***
Residuals   32   9.77   0.305                     
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	-0.17167	-1.17428	0.830945	0.998006
250-25	-0.42417	-1.42678	0.578445	0.832959
350-25	0.668601	-0.33401	1.671213	0.378984
450-25	2.099934	1.097323	3.102546	3.98E-06
550-25	1.741157	0.738545	2.743768	9.87E-05
650-25	2.348334	1.120391	3.576278	2.03E-05
250-150	-0.2525	-1.25511	0.750111	0.984166
350-150	0.840268	-0.16234	1.842879	0.149353
450-150	2.271601	1.26899	3.274213	8.77E-07
550-150	1.912823	0.910212	2.915435	2.11E-05
650-150	2.520001	1.292058	3.747944	5.80E-06
350-250	1.092768	0.090156	2.095379	0.025466
450-250	2.524101	1.52149	3.526713	9.97E-08
550-250	2.165323	1.162712	3.167935	2.23E-06
650-250	2.772501	1.544558	4.000444	9.39E-07
450-350	1.431333	0.428722	2.433945	0.001543
550-350	1.072556	0.069944	2.075167	0.029728
650-350	1.679733	0.45179	2.907677	0.002589
550-450	-0.35878	-1.36139	0.643834	0.915668

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
650-450	0.2484	-0.97954	1.476343	0.995013
650-550	0.607178	-0.62077	1.835121	0.710922

One-way analysis of variance for **N (weight %)**

```
           Df  Sum Sq  Mean Sq F value Pr(>F)
Temp        6 0.14249 0.023749   174.4 <2e-16 ***
Residuals  41 0.00558 0.000136
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	-0.01018	-0.03106	0.0107	0.736676
250-25	-0.02977	-0.05065	-0.00889	0.001293
350-25	-0.05438	-0.07527	-0.0335	1.08E-08
450-25	-0.10249	-0.12337	-0.08161	8.16E-13
550-25	-0.1336	-0.15169	-0.11552	8.16E-13
650-25	-0.13686	-0.15774	-0.11598	8.16E-13
250-150	-0.01959	-0.04047	0.001294	0.078597
350-150	-0.0442	-0.06508	-0.02332	1.39E-06
450-150	-0.09231	-0.11319	-0.07143	8.21E-13
550-150	-0.12342	-0.14151	-0.10534	8.16E-13
650-150	-0.12668	-0.14756	-0.1058	8.16E-13
350-250	-0.02462	-0.0455	-0.00374	0.011864
450-250	-0.07272	-0.0936	-0.05184	3.95E-12
550-250	-0.10384	-0.12192	-0.08575	8.16E-13
650-250	-0.10709	-0.12798	-0.08621	8.16E-13
450-350	-0.04811	-0.06899	-0.02723	2.12E-07
550-350	-0.07922	-0.0973	-0.06114	8.22E-13
650-350	-0.08248	-0.10336	-0.0616	8.90E-13
550-450	-0.03111	-0.0492	-0.01303	7.41E-05
650-450	-0.03437	-0.05525	-0.01349	0.000155
650-550	-0.00326	-0.02134	0.014825	0.997624

One-way analysis of variance for **C (weight %)**

```
           Df Sum Sq Mean Sq F value Pr(>F)
Temp        6 15.197   2.533   57.61 <2e-16 ***
Residuals  41  1.803   0.044
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	-0.39558	-0.77078	-0.02039	0.032936
250-25	-0.50336	-0.87855	-0.12816	0.002817
350-25	-1.06566	-1.44086	-0.69047	1.11E-09
450-25	-1.43611	-1.8113	-1.06091	9.98E-13
550-25	-1.48973	-1.81466	-1.1648	8.17E-13
650-25	-1.49848	-1.87367	-1.12328	8.70E-13
250-150	-0.10777	-0.48297	0.26742	0.972047
350-150	-0.67008	-1.04528	-0.29489	3.87E-05
450-150	-1.04053	-1.41572	-0.66533	2.11E-09
550-150	-1.09415	-1.41908	-0.76922	9.43E-12
650-150	-1.1029	-1.47809	-0.7277	4.35E-10
350-250	-0.56231	-0.9375	-0.18711	0.000647
450-250	-0.93275	-1.30795	-0.55756	3.47E-08
550-250	-0.98638	-1.3113	-0.66145	1.77E-10
650-250	-0.99512	-1.37032	-0.61993	6.81E-09
450-350	-0.37045	-0.74564	0.004749	0.054958
550-350	-0.42407	-0.749	-0.09914	0.003923
650-350	-0.43281	-0.80801	-0.05762	0.014705
550-450	-0.05362	-0.37855	0.271307	0.998546
650-450	-0.06237	-0.43756	0.312828	0.998486
650-550	-0.00874	-0.33367	0.316183	1

One-way analysis of variance for **`C/N ratio`**

```
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         6  577.2    96.2   74.06 <2e-16 ***
Residuals   32   41.6     1.3
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	-2.15428	-4.22252	-0.08603	0.036782
250-25	-1.85542	-3.92366	0.212828	0.102312
350-25	-5.89259	-7.96083	-3.82434	6.36E-09
450-25	-9.18243	-11.2507	-7.11419	1.81E-13
550-25	-9.73663	-11.8049	-7.66839	1.18E-13
650-25	-10.0536	-12.5867	-7.52058	1.72E-12
250-150	0.29886	-1.76938	2.367104	0.999234

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
350-150	-3.73831	-5.80655	-1.67007	5.22E-05
450-150	-7.02816	-9.0964	-4.95991	9.05E-11
550-150	-7.58236	-9.6506	-5.51412	1.31E-11
650-150	-7.89937	-10.4324	-5.3663	7.52E-10
350-250	-4.03717	-6.10541	-1.96893	1.42E-05
450-250	-7.32702	-9.39526	-5.25877	3.15E-11
550-250	-7.88122	-9.94946	-5.81298	4.84E-12
650-250	-8.19823	-10.7313	-5.66516	3.04E-10
450-350	-3.28984	-5.35809	-1.2216	0.000365
550-350	-3.84405	-5.91229	-1.7758	3.29E-05
650-350	-4.16106	-6.69413	-1.62799	0.000229
550-450	-0.5542	-2.62245	1.51404	0.978327
650-450	-0.87122	-3.40429	1.661855	0.929148
650-550	-0.31701	-2.85008	2.216058	0.999664

Musick series (1384m)

One-way analysis of variance for **Aggregate stability (water stable %)**

```
            Df Sum Sq Mean Sq F value   Pr(>F)    
Temp         6   3361   560.2   24.27 1.23e-06 ***
Residuals   14    323    23.1                     
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	-5.03667	-18.4317	8.358318	0.84835
250-25	-10.5133	-23.9083	2.881652	0.17439
350-25	-8.05667	-21.4517	5.338318	0.42655
450-25	-25.3167	-38.7117	-11.9217	0.000238
550-25	-28.9667	-42.3617	-15.5717	5.56E-05
650-25	-35.9133	-49.3083	-22.5183	4.59E-06
250-150	-5.47667	-18.8717	7.918318	0.795366
350-150	-3.02	-16.415	10.37499	0.9844
450-150	-20.28	-33.675	-6.88501	0.002103
550-150	-23.93	-37.325	-10.535	0.000426
650-150	-30.8767	-44.2717	-17.4817	2.70E-05
350-250	2.456667	-10.9383	15.85165	0.994654
450-250	-14.8033	-28.1983	-1.40835	0.026204
550-250	-18.4533	-31.8483	-5.05835	0.004829
650-250	-25.4	-38.795	-12.005	0.00023
450-350	-17.26	-30.655	-3.86501	0.008378
550-350	-20.91	-34.305	-7.51501	0.001586
650-350	-27.8567	-41.2517	-14.4617	8.56E-05
550-450	-3.65	-17.045	9.744985	0.960944
650-450	-10.5967	-23.9917	2.798318	0.168587
650-550	-6.94667	-20.3417	6.448318	0.585346

One-way analysis of variance for **pH (water)**

```
            Df Sum Sq Mean Sq F value   Pr(>F)    
Temp         6  79.77  13.295   211.2 6.57e-13 ***
Residuals   14   0.88   0.063                     
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	-0.12667	-0.82616	0.572824	0.995005
250-25	-0.12667	-0.82616	0.572824	0.995005
350-25	1.663333	0.963842	2.362824	1.89E-05
450-25	3.91	3.210509	4.609491	3.81E-10
550-25	4.14	3.440509	4.839491	1.91E-10
650-25	4.283333	3.583842	4.982824	1.24E-10
250-150	-1.78E-15	-0.69949	0.699491	1
350-150	1.79	1.090509	2.489491	8.01E-06
450-150	4.036667	3.337176	4.736158	2.60E-10
550-150	4.266667	3.567176	4.966158	1.31E-10
650-150	4.41	3.710509	5.109491	8.48E-11
350-250	1.79	1.090509	2.489491	8.01E-06
450-250	4.036667	3.337176	4.736158	2.60E-10
550-250	4.266667	3.567176	4.966158	1.31E-10
650-250	4.41	3.710509	5.109491	8.48E-11
450-350	2.246667	1.547176	2.946158	4.99E-07
550-350	2.476667	1.777176	3.176158	1.46E-07
650-350	2.62	1.920509	3.319491	7.08E-08
550-450	0.23	-0.46949	0.929491	0.910625
650-450	0.373333	-0.32616	1.072824	0.555301
650-550	0.143333	-0.55616	0.842824	0.990422

One-way analysis of variance for **pH (CaCl2)**

```
           Df Sum Sq Mean Sq F value Pr(>F)
Temp        6 105.27   17.54   219.7  5e-13 ***
Residuals  14   1.12    0.08
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	0.133333	-0.65453	0.921194	0.996531
250-25	0.133333	-0.65453	0.921194	0.996531
350-25	2.3	1.512139	3.087861	1.63E-06
450-25	4.533333	3.745473	5.321194	2.69E-10
550-25	5.083333	4.295473	5.871194	6.19E-11
650-25	5.106667	4.318806	5.894527	5.80E-11
250-150	-8.88E-16	-0.78786	0.787861	1

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
350-150	2.166667	1.378806	2.954527	3.38E-06
450-150	4.4	3.612139	5.187861	3.85E-10
550-150	4.95	4.162139	5.737861	8.88E-11
650-150	4.973333	4.185473	5.761194	8.34E-11
350-250	2.166667	1.378806	2.954527	3.38E-06
450-250	4.4	3.612139	5.187861	3.85E-10
550-250	4.95	4.162139	5.737861	8.88E-11
650-250	4.973333	4.185473	5.761194	8.34E-11
450-350	2.233333	1.445473	3.021194	2.34E-06
550-350	2.783333	1.995473	3.571194	1.50E-07
650-350	2.806667	2.018806	3.594527	1.35E-07
550-450	0.55	-0.23786	1.337861	0.273724
650-450	0.573333	-0.21453	1.361194	0.235819
650-550	0.023333	-0.76453	0.811194	1

One-way analysis of variance for **SSA (m²/g)**

```
            Df  Sum Sq Mean Sq F value   Pr(>F)
Temp         6  42.50   7.083   34.69 1.27e-07 ***
Residuals   14   2.86   0.204
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	-0.66623	-1.92614	0.593678	0.565067
250-25	-1.07096	-2.33088	0.188946	0.121337
350-25	2.802559	1.542648	4.062469	4.05E-05
450-25	2.061074	0.801163	3.320984	0.001018
550-25	2.064792	0.804881	3.324703	0.001
650-25	1.769851	0.509941	3.029762	0.004088
250-150	-0.40473	-1.66464	0.855179	0.918925
350-150	3.468792	2.208881	4.728703	3.34E-06
450-150	2.727307	1.467396	3.987218	5.49E-05
550-150	2.731025	1.471114	3.990936	5.41E-05
650-150	2.436085	1.176174	3.695995	0.000188
350-250	3.873524	2.613613	5.133434	8.62E-07
450-250	3.132039	1.872128	4.391949	1.13E-05
550-250	3.135757	1.875846	4.395667	1.11E-05
650-250	2.840816	1.580906	4.100727	3.47E-05
450-350	-0.74149	-2.0014	0.518426	0.450092

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
550-350	-0.73777	-1.99768	0.522144	0.455542
650-350	-1.03271	-2.29262	0.227203	0.143996
550-450	0.003718	-1.25619	1.263629	1
650-450	-0.29122	-1.55113	0.968688	0.982328
650-550	-0.29494	-1.55485	0.96497	0.981178

One-way analysis of variance for **CEC (cmolc/kg)**

```
            Df Sum Sq Mean Sq F value   Pr(>F)    
Temp         6 1460.9  243.49    91.4 2.04e-10 ***
Residuals   14   37.3    2.66                     
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	-1.73516	-6.28573	2.815414	0.840299
250-25	-7.65856	-12.2091	-3.10799	0.000773
350-25	-16.2582	-20.8088	-11.7077	1.30E-07
450-25	-19.3394	-23.89	-14.7888	1.34E-08
550-25	-20.424	-24.9746	-15.8735	6.39E-09
650-25	-20.7445	-25.2951	-16.1939	5.17E-09
250-150	-5.9234	-10.474	-1.37283	0.007722
350-150	-14.5231	-19.0736	-9.97251	5.41E-07
450-150	-17.6043	-22.1548	-13.0537	4.66E-08
550-150	-18.6889	-23.2395	-14.1383	2.12E-08
650-150	-19.0093	-23.5599	-14.4588	1.69E-08
350-250	-8.59967	-13.1502	-4.0491	0.000239
450-250	-11.6809	-16.2314	-7.13029	7.72E-06
550-250	-12.7655	-17.3161	-8.21492	2.66E-06
650-250	-13.0859	-17.6365	-8.53535	1.96E-06
450-350	-3.08119	-7.63176	1.469384	0.303191
550-350	-4.16581	-8.71638	0.384757	0.083011
650-350	-4.48625	-9.03682	0.06432	0.054476
550-450	-1.08463	-5.6352	3.465944	0.979427
650-450	-1.40506	-5.95563	3.145507	0.931546
650-550	-0.32044	-4.87101	4.230134	0.999977

One-way analysis of variance for **Macro aggregate weight (%)**

```
            Df Sum Sq Mean Sq F value   Pr(>F)    
Temp         6 1243.8  207.30   15.39 1.93e-05 ***
Residuals   14  188.6   13.47                     
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	-3.47332	-13.7054	6.758739	0.898147
250-25	-11.7035	-21.9356	-1.47145	0.020614
350-25	-16.0988	-26.3309	-5.86675	0.001474
450-25	-19.2834	-29.5155	-9.05133	0.000246
550-25	-21.0115	-31.2436	-10.7795	9.82E-05
650-25	-19.3156	-29.5476	-9.08351	0.000241
250-150	-8.23019	-18.4622	2.001873	0.156762
350-150	-12.6255	-22.8575	-2.39343	0.011765
450-150	-15.8101	-26.0421	-5.57801	0.001744
550-150	-17.5382	-27.7703	-7.30617	0.000645
650-150	-15.8422	-26.0743	-5.61019	0.001712
350-250	-4.3953	-14.6274	5.836761	0.758701
450-250	-7.57988	-17.8119	2.652176	0.220417
550-250	-9.30804	-19.5401	0.924022	0.085874
650-250	-7.61206	-17.8441	2.620002	0.216838
450-350	-3.18459	-13.4166	7.047475	0.929151
550-350	-4.91274	-15.1448	5.319321	0.661988
650-350	-3.21676	-13.4488	7.015301	0.926027
550-450	-1.72815	-11.9602	8.503906	0.996568
650-450	-0.03217	-10.2642	10.19989	1
650-550	1.69598	-8.53608	11.92804	0.996902

One-way analysis of variance for **Micro aggregate weight (%)**

```
            Df Sum Sq Mean Sq F value   Pr(>F)    
Temp         6 1402.1  233.68   25.48 9.04e-07 ***
Residuals   14  128.4    9.17                     
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	3.785301	-4.65809	12.22869	0.723787
250-25	10.84056	2.397174	19.28395	0.008622
350-25	17.81534	9.371947	26.25873	7.30E-05
450-25	21.91129	13.4679	30.35468	6.78E-06
550-25	21.06403	12.62064	29.50742	1.08E-05
650-25	19.59251	11.14912	28.0359	2.51E-05
250-150	7.055264	-1.38813	15.49865	0.131685
350-150	14.03004	5.586647	22.47343	0.000875
450-150	18.12599	9.682603	26.56938	6.03E-05
550-150	17.27873	8.835338	25.72212	0.000102
650-150	15.80721	7.363821	24.2506	0.000263
350-250	6.974773	-1.46862	15.41816	0.138937
450-250	11.07073	2.627339	19.51412	0.007281
550-250	10.22346	1.780074	18.66685	0.013584
650-250	8.751947	0.308557	17.19534	0.040001
450-350	4.095956	-4.34743	12.53935	0.652133
550-350	3.248691	-5.1947	11.69208	0.834936
650-350	1.777174	-6.66622	10.22056	0.989
550-450	-0.84727	-9.29065	7.596125	0.999818
650-450	-2.31878	-10.7622	6.124608	0.959505
650-550	-1.47152	-9.91491	6.971873	0.995933

One-way analysis of variance for **Silt-clay size particles weight (%)**

```
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         6  25.04   4.173   0.925  0.506
Residuals   14  63.15   4.511
```

One-way analysis of variance for **δ15N (‰)**

```
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         6 108.94  18.156   52.02 <2e-16 ***
Residuals   41  14.31   0.349
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	0.008333	-1.04876	1.065423	1
250-25	1.009167	-0.04792	2.066256	0.069796
350-25	1.888879	0.831789	2.945968	3.83E-05

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
450-25	0.985712	-0.07138	2.042802	0.08174
550-25	-1.7554	-2.67087	-0.83993	1.03E-05
650-25	-2.66191	-3.719	-1.60482	2.53E-08
250-150	1.000833	-0.05626	2.057923	0.073856
350-150	1.880545	0.823456	2.937635	4.15E-05
450-150	0.977379	-0.07971	2.034468	0.086384
550-150	-1.76373	-2.6792	-0.84827	9.44E-06
650-150	-2.67024	-3.72733	-1.61315	2.34E-08
350-250	0.879712	-0.17738	1.936802	0.159134
450-250	-0.02345	-1.08054	1.033635	1
550-250	-2.76457	-3.68003	-1.8491	2.05E-10
650-250	-3.67108	-4.72817	-2.61399	4.23E-12
450-350	-0.90317	-1.96026	0.153923	0.138306
550-350	-3.64428	-4.55974	-2.72881	8.75E-13
650-350	-4.55079	-5.60788	-3.4937	8.23E-13
550-450	-2.74111	-3.65658	-1.82564	2.60E-10
650-450	-3.64762	-4.70471	-2.59053	4.95E-12
650-550	-0.90651	-1.82198	0.008955	0.053795

One-way analysis of variance for **δ13C (‰)**

```
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         6  55.71   9.285   84.86 <2e-16 ***
Residuals   32   3.50   0.109
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	-0.108	-0.70827	0.492274	0.997374
250-25	-0.1965	-0.79677	0.403774	0.943314
350-25	0.338601	-0.26167	0.938875	0.574721
450-25	2.124434	1.524161	2.724708	3.23E-11
550-25	2.35849	1.758216	2.958764	2.22E-12
650-25	3.054668	2.319486	3.78985	5.78E-13
250-150	-0.0885	-0.68877	0.511774	0.999141
350-150	0.446601	-0.15367	1.046875	0.257618
450-150	2.232434	1.632161	2.832708	9.06E-12
550-150	2.46649	1.866216	3.066764	7.44E-13
650-150	3.162668	2.427486	3.89785	2.90E-13
350-250	0.535101	-0.06517	1.135375	0.106215

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
450-250	2.320934	1.720661	2.921208	3.33E-12
550-250	2.55499	1.954716	3.155264	3.51E-13
650-250	3.251168	2.515986	3.98635	1.91E-13
450-350	1.785833	1.18556	2.386107	2.32E-09
550-350	2.019889	1.419615	2.620163	1.16E-10
650-350	2.716067	1.980885	3.451249	1.07E-11
550-450	0.234056	-0.36622	0.834329	0.878939
650-450	0.930233	0.195051	1.665415	0.006189
650-550	0.696178	-0.039	1.43136	0.072927

One-way analysis of variance for **N (weight %)**

```
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         6 0.6827 0.11378   400.4 <2e-16 ***
Residuals   41 0.0117 0.00028
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	-0.01239	-0.04255	0.017772	0.86004
250-25	-0.01992	-0.05009	0.01024	0.402202
350-25	-0.0493	-0.07947	-0.01914	0.000173
450-25	-0.21542	-0.24559	-0.18526	8.16E-13
550-25	-0.26802	-0.29414	-0.2419	8.16E-13
650-25	-0.26971	-0.29988	-0.23955	8.16E-13
250-150	-0.00753	-0.0377	0.022631	0.986226
350-150	-0.03691	-0.06707	-0.00675	0.008074
450-150	-0.20303	-0.2332	-0.17287	8.16E-13
550-150	-0.25563	-0.28175	-0.2295	8.16E-13
650-150	-0.25732	-0.28749	-0.22716	8.16E-13
350-250	-0.02938	-0.05954	0.000785	0.060662
450-250	-0.1955	-0.22566	-0.16534	8.16E-13
550-250	-0.24809	-0.27422	-0.22197	8.16E-13
650-250	-0.24979	-0.27995	-0.21963	8.16E-13
450-350	-0.16612	-0.19629	-0.13596	8.16E-13
550-350	-0.21872	-0.24484	-0.19259	8.16E-13
650-350	-0.22041	-0.25058	-0.19025	8.16E-13
550-450	-0.05259	-0.07872	-0.02647	3.94E-06
650-450	-0.05429	-0.08445	-0.02413	3.37E-05
650-550	-0.0017	-0.02782	0.024426	0.999994

One-way analysis of variance for **C (weight %)**

```
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         6  400.8   66.80   138.3 <2e-16 ***
Residuals   41   19.8    0.48
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	-1.65895	-2.90241	-0.41549	0.003015
250-25	-2.73545	-3.97891	-1.49199	6.03E-07
350-25	-4.95906	-6.20251	-3.7156	8.71E-13
450-25	-7.40759	-8.65104	-6.16413	8.16E-13
550-25	-7.55772	-8.63458	-6.48085	8.16E-13
650-25	-7.58201	-8.82546	-6.33855	8.16E-13
250-150	-1.0765	-2.31996	0.166959	0.128528
350-150	-3.30011	-4.54356	-2.05665	6.69E-09
450-150	-5.74864	-6.99209	-4.50518	8.17E-13
550-150	-5.89877	-6.97563	-4.8219	8.16E-13
650-150	-5.92306	-7.16652	-4.6796	8.17E-13
350-250	-2.22361	-3.46706	-0.98015	3.78E-05
450-250	-4.67214	-5.91559	-3.42868	1.13E-12
550-250	-4.82227	-5.89913	-3.7454	8.19E-13
650-250	-4.84656	-6.09002	-3.6031	9.23E-13
450-350	-2.44853	-3.69199	-1.20507	6.15E-06
550-350	-2.59866	-3.67553	-1.52179	7.15E-08
650-350	-2.62295	-3.86641	-1.37949	1.50E-06
550-450	-0.15013	-1.227	0.926736	0.999442
650-450	-0.17442	-1.41788	1.069037	0.999422
650-550	-0.02429	-1.10116	1.052576	1

One-way analysis of variance for **C/N ratio**

```
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         6   4477   746.1     140 <2e-16 ***
Residuals   32    171     5.3
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	-5.18768	-9.37757	-0.99779	0.007759
250-25	-9.03486	-13.2247	-4.84496	2.30E-06
350-25	-16.9618	-21.1516	-12.7719	1.06E-12
450-25	-26.706	-30.8959	-22.5161	1.00E-13
550-25	-27.6117	-31.8016	-23.4218	1.00E-13
650-25	-28.4236	-33.5551	-23.292	1.00E-13
250-150	-3.84717	-8.03706	0.342719	0.088827
350-150	-11.7741	-15.964	-7.58418	8.73E-09
450-150	-21.5183	-25.7082	-17.3284	1.02E-13
550-150	-22.424	-26.6139	-18.2341	1.01E-13
650-150	-23.2359	-28.3675	-18.1044	1.47E-13
350-250	-7.92689	-12.1168	-3.737	2.44E-05
450-250	-17.6712	-21.861	-13.4813	4.20E-13
550-250	-18.5768	-22.7667	-14.3869	1.84E-13
650-250	-19.3887	-24.5203	-14.2572	6.02E-12
450-350	-9.74426	-13.9342	-5.55437	5.20E-07
550-350	-10.6499	-14.8398	-6.46005	8.11E-08
650-350	-11.4618	-16.5934	-6.3303	1.16E-06
550-450	-0.90568	-5.09558	3.284207	0.992877
650-450	-1.71758	-6.84913	3.413963	0.937281
650-550	-0.8119	-5.94345	4.319648	0.998719

Shaver series（1938m）

One-way analysis of variance for **Aggregate stability (water stable %)**

```
            Df Sum Sq Mean Sq F value  Pr(>F)   
Temp         6 1323.9  220.65   5.744 0.00338 **
Residuals   14  537.8   38.41                   
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	-0.89333	-18.1725	16.38582	0.999996
250-25	-5.63333	-22.9125	11.64582	0.913741
350-25	-13.2267	-30.5058	4.052491	0.193568
450-25	-12.1333	-29.4125	5.145825	0.268219
550-25	-21.2767	-38.5558	-3.99751	0.011955
650-25	-19.9267	-37.2058	-2.64751	0.019442
250-150	-4.74	-22.0192	12.53916	0.959714
350-150	-12.3333	-29.6125	4.945825	0.253128
450-150	-11.24	-28.5192	6.039158	0.343606
550-150	-20.3833	-37.6625	-3.10418	0.016494
650-150	-19.0333	-36.3125	-1.75418	0.026799
350-250	-7.59333	-24.8725	9.685825	0.740466
450-250	-6.5	-23.7792	10.77916	0.848103
550-250	-15.6433	-32.9225	1.635825	0.088105
650-250	-14.2933	-31.5725	2.985825	0.138053
450-350	1.093333	-16.1858	18.37249	0.999988
550-350	-8.05	-25.3292	9.229158	0.689979
650-350	-6.7	-23.9792	10.57916	0.830232
550-450	-9.14333	-26.4225	8.135825	0.564353
650-450	-7.79333	-25.0725	9.485825	0.718632
650-550	1.35	-15.9292	18.62916	0.999958

One-way analysis of variance for **pH (water)**

```
            Df Sum Sq Mean Sq F value   Pr(>F)    
Temp         6  47.34   7.891   16.03 1.52e-05 ***
Residuals   14   6.89   0.492                     
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	-0.42	-2.37622	1.536221	0.987823
250-25	-0.42	-2.37622	1.536221	0.987823
350-25	0.416667	-1.53955	2.372888	0.988309
450-25	2.75	0.793779	4.706221	0.004063
550-25	2.98	1.023779	4.936221	0.001988
650-25	2.906667	0.950446	4.862888	0.002493
250-150	-8.88E-16	-1.95622	1.956221	1
350-150	0.836667	-1.11955	2.792888	0.762094
450-150	3.17	1.213779	5.126221	0.001115
550-150	3.4	1.443779	5.356221	0.000562
650-150	3.326667	1.370446	5.282888	0.000698
350-250	0.836667	-1.11955	2.792888	0.762094
450-250	3.17	1.213779	5.126221	0.001115
550-250	3.4	1.443779	5.356221	0.000562
650-250	3.326667	1.370446	5.282888	0.000698
450-350	2.333333	0.377112	4.289554	0.0152
550-350	2.563333	0.607112	4.519554	0.007318
650-350	2.49	0.533779	4.446221	0.009234
550-450	0.23	-1.72622	2.186221	0.999546
650-450	0.156667	-1.79955	2.112888	0.999951
650-550	-0.07333	-2.02955	1.882888	0.999999

One-way analysis of variance for **pH (CaCl2)**

```
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         6  59.58   9.930   15.21 3.36e-05 ***
Residuals   13   8.48   0.653
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
1 observation deleted due to missingness
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	-1.84652	-3.39474	-0.2983	0.010555
250-25	0.076667	-2.2015	2.354833	1
350-25	0.076667	-2.2015	2.354833	1
450-25	1.21	-1.06817	3.488166	0.549979
550-25	3.436667	1.158501	5.714833	0.002415
650-25	3.78	1.501834	6.058166	0.001025
250-150	4.185	1.637933	6.732067	0.001122

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
350-150	1.78E-15	-2.27817	2.278166	1
450-150	1.133333	-1.14483	3.411499	0.61702
550-150	3.36	1.081834	5.638166	0.002935
650-150	3.703333	1.425167	5.981499	0.001238
350-250	4.108333	1.561266	6.6554	0.00133
450-250	1.133333	-1.14483	3.411499	0.61702
550-250	3.36	1.081834	5.638166	0.002935
650-250	3.703333	1.425167	5.981499	0.001238
450-350	4.108333	1.561266	6.6554	0.00133
550-350	2.226667	-0.0515	4.504833	0.057167
650-350	2.57	0.291834	4.848166	0.023194
550-450	2.975	0.427933	5.522067	0.018232
650-450	0.343333	-1.93483	2.621499	0.998002
650-550	0.748333	-1.79873	3.2954	0.94151

One-way analysis of variance for **SSA (m^2/g)**

```
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         6 10.858  1.8096    16.5 1.28e-05 ***
Residuals   14  1.536  0.1097
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	-0.5625	-1.48585	0.36084	0.412789
250-25	-1.3221	-2.24544	-0.39875	0.003463
350-25	0.384585	-0.53876	1.307929	0.78207
450-25	0.965103	0.041759	1.888447	0.037926
550-25	0.628219	-0.29513	1.551562	0.298453
650-25	0.325463	-0.59788	1.248806	0.881607
250-150	-0.75959	-1.68294	0.163752	0.141614
350-150	0.947089	0.023746	1.870433	0.042743
450-150	1.527607	0.604263	2.45095	0.000913
550-150	1.190722	0.267379	2.114066	0.008324
650-150	0.887966	-0.03538	1.81131	0.063029
350-250	1.706681	0.783337	2.630024	0.000301
450-250	2.287198	1.363855	3.210542	1.18E-05
550-250	1.950314	1.02697	2.873658	7.21E-05
650-250	1.647558	0.724214	2.570902	0.000431
450-350	0.580518	-0.34283	1.503861	0.379167

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
550-350	0.243633	-0.67971	1.166977	0.966405
650-350	-0.05912	-0.98247	0.864221	0.999987
550-450	-0.33688	-1.26023	0.586459	0.864649
650-450	-0.63964	-1.56298	0.283703	0.281027
650-550	-0.30276	-1.2261	0.620588	0.911659

One-way analysis of variance for **CEC (cmolc/kg)**

```
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         6 271.33   45.22   7.709 0.000836 ***
Residuals   14  82.13    5.87
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	-2.11422	-8.86677	4.63834	0.92731
250-25	-5.74467	-12.4972	1.00789	0.120849
350-25	-4.1961	-10.9487	2.556456	0.391565
450-25	-9.0778	-15.8304	-2.32524	0.005929
550-25	-9.66667	-16.4192	-2.91411	0.003469
650-25	-9.66667	-16.4192	-2.91411	0.003469
250-150	-3.63045	-10.383	3.122106	0.547557
350-150	-2.08188	-8.83444	4.670673	0.931983
450-150	-6.96358	-13.7161	-0.21103	0.04132
550-150	-7.55245	-14.305	-0.79989	0.024128
650-150	-7.55245	-14.305	-0.79989	0.024128
350-250	1.548567	-5.20399	8.301123	0.98301
450-250	-3.33313	-10.0857	3.419423	0.635226
550-250	-3.922	-10.6746	2.830556	0.464382
650-250	-3.922	-10.6746	2.830556	0.464382
450-350	-4.8817	-11.6343	1.870856	0.241634
550-350	-5.47057	-12.2231	1.28199	0.151821
650-350	-5.47057	-12.2231	1.28199	0.151821
550-450	-0.58887	-7.34142	6.16369	0.999919
650-450	-0.58887	-7.34142	6.16369	0.999919
650-550	-1.33E-15	-6.75256	6.752556	1

One-way analysis of variance for **Macro aggregate weight (%)**

```
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         6  29.92   4.987   1.357  0.297
Residuals   14  51.47   3.676
```

One-way analysis of variance for **Micro aggregate weight (%)**

```
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         6  24.21   4.036   2.199  0.105
Residuals   14  25.69   1.835
```

One-way analysis of variance for **Silt-clay size particles weight (%)**

```
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         6   6.94   1.157   0.404  0.864
Residuals   14  40.06   2.862
```

One-way analysis of variance for **δ15N (‰)**

```
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         6  38.68   6.446   10.93 3.04e-07 ***
Residuals   41  24.19   0.590
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	-0.5185	-1.89284	0.855837	0.901535
250-25	0.720813	-0.65352	2.09515	0.667135
350-25	1.842545	0.468209	3.216882	0.00284
450-25	0.324879	-1.04946	1.699216	0.989655
550-25	-0.43865	-1.62886	0.751562	0.910954
650-25	-1.33241	-2.70675	0.041927	0.06268
250-150	1.239313	-0.13502	2.61365	0.101112
350-150	2.361045	0.986709	3.735382	7.61E-05
450-150	0.843379	-0.53096	2.217716	0.490679
550-150	0.079851	-1.11036	1.270062	0.999992
650-150	-0.81391	-2.18825	0.560427	0.532882
350-250	1.121732	-0.2526	2.496069	0.175606
450-250	-0.39593	-1.77027	0.978403	0.971642
550-250	-1.15946	-2.34967	0.030749	0.060572
650-250	-2.05322	-3.42756	-0.67889	0.000676
450-350	-1.51767	-2.892	-0.14333	0.022092
550-350	-2.28119	-3.47141	-1.09098	1.04E-05
650-350	-3.17496	-4.54929	-1.80062	2.00E-07
550-450	-0.76353	-1.95374	0.426683	0.437323

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
650-450	-1.65729	-3.03163	-0.28295	0.009422
650-550	-0.89376	-2.08397	0.29645	0.25606

One-way analysis of variance for **δ13C (‰)**

```
            Df Sum Sq Mean Sq F value   Pr(>F)    
Temp         6 30.839   5.140   16.93 1.08e-08 ***
Residuals   32  9.715   0.304                     
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	-0.14417	-1.14406	0.855724	0.999243
250-25	-0.30121	-1.3011	0.698686	0.961571
350-25	0.260768	-0.73912	1.260659	0.981089
450-25	1.835934	0.836043	2.835825	4.03E-05
550-25	0.83249	-0.1674	1.832381	0.154502
650-25	2.456168	1.231556	3.680779	8.79E-06
250-150	-0.15704	-1.15693	0.842852	0.998771
350-150	0.404934	-0.59496	1.404825	0.859017
450-150	1.980101	0.98021	2.979992	1.10E-05
550-150	0.976657	-0.02323	1.976548	0.059109
650-150	2.600334	1.375723	3.824946	3.08E-06
350-250	0.561973	-0.43792	1.561864	0.578793
450-250	2.13714	1.137249	3.137031	2.72E-06
550-250	1.133695	0.133804	2.133586	0.018069
650-250	2.757373	1.532762	3.981984	9.92E-07
450-350	1.575167	0.575276	2.575058	0.000419
550-350	0.571722	-0.42817	1.571613	0.559372
650-350	2.1954	0.970789	3.420011	5.96E-05
550-450	-1.00344	-2.00334	-0.00355	0.048723
650-450	0.620233	-0.60438	1.844845	0.688146
650-550	1.623678	0.399066	2.848289	0.003712

One-way analysis of variance for **N (weight %)**

```
            Df Sum Sq  Mean Sq F value Pr(>F)    
Temp         6 0.1470 0.024497   205.1 <2e-16 ***
Residuals   41 0.0049 0.000119                   
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	-0.00478	-0.02434	0.014771	0.987636
250-25	-0.00969	-0.02924	0.009866	0.722238
350-25	-0.03005	-0.04961	-0.0105	0.000448
450-25	-0.09598	-0.11553	-0.07642	8.16E-13
550-25	-0.12578	-0.14272	-0.10885	8.16E-13
650-25	-0.12837	-0.14792	-0.10881	8.16E-13
250-150	-0.00491	-0.02446	0.014648	0.985899
350-150	-0.02527	-0.04482	-0.00572	0.0044
450-150	-0.0912	-0.11075	-0.07164	8.17E-13
550-150	-0.121	-0.13794	-0.10407	8.16E-13
650-150	-0.12359	-0.14314	-0.10403	8.16E-13
350-250	-0.02037	-0.03992	-0.00081	0.036408
450-250	-0.08629	-0.10584	-0.06674	8.22E-13
550-250	-0.1161	-0.13303	-0.09916	8.16E-13
650-250	-0.11868	-0.13823	-0.09913	8.16E-13
450-350	-0.06592	-0.08548	-0.04637	9.12E-12
550-350	-0.09573	-0.11267	-0.0788	8.16E-13
650-350	-0.09832	-0.11787	-0.07876	8.16E-13
550-450	-0.02981	-0.04674	-0.01287	5.00E-05
650-450	-0.03239	-0.05194	-0.01284	0.00014
650-550	-0.00258	-0.01952	0.01435	0.999066

One-way analysis of variance for **C (weight %)**

```
          Df Sum Sq Mean Sq F value Pr(>F)
Temp       6  74.03  12.338   117.1 <2e-16 ***
Residuals 41   4.32   0.105
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	-0.09575	-0.67662	0.485119	0.998555
250-25	-0.26093	-0.8418	0.319943	0.802736
350-25	-1.3574	-1.93827	-0.77653	1.53E-07
450-25	-2.73221	-3.31308	-2.15134	8.17E-13
550-25	-2.80411	-3.30716	-2.30106	8.16E-13
650-25	-2.81731	-3.39818	-2.23644	8.16E-13
250-150	-0.16518	-0.74604	0.415694	0.97341

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
350-150	-1.26165	-1.84252	-0.68078	7.98E-07
450-150	-2.63646	-3.21733	-2.05559	8.18E-13
550-150	-2.70836	-3.21141	-2.20531	8.16E-13
650-150	-2.72156	-3.30242	-2.14069	8.17E-13
350-250	-1.09648	-1.67735	-0.51561	1.40E-05
450-250	-2.47128	-3.05215	-1.89042	8.26E-13
550-250	-2.54318	-3.04623	-2.04014	8.16E-13
650-250	-2.55638	-3.13725	-1.97551	8.22E-13
450-350	-1.37481	-1.95568	-0.79394	1.13E-07
550-350	-1.44671	-1.94975	-0.94366	7.93E-10
650-350	-1.4599	-2.04077	-0.87903	2.65E-08
550-450	-0.0719	-0.57495	0.431148	0.999357
650-450	-0.0851	-0.66596	0.495774	0.99926
650-550	-0.0132	-0.51624	0.489852	1

One-way analysis of variance for **C/N ratio**

```
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         6   3168   528.0   188.1 <2e-16 ***
Residuals   32     90     2.8
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	-0.09705	-3.13763	2.94353	1
250-25	-0.70217	-3.74275	2.33841	0.989895
350-25	-7.53873	-10.5793	-4.49815	1.38E-07
450-25	-19.3467	-22.3872	-16.3061	1.00E-13
550-25	-20.0789	-23.1195	-17.0383	1.00E-13
650-25	-20.5746	-24.2986	-16.8507	1.00E-13
250-150	-0.60512	-3.6457	2.435459	0.995435
350-150	-7.44168	-10.4823	-4.4011	1.81E-07
450-150	-19.2496	-22.2902	-16.209	1.00E-13
550-150	-19.9818	-23.0224	-16.9413	1.00E-13
650-150	-20.4776	-24.2015	-16.7537	1.00E-13
350-250	-6.83656	-9.87714	-3.79598	1.02E-06
450-250	-18.6445	-21.6851	-15.6039	1.00E-13
550-250	-19.3767	-22.4173	-16.3361	1.00E-13
650-250	-19.8725	-23.5964	-16.1485	1.01E-13
450-350	-11.8079	-14.8485	-8.76736	2.98E-12

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
550-350	-12.5402	-15.5807	-9.49958	6.83E-13
650-350	-13.0359	-16.7598	-9.31198	4.27E-11
550-450	-0.73222	-3.7728	2.308362	0.987426
650-450	-1.22797	-4.95191	2.495959	0.94139
650-550	-0.49576	-4.21969	3.228177	0.99952

Sirretta series (2316m)

One-way analysis of variance for **Aggregate stability (water stable %)**

```
            Df Sum Sq Mean Sq F value  Pr(>F)
Temp         6   3904   650.7   5.691 0.00352 **
Residuals   14   1601   114.3
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	7.326667	-22.4842	37.13758	0.976095
250-25	-21.2967	-51.1076	8.514242	0.252336
350-25	-26.12	-55.9309	3.690909	0.104417
450-25	-26.38	-56.1909	3.430909	0.099268
550-25	-29.11	-58.9209	0.700909	0.057654
650-25	-26.2433	-56.0542	3.567575	0.101945
250-150	-28.6233	-58.4342	1.187575	0.063608
350-150	-33.4467	-63.2576	-3.63576	0.023609
450-150	-33.7067	-63.5176	-3.89576	0.022365
550-150	-36.4367	-66.2476	-6.62576	0.012651
650-150	-33.57	-63.3809	-3.75909	0.023011
350-250	-4.82333	-34.6342	24.98758	0.997284
450-250	-5.08333	-34.8942	24.72758	0.996386
550-250	-7.81333	-37.6242	21.99758	0.967453
650-250	-4.94667	-34.7576	24.86424	0.996883
450-350	-0.26	-30.0709	29.55091	1
550-350	-2.99	-32.8009	26.82091	0.999818
650-350	-0.12333	-29.9342	29.68758	1
550-450	-2.73	-32.5409	27.08091	0.999893
650-450	0.136667	-29.6742	29.94758	1
650-550	2.866667	-26.9442	32.67758	0.999858

One-way analysis of variance for **pH (water)**

```
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         6  46.90   7.817   22.91 1.76e-06 ***
Residuals   14   4.78   0.341
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	-0.44333	-2.07206	1.185394	0.96114
250-25	-0.48667	-2.11539	1.142061	0.940693
350-25	0.83	-0.79873	2.458728	0.603312
450-25	2.746667	1.117939	4.375394	0.000757
550-25	2.843333	1.214606	4.472061	0.000538
650-25	3.05	1.421272	4.678728	0.000262
250-150	-0.04333	-1.67206	1.585394	1
350-150	1.273333	-0.35539	2.902061	0.177319
450-150	3.19	1.561272	4.818728	0.000164
550-150	3.286667	1.657939	4.915394	0.000119
650-150	3.493333	1.864606	5.122061	6.09E-05
350-250	1.316667	-0.31206	2.945394	0.153295
450-250	3.233333	1.604606	4.862061	0.000142
550-250	3.33	1.701272	4.958728	0.000103
650-250	3.536667	1.907939	5.165394	5.31E-05
450-350	1.916667	0.287939	3.545394	0.01679
550-350	2.013333	0.384606	3.642061	0.011604
650-350	2.22	0.591272	3.848728	0.005284
550-450	0.096667	-1.53206	1.725394	0.999992
650-450	0.303333	-1.32539	1.932061	0.994199
650-550	0.206667	-1.42206	1.835394	0.9993

One-way analysis of variance for **pH (CaCl2)**

```
            Df  Sum Sq Mean Sq F value    Pr(>F)
Temp         6  61.11  10.186   28.16 4.81e-07 ***
Residuals   14   5.06   0.362
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	0.086667	-1.59002	1.763355	0.999996
250-25	0.22	-1.45669	1.896689	0.999154
350-25	1.59	-0.08669	3.266689	0.068295
450-25	3.516667	1.839978	5.193355	7.79E-05
550-25	3.783333	2.106645	5.460022	3.45E-05
650-25	3.996667	2.319978	5.673355	1.84E-05
250-150	0.133333	-1.54336	1.810022	0.999953

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
350-150	1.503333	-0.17336	3.180022	0.092724
450-150	3.43	1.753311	5.106689	0.000102
550-150	3.696667	2.019978	5.373355	4.48E-05
650-150	3.91	2.233311	5.586689	2.37E-05
350-250	1.37	-0.30669	3.046689	0.146082
450-250	3.296667	1.619978	4.973355	0.000157
550-250	3.563333	1.886645	5.240022	6.74E-05
650-250	3.776667	2.099978	5.453355	3.52E-05
450-350	1.926667	0.249978	3.603355	0.019948
550-350	2.193333	0.516645	3.870022	0.007419
650-350	2.406667	0.729978	4.083355	0.00339
550-450	0.266667	-1.41002	1.943355	0.997528
650-450	0.48	-1.19669	2.156689	0.951025
650-550	0.213333	-1.46336	1.890022	0.999289

One-way analysis of variance for **SSA (m^2/g)**

```
           Df Sum Sq Mean Sq F value Pr(>F)
Temp        6  71.48  11.914   1.831  0.165
Residuals  14  91.10   6.507
```

One-way analysis of variance for **CEC (cmolc/kg)**

```
           Df Sum Sq Mean Sq F value   Pr(>F)
Temp        6  330.7   55.11    8.85 0.000414 ***
Residuals  14   87.2    6.23
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	-2.42711	-9.38415	4.529925	0.886329
250-25	-7.2009	-14.1579	-0.24386	0.040369
350-25	-6.10599	-13.063	0.851045	0.103526
450-25	-9.94712	-16.9042	-2.99008	0.003507
550-25	-10.6281	-17.5851	-3.67107	0.001937
650-25	-11.2333	-18.1904	-4.27629	0.001153
250-150	-4.77379	-11.7308	2.183252	0.290179
350-150	-3.67888	-10.6359	3.278159	0.565056
450-150	-7.52001	-14.477	-0.56297	0.03044
550-150	-8.20099	-15.158	-1.24395	0.016581
650-150	-8.80622	-15.7633	-1.84918	0.009649

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
350-250	1.094907	-5.86213	8.051945	0.997667
450-250	-2.74622	-9.70326	4.210819	0.818999
550-250	-3.42721	-10.3842	3.529832	0.637191
650-250	-4.03243	-10.9895	2.924605	0.466622
450-350	-3.84113	-10.7982	3.115912	0.519171
550-350	-4.52211	-11.4792	2.434925	0.34438
650-350	-5.12734	-12.0844	1.829699	0.224801
550-450	-0.68099	-7.63803	6.276052	0.999842
650-450	-1.28621	-8.24325	5.670825	0.99442
650-550	-0.60523	-7.56227	6.351812	0.999921

One-way analysis of variance for **Macro aggregate weight (%)**

```
           Df Sum Sq Mean Sq F value Pr(>F)
Temp        6  135.3   22.55   2.147  0.112
Residuals  14  147.1   10.51
```

One-way analysis of variance for **Micro aggregate weight (%)**

```
           Df Sum Sq Mean Sq F value Pr(>F)
Temp        6  35.71   5.952   0.836  0.562
Residuals  14  99.72   7.123
```

One-way analysis of variance for **Silt-clay size particles weight (%)**

```
           Df Sum Sq Mean Sq F value   Pr(>F)
Temp        6  62.18  10.364   8.517 0.000505 ***
Residuals  14  17.04   1.217
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	0.683154	-2.39235	3.758662	0.985527
250-25	1.187633	-1.88787	4.263141	0.832745
350-25	3.156077	0.080569	6.231585	0.042618
450-25	3.966435	0.890927	7.041943	0.008318
550-25	4.82334	1.747832	7.898848	0.001519
650-25	3.715029	0.63952	6.790537	0.01383
250-150	0.504479	-2.57103	3.579987	0.997073
350-150	2.472922	-0.60259	5.54843	0.157007
450-150	3.283281	0.207773	6.358789	0.033057
550-150	4.140185	1.064677	7.215693	0.005863

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
650-150	3.031874	-0.04363	6.107382	0.054494
350-250	1.968444	-1.10706	5.043952	0.360406
450-250	2.778802	-0.29671	5.85431	0.089042
550-250	3.635707	0.560199	6.711215	0.016239
650-250	2.527395	-0.54811	5.602904	0.142306
450-350	0.810359	-2.26515	3.885867	0.966628
550-350	1.667263	-1.40825	4.742771	0.538755
650-350	0.558952	-2.51656	3.63446	0.994907
550-450	0.856904	-2.2186	3.932412	0.956718
650-450	-0.25141	-3.32691	2.824101	0.999945
650-550	-1.10831	-4.18382	1.967197	0.870937

One-way analysis of variance for **δ15N (‰)**

```
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         6  52.38   8.730   25.43 2.34e-12 ***
Residuals   41  14.08   0.343
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	-0.03017	-1.07861	1.018277	1
250-25	0.957212	-0.09123	2.005656	0.093628
350-25	1.922379	0.873935	2.970822	2.40E-05
450-25	-0.62195	-1.6704	0.426489	0.530906
550-25	-1.09273	-2.00071	-0.18475	0.009619
650-25	-1.23291	-2.28135	-0.18447	0.012174
250-150	0.987379	-0.06106	2.035822	0.076548
350-150	1.952545	0.904102	3.000989	1.80E-05
450-150	-0.59179	-1.64023	0.456656	0.588216
550-150	-1.06257	-1.97054	-0.15459	0.012776
650-150	-1.20274	-2.25119	-0.1543	0.015513
350-250	0.965167	-0.08328	2.01361	0.088839
450-250	-1.57917	-2.62761	-0.53072	0.000602
550-250	-2.04994	-2.95792	-1.14197	3.37E-07
650-250	-2.19012	-3.23857	-1.14168	1.84E-06
450-350	-2.54433	-3.59278	-1.49589	6.25E-08
550-350	-3.01511	-3.92309	-2.10713	1.39E-11
650-350	-3.15529	-4.20373	-2.10685	2.26E-10
550-450	-0.47078	-1.37876	0.437201	0.678717

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
650-450	-0.61096	-1.6594	0.437488	0.551754
650-550	-0.14018	-1.04816	0.767801	0.999002

One-way analysis of variance for **δ13C (‰)**

```
            Df Sum Sq Mean Sq F value   Pr(>F)    
Temp         6 28.979   4.830   35.36 8.91e-13 ***
Residuals   32  4.371   0.137                     
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	-0.20717	-0.87784	0.463511	0.956714
250-25	0.627601	-0.04308	1.298278	0.078789
350-25	0.492768	-0.17791	1.163445	0.270673
450-25	2.367268	1.69659	3.037945	3.46E-11
550-25	1.504157	0.833479	2.174834	1.07E-06
650-25	1.261168	0.439759	2.082576	0.000598
250-150	0.834768	0.16409	1.505445	0.007351
350-150	0.699934	0.029257	1.370612	0.036227
450-150	2.574434	1.903757	3.245112	4.01E-12
550-150	1.711323	1.040646	2.382001	7.47E-08
650-150	1.468334	0.646926	2.289743	6.24E-05
350-250	-0.13483	-0.80551	0.535844	0.995177
450-250	1.739667	1.068989	2.410344	5.23E-08
550-250	0.876556	0.205878	1.547233	0.004358
650-250	0.633567	-0.18784	1.454975	0.221646
450-350	1.8745	1.203823	2.545177	9.88E-09
550-350	1.011389	0.340711	1.682066	0.000762
650-350	0.7684	-0.05301	1.589809	0.078955
550-450	-0.86311	-1.53379	-0.19243	0.005163
650-450	-1.1061	-1.92751	-0.28469	0.00311
650-550	-0.24299	-1.0644	0.57842	0.964772

One-way analysis of variance for **N (weight %)**

```
            Df  Sum Sq  Mean Sq F value Pr(>F)    
Temp         6 0.18121 0.030202   58.85 <2e-16 ***
Residuals   41 0.02104 0.000513                   
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	-0.01509	-0.05562	0.025448	0.907065
250-25	-0.02573	-0.06626	0.014808	0.450193
350-25	-0.03529	-0.07583	0.005244	0.124469
450-25	-0.11946	-0.15999	-0.07892	4.05E-10
550-25	-0.14525	-0.18035	-0.11014	8.39E-13
650-25	-0.14765	-0.18819	-0.10712	1.62E-12
250-150	-0.01064	-0.05118	0.029896	0.982215
350-150	-0.0202	-0.06074	0.020332	0.716724
450-150	-0.10437	-0.14491	-0.06383	1.45E-08
550-150	-0.13016	-0.16527	-0.09506	1.29E-12
650-150	-0.13257	-0.1731	-0.09203	2.13E-11
350-250	-0.00956	-0.0501	0.030971	0.989755
450-250	-0.09373	-0.13427	-0.05319	1.95E-07
550-250	-0.11952	-0.15463	-0.08442	7.00E-12
650-250	-0.12193	-0.16246	-0.08139	2.29E-10
450-350	-0.08417	-0.1247	-0.04363	2.09E-06
550-350	-0.10996	-0.14506	-0.07485	7.30E-11
650-350	-0.11236	-0.1529	-0.07183	2.14E-09
550-450	-0.02579	-0.0609	0.009313	0.279401
650-450	-0.0282	-0.06873	0.012338	0.341033
650-550	-0.00241	-0.03751	0.0327	0.999991

One-way analysis of variance for **C (weight %)**

```
            Df Sum Sq Mean Sq F value  Pr(>F)
Temp         6 162.05  27.008    32.5 4.4e-14 ***
Residuals   41  34.07   0.831
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	-0.82377	-2.45493	0.807387	0.704377
250-25	-1.61873	-3.24989	0.012424	0.052934
350-25	-3.15271	-4.78387	-1.52155	8.87E-06
450-25	-4.6437	-6.27486	-3.01254	1.05E-09
550-25	-4.6945	-6.10712	-3.28187	1.36E-11
650-25	-4.70607	-6.33723	-3.07491	7.27E-10
250-150	-0.79496	-2.42612	0.836196	0.737064

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
350-150	-2.32894	-3.9601	-0.69778	0.001267
450-150	-3.81993	-5.45109	-2.18877	1.45E-07
550-150	-3.87072	-5.28335	-2.4581	2.91E-09
650-150	-3.8823	-5.51346	-2.25114	9.93E-08
350-250	-1.53398	-3.16514	0.097181	0.077277
450-250	-3.02497	-4.65613	-1.39381	1.95E-05
550-250	-3.07576	-4.48839	-1.66314	7.56E-07
650-250	-3.08734	-4.71849	-1.45618	1.33E-05
450-350	-1.49099	-3.12215	0.140168	0.09293
550-350	-1.54178	-2.95441	-0.12916	0.024516
650-350	-1.55336	-3.18452	0.077799	0.070991
550-450	-0.05079	-1.46342	1.361831	1
650-450	-0.06237	-1.69353	1.56879	1
650-550	-0.01158	-1.4242	1.401049	1

One-way analysis of variance for **C/N ratio**

```
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         6   5946   990.9   70.03 <2e-16 ***
Residuals   32    453    14.2
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	-2.53094	-9.3574	4.295522	0.901827
250-25	-6.43251	-13.259	0.393954	0.075322
350-25	-17.4154	-24.2418	-10.5889	7.50E-08
450-25	-29.1358	-35.9623	-22.3093	3.33E-13
550-25	-29.7579	-36.5844	-22.9314	2.34E-13
650-25	-30.1558	-38.5164	-21.7951	1.99E-11
250-150	-3.90157	-10.728	2.924894	0.559867
350-150	-14.8844	-21.7109	-8.05796	1.86E-06
450-150	-26.6049	-33.4313	-19.7784	2.72E-12
550-150	-27.227	-34.0534	-20.4005	1.52E-12
650-150	-27.6248	-35.9855	-19.2641	1.82E-10
350-250	-10.9829	-17.8093	-4.15639	0.000311
450-250	-22.7033	-29.5298	-15.8768	1.55E-10
550-250	-23.3254	-30.1519	-16.4989	7.88E-11
650-250	-23.7232	-32.0839	-15.3626	6.99E-09
450-350	-11.7204	-18.5469	-4.89398	0.000118

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
550-350	-12.3425	-19.169	-5.51608	5.19E-05
650-350	-12.7404	-21.1011	-4.37972	0.000662
550-450	-0.62209	-7.44856	6.204369	0.999947
650-450	-1.01995	-9.38063	7.340722	0.99971
650-550	-0.39786	-8.75853	7.962815	0.999999

Chiquito series (2865m)

One-way analysis of variance for **Aggregate stability (water stable %)**

```
            Df Sum Sq Mean Sq F value   Pr(>F)    
Temp         6   9865  1644.1   15.61 1.78e-05 ***
Residuals   14   1475   105.3                     
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	3.63	-24.9847	32.24467	0.999301
250-25	1.19	-27.4247	29.80467	0.999999
350-25	-37.5867	-66.2013	-8.972	0.007174
450-25	-41.06	-69.6747	-12.4453	0.003399
550-25	-44.658	-73.2727	-16.0433	0.00159
650-25	-44.3867	-73.0013	-15.772	0.001682
250-150	-2.44	-31.0547	26.17467	0.999929
350-150	-41.2167	-69.8313	-12.602	0.003287
450-150	-44.69	-73.3047	-16.0753	0.001579
550-150	-48.288	-76.9027	-19.6733	0.000752
650-150	-48.0167	-76.6313	-19.402	0.000795
350-250	-38.7767	-67.3913	-10.162	0.005547
450-250	-42.25	-70.8647	-13.6353	0.002639
550-250	-45.848	-74.4627	-17.2333	0.001241
650-250	-45.5767	-74.1913	-16.962	0.001313
450-350	-3.47333	-32.088	25.14134	0.999456
550-350	-7.07133	-35.686	21.54334	0.97545
650-350	-6.8	-35.4147	21.81467	0.979727
550-450	-3.598	-32.2127	25.01667	0.999335
650-450	-3.32667	-31.9413	25.288	0.999575
650-550	0.271333	-28.3433	28.886	1

One-way analysis of variance for **pH (water)**

```
            Df Sum Sq Mean Sq F value   Pr(>F)    
Temp         6 28.176   4.696   22.32 2.06e-06 ***
Residuals   14  2.946   0.210                     
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	-0.45	-1.72888	0.828881	0.882415
250-25	-0.30333	-1.58221	0.975548	0.979917
350-25	0.863333	-0.41555	2.142214	0.306154
450-25	2.023333	0.744452	3.302214	0.001399
550-25	2.363333	1.084452	3.642214	0.000301
650-25	2.293333	1.014452	3.572214	0.00041
250-150	0.146667	-1.13221	1.425548	0.999606
350-150	1.313333	0.034452	2.592214	0.042425
450-150	2.473333	1.194452	3.752214	0.000187
550-150	2.813333	1.534452	4.092214	4.59E-05
650-150	2.743333	1.464452	4.022214	6.08E-05
350-250	1.166667	-0.11221	2.445548	0.084588
450-250	2.326667	1.047786	3.605548	0.000354
550-250	2.666667	1.387786	3.945548	8.31E-05
650-250	2.596667	1.317786	3.875548	0.000111
450-350	1.16	-0.11888	2.438881	0.087223
550-350	1.5	0.221119	2.778881	0.017201
650-350	1.43	0.151119	2.708881	0.024172
550-450	0.34	-0.93888	1.618881	0.965191
650-450	0.27	-1.00888	1.548881	0.988827
650-550	-0.07	-1.34888	1.208881	0.999995

One-way analysis of variance for **pH (CaCl2)**

```
            Df  Sum Sq Mean Sq F value  Pr(>F)
Temp         6  39.54   6.590   40.98 4.3e-08 ***
Residuals   14   2.25   0.161
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	0.033333	-1.08465	1.151317	1
250-25	0.14	-0.97798	1.257984	0.99935
350-25	1.456667	0.338683	2.57465	0.007662
450-25	2.766667	1.648683	3.88465	1.19E-05
550-25	2.996667	1.878683	4.11465	4.61E-06
650-25	3.256667	2.138683	4.37465	1.68E-06
250-150	0.106667	-1.01132	1.22465	0.999864

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
350-150	1.423333	0.30535	2.541317	0.009219
450-150	2.733333	1.61535	3.851317	1.37E-05
550-150	2.963333	1.84535	4.081317	5.27E-06
650-150	3.223333	2.10535	4.341317	1.90E-06
350-250	1.316667	0.198683	2.43465	0.016694
450-250	2.626667	1.508683	3.74465	2.17E-05
550-250	2.856667	1.738683	3.97465	8.15E-06
650-250	3.116667	1.998683	4.23465	2.87E-06
450-350	1.31	0.192016	2.427984	0.017325
550-350	1.54	0.422016	2.657984	0.004834
650-350	1.8	0.682016	2.917984	0.001185
550-450	0.23	-0.88798	1.347984	0.990223
650-450	0.49	-0.62798	1.607984	0.742629
650-550	0.26	-0.85798	1.377984	0.981783

One-way analysis of variance for **SSA (m²/g)**

```
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         6 12.113   2.019    7.56 0.000922 ***
Residuals   14  3.739   0.267
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	-0.32903	-1.76978	1.11172	0.983361
250-25	-0.27811	-1.71886	1.162644	0.992989
350-25	1.383205	-0.05754	2.823955	0.063648
450-25	1.350353	-0.0904	2.791103	0.072946
550-25	1.417901	-0.02285	2.858651	0.055048
650-25	1.072001	-0.36875	2.512752	0.216707
250-150	0.050924	-1.38983	1.491675	1
350-150	1.712235	0.271485	3.152985	0.015616
450-150	1.679383	0.238633	3.120133	0.017997
550-150	1.746931	0.306181	3.187681	0.013442
650-150	1.401032	-0.03972	2.841782	0.059082
350-250	1.661311	0.220561	3.102061	0.019458
450-250	1.628459	0.187709	3.069209	0.02242
550-250	1.696006	0.255256	3.136756	0.016751
650-250	1.350107	-0.09064	2.790857	0.07302
450-350	-0.03285	-1.4736	1.407898	1

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
550-350	0.034695	-1.40605	1.475446	1
650-350	-0.3112	-1.75195	1.129546	0.987442
550-450	0.067547	-1.3732	1.508298	0.999998
650-450	-0.27835	-1.7191	1.162398	0.992957
650-550	-0.3459	-1.78665	1.094851	0.978681

One-way analysis of variance for **CEC (cmolc/kg)**

```
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         6  66.46  11.077   3.352 0.0291 *
Residuals   14  46.27   3.305
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

One-way analysis of variance for **Macro aggregate weight (%)**

```
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         6  41.24   6.874    3.23 0.0331 *
Residuals   14  29.80   2.128
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

One-way analysis of variance for **Micro aggregate weight (%)**

```
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         6  21.04   3.507   1.445  0.266
Residuals   14  33.96   2.426
```

One-way analysis of variance for **Silt-clay size particles weight (%)**

```
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         6  62.73  10.455   3.406 0.0276 *
Residuals   14  42.97   3.069
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

One-way analysis of variance for **δ15N (‰)**

```
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         6 104.29  17.382    36.1 7.54e-15 ***
Residuals   41  19.74   0.481
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	-0.31067	-1.5522	0.930869	0.986083
250-25	1.188879	-0.05266	2.430415	0.068341

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
350-25	1.974379	0.732843	3.215915	0.000267
450-25	-0.26879	-1.51032	0.972748	0.993515
550-25	-1.76157	-2.83677	-0.68636	0.000167
650-25	-2.71358	-3.95511	-1.47204	6.95E-07
250-150	1.499545	0.25801	2.741081	0.009266
350-150	2.285045	1.04351	3.526581	2.24E-05
450-150	0.041879	-1.19966	1.283415	1
550-150	-1.4509	-2.5261	-0.3757	0.002622
650-150	-2.40291	-3.64445	-1.16137	8.64E-06
350-250	0.7855	-0.45604	2.027036	0.454006
450-250	-1.45767	-2.6992	-0.21613	0.012368
550-250	-2.95044	-4.02565	-1.87524	2.80E-09
650-250	-3.90246	-5.14399	-2.66092	6.60E-11
450-350	-2.24317	-3.4847	-1.00163	3.14E-05
550-350	-3.73594	-4.81115	-2.66074	4.18E-12
650-350	-4.68796	-5.92949	-3.44642	1.09E-12
550-450	-1.49278	-2.56798	-0.41758	0.00183
650-450	-2.44479	-3.68632	-1.20325	6.15E-06
650-550	-0.95201	-2.02721	0.12319	0.112874

One-way analysis of variance for **δ13C (‰)**

```
            Df  Sum Sq Mean Sq F value   Pr(>F)    
Temp         6  29.72   4.954   20.07 1.41e-09 ***
Residuals   32   7.90   0.247                     
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		P adj
150-25	-0.201	-1.10268	0.700679	0.991611
250-25	0.654768	-0.24691	1.556446	0.283127
350-25	1.005934	0.104256	1.907613	0.020852
450-25	2.159601	1.257922	3.06128	2.85E-07
550-25	0.95049	0.048811	1.852169	0.033472
650-25	-0.97133	-2.07566	0.132994	0.114783
250-150	0.855768	-0.04591	1.757446	0.071851
350-150	1.206934	0.305256	2.108613	0.003332
450-150	2.360601	1.458922	3.26228	4.27E-08
550-150	1.15149	0.249811	2.053169	0.005609
650-150	-0.77033	-1.87466	0.333994	0.327329

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
350-250	0.351167	-0.55051	1.252845	0.879516
450-250	1.504833	0.603155	2.406512	0.000181
550-250	0.295722	-0.60596	1.197401	0.942823
650-250	-1.6261	-2.73043	-0.52177	0.001042
450-350	1.153667	0.251988	2.055345	0.005497
550-350	-0.05544	-0.95712	0.846234	0.999995
650-350	-1.97727	-3.08159	-0.87294	6.08E-05
550-450	-1.20911	-2.11079	-0.30743	0.003263
650-450	-3.13093	-4.23526	-2.02661	7.12E-09
650-550	-1.92182	-3.02615	-0.8175	9.55E-05

One-way analysis of variance for **N (weight %)**

```
            Df  Sum Sq Mean Sq F value Pr(>F)
Temp         6 0.26900 0.04483   139.9 <2e-16 ***
Residuals   41 0.01314 0.00032
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	-0.02083	-0.05287	0.011197	0.420677
250-25	-0.02521	-0.05724	0.006821	0.208844
350-25	-0.05341	-0.08544	-0.02137	0.000126
450-25	-0.14685	-0.17888	-0.11482	8.17E-13
550-25	-0.17917	-0.20691	-0.15143	8.16E-13
650-25	-0.17816	-0.21019	-0.14613	8.16E-13
250-150	-0.00438	-0.03641	0.027656	0.999503
350-150	-0.03257	-0.0646	-0.00054	0.044029
450-150	-0.12602	-0.15805	-0.09398	9.00E-13
550-150	-0.15833	-0.18607	-0.13059	8.16E-13
650-150	-0.15732	-0.18936	-0.12529	8.16E-13
350-250	-0.02819	-0.06023	0.003838	0.116879
450-250	-0.12164	-0.15367	-0.08961	1.05E-12
550-250	-0.15396	-0.1817	-0.12622	8.16E-13
650-250	-0.15295	-0.18498	-0.12091	8.17E-13
450-350	-0.09345	-0.12548	-0.06141	5.36E-10
550-350	-0.12576	-0.1535	-0.09802	8.18E-13
650-350	-0.12475	-0.15678	-0.09272	9.26E-13
550-450	-0.03232	-0.06006	-0.00458	0.01336
650-450	-0.03131	-0.06334	0.000725	0.059161

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
650-550	0.00101	-0.02673	0.02875	1

One-way analysis of variance for **C (weight %)**

```
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         6 138.92  23.154     172 <2e-16 ***
Residuals   41   5.52   0.135
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	-0.29241	-0.94892	0.364093	0.808818
250-25	-1.0034	-1.6599	-0.34689	0.000486
350-25	-2.90058	-3.55708	-2.24407	8.21E-13
450-25	-4.01729	-4.6738	-3.36079	8.16E-13
550-25	-4.06499	-4.63354	-3.49644	8.16E-13
650-25	-4.06528	-4.72179	-3.40878	8.16E-13
250-150	-0.71098	-1.36749	-0.05448	0.026241
350-150	-2.60816	-3.26467	-1.95166	8.79E-13
450-150	-3.72488	-4.38139	-3.06837	8.16E-13
550-150	-3.77258	-4.34113	-3.20403	8.16E-13
650-150	-3.77287	-4.42938	-3.11636	8.16E-13
350-250	-1.89718	-2.55369	-1.24067	6.95E-10
450-250	-3.0139	-3.6704	-2.35739	8.17E-13
550-250	-3.0616	-3.63015	-2.49304	8.16E-13
650-250	-3.06189	-3.71839	-2.40538	8.17E-13
450-350	-1.11672	-1.77322	-0.46021	9.00E-05
550-350	-1.16442	-1.73297	-0.59586	2.78E-06
650-350	-1.16471	-1.82121	-0.5082	4.35E-05
550-450	-0.0477	-0.61625	0.520853	0.999971
650-450	-0.04799	-0.7045	0.608517	0.999987
650-550	-0.00029	-0.56884	0.568261	1

One-way analysis of variance for **C/N ratio**

```
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         6   3821   636.9   950.6 <2e-16 ***
Residuals   32     21     0.7
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Temperature Comparison	Difference Between Means	Simultaneous Confidence Limits	95%	P adj
150-25	0.60896	-0.87638	2.094301	0.852039
250-25	-3.16802	-4.65336	-1.68267	2.83E-06
350-25	-13.9972	-15.4826	-12.5119	1.00E-13
450-25	-21.8152	-23.3005	-20.3299	1.00E-13
550-25	-22.3786	-23.8639	-20.8933	1.00E-13
650-25	-22.3446	-24.1637	-20.5254	1.00E-13
250-150	-3.77698	-5.26232	-2.29163	8.05E-08
350-150	-14.6062	-16.0915	-13.1209	1.00E-13
450-150	-22.4242	-23.9095	-20.9388	1.00E-13
550-150	-22.9876	-24.4729	-21.5022	1.00E-13
650-150	-22.9535	-24.7727	-21.1344	1.00E-13
350-250	-10.8292	-12.3146	-9.34388	1.00E-13
450-250	-18.6472	-20.1325	-17.1618	1.00E-13
550-250	-19.2106	-20.6959	-17.7252	1.00E-13
650-250	-19.1766	-20.9957	-17.3574	1.00E-13
450-350	-7.81797	-9.30331	-6.33263	1.01E-13
550-350	-8.38137	-9.86671	-6.89603	1.00E-13
650-350	-8.34733	-10.1665	-6.52817	1.34E-13
550-450	-0.5634	-2.04874	0.92194	0.891954
650-450	-0.52937	-2.34853	1.289797	0.967461
650-550	0.034035	-1.78513	1.853199	1

B. Aggregate fraction analysis

Tables ordered alphabetically by soil series name and aggregate size.

One-way analysis of variance

(Significance codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1)

```
       Chiquito series Macro aggregates: C concentration
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         3  23.06   7.687    35.3 2.64e-05 ***
Residuals    9   1.96   0.218


       Chiquito series Macro aggregates: C:N ratio
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         3   3290  1096.8   23.88 0.000128 ***
Residuals    9    413    45.9


       Chiquito series Macro aggregates: d13C
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         3  12.65   4.215   3.165 0.0783 .
Residuals    9  11.98   1.332


       Chiquito series Macro aggregates: d15N
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         3  4.836  1.6120    2.88 0.0954 .
Residuals    9  5.037  0.5597


       Chiquito series Macro aggregates: N concentration
            Df   Sum Sq  Mean Sq F value  Pr(>F)
Temp         3 0.022504 0.007501   16.12 0.00058 ***
Residuals    9 0.004188 0.000465


       Chiquito series Micro aggregates: C concentration
            Df Sum Sq Mean Sq F value  Pr(>F)
Temp         3  47.78  15.928   8.864 0.00473 **
Residuals    9  16.17   1.797


       Chiquito series Micro aggregates: C:N ratio
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         3   1178   392.6   70.65 1.41e-06 ***
Residuals    9     50     5.6


       Chiquito series Micro aggregates: d13C
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         3 12.534   4.178   25.35 0.000101 ***
Residuals    9  1.483   0.165


       Chiquito series Micro aggregates: d15N
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         3  10.47   3.491   0.821  0.514
Residuals    9  38.26   4.252
```

```
       Chiquito series Micro aggregates: N concentration
            Df  Sum Sq  Mean Sq F value Pr(>F)
Temp         3 0.07893 0.026310   6.459 0.0127 *
Residuals    9 0.03666 0.004074


       Chiquito series Silt-clay size aggregates: C concentration
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         3 113.61   37.87   19.97 0.000451 ***
Residuals    8  15.17    1.90


       Chiquito series Silt-clay size aggregates: C:N ratio
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         3  992.2   330.7   228.9 4.31e-08 ***
Residuals    8   11.6     1.4


       Chiquito series Silt-clay size aggregates: d13C
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         3  4.176  1.3921   25.05 0.000203 ***
Residuals    8  0.445  0.0556


       Chiquito series Silt-clay size aggregates: d15N
            Df Sum Sq Mean Sq F value  Pr(>F)
Temp         3 13.064   4.355   12.73 0.00206 **
Residuals    8  2.737   0.342


       Chiquito series Silt-clay size aggregates: N concentration
            Df  Sum Sq Mean Sq F value  Pr(>F)
Temp         3 0.19049 0.06350   11.95 0.00252 **
Residuals    8 0.04251 0.00531


       Musick series Macro aggregates: C concentration
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         4  62.54   15.63   74.43 2.12e-07 ***
Residuals   10   2.10    0.21


       Musick series Macro aggregates: C:N ratio
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         4  944.6  236.15   62.01 5.07e-07 ***
Residuals   10   38.1    3.81


       Musick series Macro aggregates: d13C
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         4 15.183   3.796   35.39 7.09e-06 ***
Residuals   10  1.072   0.107


       Musick series Macro aggregates: d15N
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         4  5.395  1.3488   2.374  0.122
Residuals   10  5.682  0.5682
```

```
      Musick series Macro aggregates: N concentration
          Df  Sum Sq  Mean Sq F value   Pr(>F)    
Temp       4 0.10553 0.026382    38.4 4.86e-06 ***
Residuals 10 0.00687 0.000687                     


      Musick series Micro aggregates: C concentration
          Df Sum Sq Mean Sq F value  Pr(>F)   
Temp       4 136.14   34.04   10.41 0.00137 **
Residuals 10  32.68    3.27                   


      Musick series Micro aggregates: C:N ratio
          Df Sum Sq Mean Sq F value   Pr(>F)    
Temp       4  761.5  190.38   82.22 1.31e-07 ***
Residuals 10   23.2    2.32                     


      Musick series Micro aggregates: d13C
          Df Sum Sq Mean Sq F value   Pr(>F)    
Temp       4  9.324   2.331   33.32 9.36e-06 ***
Residuals 10  0.700   0.070                     


      Musick series Micro aggregates: d15N
          Df Sum Sq Mean Sq F value  Pr(>F)   
Temp       4 20.774   5.194   9.647 0.00184 **
Residuals 10  5.384   0.538                   


      Musick series Micro aggregates: N concentration
          Df  Sum Sq Mean Sq F value Pr(>F)   
Temp       4 0.24546 0.06137   8.109 0.0035 **
Residuals 10 0.07567 0.00757                  


      Musick series Silt-clay size aggregates: C concentration
          Df Sum Sq Mean Sq F value   Pr(>F)    
Temp       4 137.13   34.28   66.56 3.62e-07 ***
Residuals 10   5.15    0.52                     


      Musick series Silt-clay size aggregates: C:N ratio
          Df Sum Sq Mean Sq F value   Pr(>F)    
Temp       4  746.5  186.62   104.9 4.02e-08 ***
Residuals 10   17.8    1.78                     


      Musick series Silt-clay size aggregates: d13C
          Df Sum Sq Mean Sq F value   Pr(>F)    
Temp       4  4.951  1.2377    29.2 1.71e-05 ***
Residuals 10  0.424  0.0424                     


      Musick series Silt-clay size aggregates: d15N
          Df Sum Sq Mean Sq F value   Pr(>F)    
Temp       4 11.245  2.8113    16.8 0.000195 ***
Residuals 10  1.674  0.1674                     
```

```
      Musick series Silt-clay size aggregates: N concentration
            Df  Sum Sq Mean Sq F value   Pr(>F)
Temp         4 0.27575 0.06894   43.51 2.71e-06 ***
Residuals   10 0.01585 0.00158


      Shaver series Macro aggregates: C concentration
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         4  9.788  2.4470   2.963 0.0745 .
Residuals   10  8.259  0.8259


      Shaver series Macro aggregates: C:N ratio
            Df Sum Sq Mean Sq F value  Pr(>F)
Temp         4   3413   853.3   41.46 3.4e-06 ***
Residuals   10    206    20.6


      Shaver series Macro aggregates: d13C
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         4  3.095  0.7738   2.628 0.0981 .
Residuals   10  2.944  0.2944


      Shaver series Macro aggregates: d15N
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         4  10.79   2.697   1.463  0.284
Residuals   10  18.43   1.843


      Shaver series Macro aggregates: N concentration
            Df   Sum Sq   Mean Sq F value Pr(>F)
Temp         4 0.011015 0.0027538   4.274 0.0284 *
Residuals   10 0.006443 0.0006443


      Shaver series Micro aggregates: C concentration
            Df Sum Sq Mean Sq F value  Pr(>F)
Temp         4  28.57   7.144   6.832 0.00643 **
Residuals   10  10.46   1.046


      Shaver series Micro aggregates: C:N ratio
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         4 1458.7   364.7   21.67 6.49e-05 ***
Residuals   10  168.3    16.8


      Shaver series Micro aggregates: d13C
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         4 13.459   3.365   14.34 0.000379 ***
Residuals   10  2.347   0.235


      Shaver series Micro aggregates: d15N
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         4  15.02   3.756   3.009 0.0718 .
Residuals   10  12.48   1.248
```

```
      Shaver series Micro aggregates: N concentration
            Df  Sum Sq  Mean Sq F value  Pr(>F)
Temp         4 0.03518 0.008794    7.39 0.00489 **
Residuals   10 0.01190 0.001190


      Shaver series Silt-clay size aggregates: C concentration
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         4  120.9  30.234   54.52 3.49e-07 ***
Residuals   11    6.1   0.555


      Shaver series Silt-clay size aggregates: C:N ratio
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         4 1559.0   389.8   62.94 1.65e-07 ***
Residuals   11   68.1     6.2


      Shaver series Silt-clay size aggregates: d13C
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         4  13.15   3.288    33.8 4.02e-06 ***
Residuals   11   1.07   0.097


      Shaver series Silt-clay size aggregates: d15N
            Df Sum Sq Mean Sq F value  Pr(>F)
Temp         4 14.036   3.509   9.781 0.00126 **
Residuals   11  3.946   0.359


      Shaver series Silt-clay size aggregates: N concentration
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         4 0.1286 0.03215   86.23 3.14e-08 ***
Residuals   11 0.0041 0.00037


      Sirretta series Macro aggregates: C concentration
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         4  48.11  12.028   8.179 0.0034 **
Residuals   10  14.71   1.471


      Sirretta series Macro aggregates: C:N ratio
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         4   5831    1458   56.05 8.21e-07 ***
Residuals   10    260      26


      Sirretta series Macro aggregates: d13C
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         4 19.138   4.784   12.61 0.000641 ***
Residuals   10  3.794   0.379


      Sirretta series Macro aggregates: d15N
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         4  8.651  2.1627   2.719 0.0909 .
Residuals   10  7.954  0.7954
```

```
       Sirretta series Macro aggregates: N concentration
            Df   Sum Sq  Mean Sq F value  Pr(>F)
Temp         4 0.025007 0.006252   6.441 0.00786 **
Residuals   10 0.009706 0.000971


       Sirretta series Micro aggregates: C concentration
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         4  92.16  23.041   3.977  0.031 *
Residuals   11  63.73   5.794


       Sirretta series Micro aggregates: C:N ratio
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         4 2916.7   729.2   116.7 6.25e-09 ***
Residuals   11   68.7     6.2


       Sirretta series Micro aggregates: d13C
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         4 16.626   4.157   46.83 7.66e-07 ***
Residuals   11  0.976   0.089


       Sirretta series Micro aggregates: d15N
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         4  12.43   3.107   0.721  0.595
Residuals   11  47.39   4.308


       Sirretta series Micro aggregates: N concentration
            Df  Sum Sq Mean Sq F value Pr(>F)
Temp         4 0.06160  0.0154    2.61 0.0936 .
Residuals   11 0.06491  0.0059


       Sirretta series Silt-clay size aggregates: C concentration
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         4 112.07  28.016    5.19 0.0159 *
Residuals   10  53.99   5.399


       Sirretta series Silt-clay size aggregates: C:N ratio
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         4 1992.2   498.0   70.37 2.77e-07 ***
Residuals   10   70.8     7.1


       Sirretta series Silt-clay size aggregates: d13C
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         4 12.066  3.0165   32.63 1.03e-05 ***
Residuals   10  0.924  0.0924


       Sirretta series Silt-clay size aggregates: d15N
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         4  6.935   1.734   1.571  0.256
Residuals   10 11.039   1.104
```

```
      Sirretta series Silt-clay size aggregates: N concentration
           Df  Sum Sq  Mean Sq F value Pr(>F)
Temp        4 0.09671 0.024177   3.759 0.0407 *
Residuals  10 0.06432 0.006432


      Vista series Macro aggregates: C concentration
           Df Sum Sq Mean Sq F value  Pr(>F)
Temp        4 2.8634  0.7158   10.95 0.00113 **
Residuals  10 0.6538  0.0654


      Vista series Macro aggregates: C:N ratio
           Df Sum Sq Mean Sq F value   Pr(>F)
Temp        4 199.87   49.97   15.52 0.000273 ***
Residuals  10  32.19    3.22


      Vista series Macro aggregates: d13C
           Df Sum Sq Mean Sq F value   Pr(>F)
Temp        4 24.106   6.026    15.1 0.000306 ***
Residuals  10  3.992   0.399


      Vista series Macro aggregates: d15N
           Df Sum Sq Mean Sq F value Pr(>F)
Temp        4  21.11   5.277   4.263 0.0287 *
Residuals  10  12.38   1.238


      Vista series Macro aggregates: N concentration
           Df   Sum Sq  Mean Sq F value   Pr(>F)
Temp        4 0.022765 0.005691   15.24 0.000294 ***
Residuals  10 0.003735 0.000373


      Vista series Micro aggregates: C concentration
           Df Sum Sq Mean Sq F value Pr(>F)
Temp        4  9.987  2.4966    2.72 0.0909 .
Residuals  10  9.181  0.9181


      Vista series Micro aggregates: C:N ratio
           Df Sum Sq Mean Sq F value   Pr(>F)
Temp        4 125.69  31.423   19.23 0.000109 ***
Residuals  10  16.34   1.634


      Vista series Micro aggregates: d13C
           Df Sum Sq Mean Sq F value Pr(>F)
Temp        4 11.217  2.8041   4.264 0.0286 *
Residuals  10  6.577  0.6577


      Vista series Micro aggregates: d15N
           Df Sum Sq Mean Sq F value Pr(>F)
Temp        4  13.28   3.319   2.894 0.0788 .
Residuals  10  11.47   1.147
```

```
      Vista series Micro aggregates: N concentration
            Df  Sum Sq  Mean Sq F value Pr(>F)
Temp         4 0.05525 0.013812   3.218 0.0609 .
Residuals   10 0.04293 0.004293
```

```
      Vista series Silt-clay size aggregates: C concentration
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         4  5.622  1.4055   22.39 5.62e-05 ***
Residuals   10  0.628  0.0628
```

```
      Vista series Silt-clay size aggregates: C:N ratio
            Df Sum Sq Mean Sq F value   Pr(>F)
Temp         4  43.22  10.806   54.66 9.26e-07 ***
Residuals   10   1.98   0.198
```

```
      Vista series Silt-clay size aggregates: d13C
            Df Sum Sq Mean Sq F value  Pr(>F)
Temp         4  6.187  1.5467   8.468 0.00299 **
Residuals   10  1.827  0.1827
```

```
      Vista series Silt-clay size aggregates: d15N
            Df Sum Sq Mean Sq F value Pr(>F)
Temp         4  4.196  1.0490    2.97 0.0741 .
Residuals   10  3.532  0.3532
```

```
      Vista series Silt-clay size aggregates: N concentration
            Df  Sum Sq  Mean Sq F value   Pr(>F)
Temp         4 0.05266 0.013166   23.29 4.72e-05 ***
Residuals   10 0.00565 0.000565
```

Tukey's HSD test comparisons of means 95% family-wise confidence level

Chiquito series Macro aggregates: C concentration

Temp. Comparison		Difference	Lower	Upper	p adj
150-25	-0.4234364	-1.53606	0.689185	0.648668
250-25	-1.50416026	-2.6936	-0.31472	0.01464
450-25	-3.52071363	-4.71016	-2.33127	3.32E-05
250-150	-1.08072386	-2.19334	0.031897	0.05721
450-150	-3.09727723	-4.2099	-1.98466	5.47E-05
450-250	-2.01655337	-3.206	-0.82711	0.002291

Chiquito series Macro aggregates: C:N ratio

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.362332382	-15.7964	16.52105	0.999867
250-25	-11.8851013	-29.1595	5.389291	0.209621
450-25	-39.3740134	-56.6484	-22.0996	0.000264
250-150	-12.2474337	-28.4061	3.911281	0.153777
450-150	-39.7363458	-55.8951	-23.5776	0.000147
450-250	-27.4889121	-44.7633	-10.2145	0.003514

Chiquito series Macro aggregates: d13C

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.11472474	-2.86622	2.636773	0.999151
250-25	0.062494953	-2.87898	3.00397	0.999887
450-25	2.30851389	-0.63296	5.249989	0.136154
250-150	0.177219697	-2.57428	2.928718	0.996907
450-150	2.423238633	-0.32826	5.174737	0.087474
450-250	2.246018937	-0.69546	5.187494	0.149926

Chiquito series Macro aggregates: d15N

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.684113637	-1.09965	2.467882	0.643446
250-25	1.248060607	-0.65887	3.154989	0.242098
450-25	1.687	-0.21993	3.593928	0.085869
250-150	0.56394697	-1.21982	2.347715	0.760298
450-150	1.002886364	-0.78088	2.786654	0.352555
450-250	0.438939394	-1.46799	2.345868	0.887277

Chiquito series Macro aggregates: N concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.00896543	-0.0604	0.042469	0.945824
250-25	-0.01895315	-0.07394	0.036033	0.711736
450-25	-0.1068326	-0.16182	-0.05185	0.000874
250-150	-0.00998772	-0.06142	0.041447	0.927556
450-150	-0.09786718	-0.1493	-0.04643	0.001016
450-250	-0.08787945	-0.14287	-0.03289	0.003414

Chiquito series Micro aggregates: C concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.021861442	-3.17426	3.217987	0.999996
250-25	-0.39125051	-3.80805	3.025551	0.983352
450-25	-4.64273265	-8.05953	-1.22593	0.009583
250-150	-0.41311196	-3.60924	2.783013	0.97646
450-150	-4.66459409	-7.86072	-1.46847	0.006158
450-250	-4.25148214	-7.66828	-0.83468	0.016059

Chiquito series Micro aggregates: C:N ratio

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-1.11151707	-6.73223	4.509193	0.923967
250-25	-7.70852427	-13.7173	-1.69973	0.013475
450-25	-24.2973769	-30.3062	-18.2886	2.44E-06
250-150	-6.5970072	-12.2177	-0.9763	0.022213
450-150	-23.1858599	-28.8066	-17.5652	2.06E-06
450-250	-16.5888527	-22.5976	-10.5801	5.84E-05

Chiquito series Micro aggregates: d13C

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.04247474	-1.01037	0.925417	0.999011
250-25	0.102494953	-0.93222	1.137215	0.989052
450-25	2.340847223	1.306127	3.375567	0.00028
250-150	0.144969697	-0.82292	1.112862	0.964341
450-150	2.383321967	1.41543	3.351214	0.000145
450-250	2.23835227	1.203632	3.273072	0.000394

Chiquito series Micro aggregates: d15N

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	1.325113637	-3.59117	6.241398	0.833731
250-25	1.70139394	-3.55433	6.957123	0.747624
450-25	2.597	-2.65873	7.852729	0.453828
250-150	0.376280303	-4.54	5.292565	0.994853
450-150	1.271886364	-3.6444	6.188171	0.849349
450-250	0.89560606	-4.36012	6.151335	0.949068

Chiquito series Micro aggregates: N concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.011163967	-0.14101	0.163342	0.995457
250-25	0.048859938	-0.11382	0.211545	0.786198
450-25	-0.16106414	-0.32375	0.001621	0.052396
250-150	0.037695971	-0.11448	0.189874	0.864551
450-150	-0.1722281	-0.32441	-0.02005	0.026983
450-250	-0.20992408	-0.37261	-0.04724	0.013025

Chiquito series Silt-clay size aggregates: C concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.5830327	-4.18389	3.017821	0.952276
250-25	-0.69222561	-4.29308	2.908628	0.924242
450-25	-7.50477388	-11.1056	-3.90392	0.000713
250-150	-0.10919291	-3.71005	3.49166	0.999643
450-150	-6.92174118	-10.5226	-3.32089	0.001228
450-250	-6.81254827	-10.4134	-3.21169	0.001364

Chiquito series Silt-clay size aggregates: C:N ratio

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.53846159	-3.68165	2.604729	0.944349
250-25	-6.12076608	-9.26396	-2.97758	0.001126
450-25	-22.4763238	-25.6195	-19.3331	4.89E-08
250-150	-5.58230449	-8.7255	-2.43911	0.002061
450-150	-21.9378622	-25.0811	-18.7947	5.95E-08
450-250	-16.3555577	-19.4987	-13.2124	8.13E-07

Chiquito series Silt-clay size aggregates: d13C

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.02757071	-0.58883	0.643975	0.998861
250-25	0.13977273	-0.47663	0.756177	0.884
450-25	1.412791667	0.796388	2.029196	0.00037
250-150	0.11220202	-0.5042	0.728606	0.934473
450-150	1.385220957	0.768817	2.001625	0.000424
450-250	1.273018937	0.656615	1.889423	0.000758

Chiquito series Silt-clay size aggregates: d15N

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	1.175318182	-0.35416	2.704795	0.141935
250-25	1.231227273	-0.29825	2.760704	0.120572
450-25	2.9275	1.398023	4.456977	0.001263
250-150	0.055909091	-1.47357	1.585386	0.999376
450-150	1.752181818	0.222705	3.281659	0.026119
450-250	1.696272727	0.166796	3.22575	0.030697

Chiquito series Silt-clay size aggregates: N concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.0167294	-0.20733	0.173872	0.991647
250-25	0.061348682	-0.12925	0.251951	0.737358
450-25	-0.26824761	-0.45885	-0.07765	0.008566
250-150	0.078078082	-0.11252	0.26868	0.581181
450-150	-0.25151821	-0.44212	-0.06092	0.012338
450-250	-0.32959629	-0.5202	-0.13899	0.002445

Musick series Macro aggregates: C concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-1.004509	-2.23609	0.227071	0.126723
250-25	-1.29566573	-2.52725	-0.06409	0.038324
350-25	-3.54349603	-4.77508	-2.31192	2.01E-05
450-25	-5.66502423	-6.8966	-4.43344	2.56E-07
250-150	-0.29115673	-1.52274	0.940424	0.931328
350-150	-2.53898703	-3.77057	-1.30741	0.00036
450-150	-4.66051523	-5.8921	-3.42893	1.60E-06
350-250	-2.2478303	-3.47941	-1.01625	0.000959
450-250	-4.3693585	-5.60094	-3.13778	2.93E-06
450-350	-2.1215282	-3.35311	-0.88995	0.0015

Musick series Macro aggregates: C:N ratio

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	1.499721223	-3.74413	6.743569	0.874437
250-25	-6.21711147	-11.461	-0.97326	0.019421
350-25	-10.2894054	-15.5333	-5.04556	0.000539
450-25	-20.4995819	-25.7434	-15.2557	1.18E-06
250-150	-7.71683269	-12.9607	-2.47299	0.004756
350-150	-11.7891266	-17.033	-6.54528	0.000175
450-150	-21.9993032	-27.2432	-16.7555	6.04E-07
350-250	-4.07229388	-9.31614	1.171554	0.15336
450-250	-14.2824705	-19.5263	-9.03862	3.29E-05
450-350	-10.2101766	-15.454	-4.96633	0.000573

Musick series Macro aggregates: d13C

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.433500003	-0.4465	1.313498	0.517256
250-25	0.3949394	-0.48506	1.274937	0.597538
350-25	0.466166673	-0.41383	1.346164	0.45246
450-25	2.80329167	1.923294	3.683289	7.97E-06
250-150	-0.0385606	-0.91856	0.841437	0.999884
350-150	0.03266667	-0.84733	0.912664	0.99994
450-150	2.369791667	1.489794	3.249789	3.64E-05
350-250	0.071227273	-0.80877	0.951225	0.998693
450-250	2.40835227	1.528355	3.28835	3.15E-05
450-350	2.337124997	1.457127	3.217123	4.12E-05

Musick series Macro aggregates: d15N

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.729833333	-1.29574	2.755412	0.759222
250-25	1.610060607	-0.41552	3.635639	0.140312
350-25	1.272666667	-0.75291	3.298245	0.303753
450-25	1.532	-0.49358	3.557578	0.169082
250-150	0.880227273	-1.14535	2.905805	0.624053
350-150	0.542833334	-1.48274	2.568412	0.897217
450-150	0.802166667	-1.22341	2.827745	0.695447
350-250	-0.33739394	-2.36297	1.688184	0.979704
450-250	-0.07806061	-2.10364	1.947518	0.99993
450-350	0.259333333	-1.76624	2.284912	0.992353

Musick series Macro aggregates: N concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.0540035	-0.12444	0.016428	0.160824
250-25	0.000498633	-0.06993	0.07093	1
350-25	-0.0920909	-0.16252	-0.02166	0.010551
450-25	-0.2270506	-0.29748	-0.15662	7.15E-06
250-150	0.054502133	-0.01593	0.124934	0.15542
350-150	-0.0380874	-0.10852	0.032344	0.433999
450-150	-0.1730471	-0.24348	-0.10262	8.15E-05
350-250	-0.09258953	-0.16302	-0.02216	0.010188
450-250	-0.22754923	-0.29798	-0.15712	7.00E-06
450-350	-0.1349597	-0.20539	-0.06453	0.000652

Musick series Micro aggregates: C concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-1.12607077	-5.98392	3.731776	0.935658
250-25	-1.78494593	-6.64279	3.072901	0.746793
350-25	-4.8910031	-9.74885	-0.03316	0.048286
450-25	-8.29695887	-13.1548	-3.43911	0.001601
250-150	-0.65887517	-5.51672	4.198972	0.990499
350-150	-3.76493233	-8.62278	1.092915	0.154526
450-150	-7.1708881	-12.0287	-2.31304	0.004654
350-250	-3.10605717	-7.9639	1.75179	0.289475
450-250	-6.51201293	-11.3699	-1.65417	0.008967
450-350	-3.40595577	-8.2638	1.451891	0.219277

Musick series Micro aggregates: C:N ratio

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.1830991	-3.90591	4.272105	0.999874
250-25	-6.38040813	-10.4694	-2.2914	0.003132
350-25	-11.5180894	-15.6071	-7.42908	2.44E-05
450-25	-18.5219654	-22.611	-14.433	2.95E-07
250-150	-6.56350723	-10.6525	-2.4745	0.002547
350-150	-11.7011885	-15.7902	-7.61218	2.11E-05
450-150	-18.7050645	-22.7941	-14.6161	2.70E-07
350-250	-5.13768126	-9.22669	-1.04868	0.013601
450-250	-12.1415573	-16.2306	-8.05255	1.51E-05
450-350	-7.00387604	-11.0929	-2.91487	0.001566

Musick series Micro aggregates: d13C

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.18616667	-0.52461	0.896947	0.904363
250-25	0.287606067	-0.42317	0.998386	0.679622
350-25	0.650166673	-0.06061	1.360947	0.077179
450-25	2.179625003	1.468845	2.890405	1.13E-05
250-150	0.101439397	-0.60934	0.81222	0.988507
350-150	0.464000003	-0.24678	1.17478	0.272892
450-150	1.993458333	1.282678	2.704239	2.53E-05
350-250	0.362560607	-0.34822	1.073341	0.486283
450-250	1.892018937	1.181239	2.602799	4.04E-05
450-350	1.52945833	0.818678	2.240239	0.000252

Musick series Micro aggregates: d15N

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.2825	-1.68917	2.254174	0.988337
250-25	1.264060607	-0.70761	3.235735	0.287306
350-25	-0.658	-2.62967	1.313674	0.803789
450-25	2.725	0.753326	4.696674	0.007318
250-150	0.981560607	-0.99011	2.953235	0.507931
350-150	-0.9405	-2.91217	1.031174	0.545508
450-150	2.4425	0.470826	4.414174	0.014858
350-250	-1.92206061	-3.89373	0.049614	0.056854
450-250	1.460939394	-0.51073	3.432614	0.181938
450-350	3.383	1.411326	5.354674	0.001546

Musick series Micro aggregates: N concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.0556976	-0.28945	0.178057	0.929528
250-25	0.026422033	-0.20733	0.260177	0.995237
350-25	-0.082588	-0.31634	0.151167	0.771246
450-25	-0.3327758	-0.56653	-0.09902	0.005984
250-150	0.082119633	-0.15164	0.315875	0.774653
350-150	-0.0268904	-0.26065	0.206865	0.994907
450-150	-0.2770782	-0.51083	-0.04332	0.019447
350-250	-0.10901003	-0.34277	0.124745	0.565057
450-250	-0.35919783	-0.59295	-0.12544	0.003499
450-350	-0.2501878	-0.48394	-0.01643	0.034909

Musick series Silt-clay size aggregates: C concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.21265267	-2.14123	1.715925	0.995669
250-25	-0.6852983	-2.61388	1.24328	0.76778
350-25	-4.04664093	-5.97522	-2.11806	0.000311
450-25	-7.844158	-9.77274	-5.91558	8.09E-07
250-150	-0.47264563	-2.40122	1.455932	0.922731
350-150	-3.83398827	-5.76257	-1.90541	0.000485
450-150	-7.63150533	-9.56008	-5.70293	1.05E-06
350-250	-3.36134263	-5.28992	-1.43276	0.001371
450-250	-7.1588597	-9.08744	-5.23028	1.92E-06
450-350	-3.79751707	-5.72609	-1.86894	0.000524

Musick series Silt-clay size aggregates: C:N ratio

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.91929062	-2.66487	4.50345	0.910523
250-25	-5.89934754	-9.48351	-2.31519	0.002115
350-25	-11.2784943	-14.8627	-7.69434	8.92E-06
450-25	-17.8511121	-21.4353	-14.267	1.24E-07
250-150	-6.81863816	-10.4028	-3.23448	0.000691
350-150	-12.1977849	-15.7819	-8.61363	4.33E-06
450-150	-18.7704028	-22.3546	-15.1862	7.77E-08
350-250	-5.37914671	-8.96331	-1.79499	0.00414
450-250	-11.9517646	-15.5359	-8.36761	5.23E-06
450-350	-6.57261789	-10.1568	-2.98846	0.000924

Musick series Silt-clay size aggregates: d13C

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.005500003	-0.54776	0.558758	1
250-25	0.0869394	-0.46632	0.640198	0.983592
350-25	0.551500007	-0.00176	1.104758	0.050818
450-25	1.503625003	0.950367	2.056883	3.36E-05
250-150	0.081439397	-0.47182	0.634698	0.987107
350-150	0.546000003	-0.00726	1.099258	0.053465
450-150	1.498125	0.944867	2.051383	3.47E-05
350-250	0.464560607	-0.0887	1.017819	0.112499
450-250	1.416685603	0.863427	1.969944	5.68E-05
450-350	0.952124997	0.398867	1.505383	0.001511

Musick series Silt-clay size aggregates: d15N

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.226833333	-0.87252	1.326187	0.956633
250-25	0.957060607	-0.14229	2.056414	0.09642
350-25	-0.921	-2.02035	0.178354	0.113575
450-25	1.627	0.527646	2.726354	0.00457
250-150	0.730227273	-0.36913	1.829581	0.259353
350-150	-1.14783333	-2.24719	-0.04848	0.03991
450-150	1.400166667	0.300813	2.49952	0.012485
350-250	-1.87806061	-2.97741	-0.77871	0.001598
450-250	0.669939394	-0.42941	1.769293	0.329273
450-350	2.548	1.448646	3.647354	0.000135

Musick series Silt-clay size aggregates: N concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.02320857	-0.13017	0.083758	0.948484
250-25	0.078529	-0.02844	0.185495	0.187909
350-25	-0.02316263	-0.13013	0.083804	0.94883
450-25	-0.31779277	-0.42476	-0.21083	1.51E-05
250-150	0.101737567	-0.00523	0.208704	0.064157
350-150	4.59E-05	-0.10692	0.107012	1
450-150	-0.2945842	-0.40155	-0.18762	2.98E-05
350-250	-0.10169163	-0.20866	0.005275	0.064298
450-250	-0.39632177	-0.50329	-0.28936	1.95E-06
450-350	-0.29463013	-0.4016	-0.18766	2.98E-05

Shaver series Macro aggregates: C concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.4070114	-2.84903	2.035004	0.979658
250-25	0.066813543	-2.3752	2.508828	0.999982
350-25	-1.00459573	-3.44661	1.437419	0.667157
450-25	-2.11647347	-4.55849	0.325541	0.098312
250-150	0.473824943	-1.96819	2.91584	0.964988
350-150	-0.59758433	-3.0396	1.844431	0.923105
450-150	-1.70946207	-4.15148	0.732553	0.220397
350-250	-1.07140928	-3.51342	1.370606	0.616256
450-250	-2.18328701	-4.6253	0.258728	0.085678
450-350	-1.11187773	-3.55389	1.330137	0.585442

Shaver series Macro aggregates: C:N ratio

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.15192557	-12.3428	12.03897	0.999999
250-25	-5.95773885	-18.1486	6.233161	0.524288
350-25	-3.30199627	-15.4929	8.888903	0.893745
450-25	-39.6604134	-51.8513	-27.4695	6.57E-06
250-150	-5.80581328	-17.9967	6.385086	0.546903
350-150	-3.1500707	-15.341	9.040829	0.908385
450-150	-39.5084879	-51.6994	-27.3176	6.81E-06
350-250	2.65574258	-9.53516	14.84664	0.947775
450-250	-33.7026746	-45.8936	-21.5118	2.88E-05
450-350	-36.3584172	-48.5493	-24.1675	1.46E-05

Shaver series Macro aggregates: d13C

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.19783333	-1.65589	1.260227	0.990485
250-25	-0.5250606	-1.98312	0.933	0.759568
350-25	0.314500007	-1.14356	1.77256	0.949505
450-25	0.805958337	-0.6521	2.264018	0.414408
250-150	-0.32722727	-1.78529	1.130833	0.942252
350-150	0.512333337	-0.94573	1.970393	0.774528
450-150	1.003791667	-0.45427	2.461852	0.232438
350-250	0.839560607	-0.6185	2.297621	0.37824
450-250	1.331018937	-0.12704	2.789079	0.077907
450-350	0.49145833	-0.9666	1.949518	0.79837

Shaver series Macro aggregates: d15N

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	1.0145	-2.63368	4.662676	0.884732
250-25	1.483060607	-2.16512	5.131237	0.676141
350-25	0.016666667	-3.63151	3.664843	1
450-25	2.189	-1.45918	5.837176	0.342469
250-150	0.468560607	-3.17962	4.116737	0.99226
350-150	-0.99783333	-4.64601	2.650343	0.890474
450-150	1.1745	-2.47368	4.822676	0.822475
350-250	-1.46639394	-5.11457	2.181782	0.68456
450-250	0.705939394	-2.94224	4.354115	0.96532
450-350	2.172333333	-1.47584	5.820509	0.349035

Shaver series Macro aggregates: N concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.00984203	-0.07805	0.058368	0.988028
250-25	0.019288369	-0.04892	0.087498	0.878676
350-25	-0.0254888	-0.0937	0.042721	0.735761
450-25	-0.06121087	-0.12942	0.006999	0.084247
250-150	0.029130402	-0.03908	0.09734	0.638002
350-150	-0.01564677	-0.08386	0.052563	0.937862
450-150	-0.05136883	-0.11958	0.016841	0.171715
350-250	-0.04477717	-0.11299	0.023433	0.268501
450-250	-0.08049924	-0.14871	-0.01229	0.019962
450-350	-0.03572207	-0.10393	0.032488	0.462714

Shaver series Micro aggregates: C concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.36625597	-3.11399	2.381482	0.991099
250-25	-0.28144841	-3.02919	2.466289	0.996737
350-25	-1.8233762	-4.57111	0.924362	0.260098
450-25	-3.68235903	-6.4301	-0.93462	0.008983
250-150	0.084807554	-2.66293	2.832545	0.999971
350-150	-1.45712023	-4.20486	1.290618	0.45151
450-150	-3.31610307	-6.06384	-0.56837	0.017446
350-250	-1.54192779	-4.28967	1.20581	0.40099
450-250	-3.40091062	-6.14865	-0.65317	0.014939
450-350	-1.85898283	-4.60672	0.888755	0.245363

Shaver series Micro aggregates: C:N ratio

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	1.158058803	-9.86458	12.1807	0.996403
250-25	-6.61594595	-17.6386	4.406692	0.3422
350-25	-6.20013674	-17.2228	4.822502	0.398893
450-25	-26.2769025	-37.2995	-15.2543	0.000106
250-150	-7.77400475	-18.7966	3.248634	0.215106
350-150	-7.35819555	-18.3808	3.664443	0.255521
450-150	-27.4349613	-38.4576	-16.4123	7.28E-05
350-250	0.415809203	-10.6068	11.43845	0.999936
450-250	-19.6609565	-30.6836	-8.63832	0.001147
450-350	-20.0767657	-31.0994	-9.05413	0.000974

Shaver series Micro aggregates: d13C

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.0255	-1.32729	1.276286	0.999995
250-25	0.1239394	-1.17785	1.425726	0.997541
350-25	0.670500007	-0.63129	1.972286	0.477614
450-25	2.474958337	1.173172	3.776745	0.000694
250-150	0.149439397	-1.15235	1.451226	0.994947
350-150	0.696000003	-0.60579	1.997786	0.444189
450-150	2.500458333	1.198672	3.802245	0.00064
350-250	0.546560607	-0.75523	1.848347	0.651431
450-250	2.351018937	1.049233	3.652805	0.001041
450-350	1.80445833	0.502672	3.106245	0.007174

Shaver series Micro aggregates: d15N

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	1.533833333	-1.46812	4.53579	0.484786
250-25	2.29939394	-0.70256	5.301351	0.161432
350-25	1.079333334	-1.92262	4.08129	0.760546
450-25	2.9	-0.10196	5.901957	0.059463
250-150	0.765560607	-2.2364	3.767518	0.912148
350-150	-0.4545	-3.45646	2.547457	0.985692
450-150	1.366166667	-1.63579	4.368124	0.585849
350-250	-1.22006061	-4.22202	1.781897	0.676324
450-250	0.60060606	-2.40135	3.602563	0.961027
450-350	1.820666666	-1.18129	4.822624	0.33332

Shaver series Micro aggregates: N concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.0163405	-0.10904	0.076356	0.975096
250-25	0.022111155	-0.07059	0.114808	0.929276
350-25	-0.04907097	-0.14177	0.043626	0.453079
450-25	-0.1170722	-0.20977	-0.02438	0.013167
250-150	0.038451655	-0.05425	0.131148	0.660797
350-150	-0.03273047	-0.12543	0.059966	0.771618
450-150	-0.1007317	-0.19343	-0.00803	0.032108
350-250	-0.07118212	-0.16388	0.021515	0.159931
450-250	-0.13918336	-0.23188	-0.04649	0.004127
450-350	-0.06800123	-0.1607	0.024696	0.188407

Shaver series Silt-clay size aggregates: C concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.29463283	-2.26094	1.671672	0.987242
250-25	-0.65681883	-2.62312	1.309486	0.81286
350-25	-2.84820507	-4.81451	-0.8819	0.004796
450-25	-6.89050448	-8.72981	-5.05119	8.51E-07
250-150	-0.36218599	-2.32849	1.604119	0.972894
350-150	-2.55357223	-4.51988	-0.58727	0.010353
450-150	-6.59587165	-8.43518	-4.75656	1.33E-06
350-250	-2.19138624	-4.15769	-0.22508	0.027286
450-250	-6.23368565	-8.073	-4.39438	2.36E-06
450-350	-4.04229941	-5.88161	-2.20299	0.000153

Shaver series Silt-clay size aggregates: C:N ratio

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	1.141678303	-5.42935	7.712706	0.978035
250-25	-5.51187619	-12.0829	1.059151	0.115383
350-25	-8.96976212	-15.5408	-2.39873	0.007343
450-25	-24.5958445	-30.7425	-18.4492	4.29E-07
250-150	-6.6535545	-13.2246	-0.08253	0.046795
350-150	-10.1114404	-16.6825	-3.54041	0.003051
450-150	-25.7375228	-31.8842	-19.5909	2.67E-07
350-250	-3.45788593	-10.0289	3.113141	0.470814
450-250	-19.0839683	-25.2306	-12.9373	5.69E-06
450-350	-15.6260824	-21.7727	-9.47945	3.97E-05

Shaver series Silt-clay size aggregates: d13C

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.24016666	-1.06373	0.583401	0.874178
250-25	0.002606067	-0.82096	0.826174	1
350-25	0.592166673	-0.2314	1.415735	0.207671
450-25	2.09054167	1.320164	2.860919	2.13E-05
250-150	0.24277273	-0.5808	1.066341	0.869993
350-150	0.832333337	0.008765	1.655901	0.04727
450-150	2.330708333	1.560331	3.101086	7.36E-06
350-250	0.589560607	-0.23401	1.413128	0.210789
450-250	2.087935603	1.317558	2.858313	2.15E-05
450-350	1.498374997	0.727998	2.268752	0.000452

Shaver series Silt-clay size aggregates: d15N

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.552166667	-1.02941	2.133739	0.788633
250-25	1.508060607	-0.07351	3.089633	0.063834
350-25	-0.55633333	-2.13791	1.025239	0.784292
450-25	1.910666667	0.431241	3.390092	0.010748
250-150	0.95589394	-0.62568	2.537466	0.3464
350-150	-1.1085	-2.69007	0.473072	0.226076
450-150	1.3585	-0.12093	2.837926	0.076726
350-250	-2.06439394	-3.64597	-0.48282	0.010003
450-250	0.40260606	-1.07682	1.882032	0.898412
450-350	2.467	0.987574	3.946426	0.001628

Shaver series Silt-clay size aggregates: N concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.01864923	-0.06964	0.032338	0.760728
250-25	0.024657634	-0.02633	0.075645	0.546507
350-25	-0.04630353	-0.09729	0.004684	0.080864
450-25	-0.21050131	-0.2582	-0.16281	1.54E-07
250-150	0.043306867	-0.00768	0.094294	0.109366
350-150	-0.0276543	-0.07864	0.023333	0.443381
450-150	-0.19185208	-0.23955	-0.14416	4.06E-07
350-250	-0.07096117	-0.12195	-0.01997	0.006402
450-250	-0.23515895	-0.28285	-0.18746	4.98E-08
450-350	-0.16419778	-0.21189	-0.1165	2.02E-06

Sirretta series Macro aggregates: C concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-1.4820218	-4.74062	1.776576	0.586384
250-25	-1.3590322	-4.61763	1.899566	0.656622
350-25	-3.94727077	-7.20587	-0.68867	0.017056
450-25	-4.846177	-8.10477	-1.58758	0.004416
250-150	0.122989598	-3.13561	3.381588	0.999936
350-150	-2.46524897	-5.72385	0.793349	0.168912
450-150	-3.3641552	-6.62275	-0.10556	0.042371
350-250	-2.58823857	-5.84684	0.670359	0.140714
450-250	-3.4871448	-6.74574	-0.22855	0.034938
450-350	-0.89890623	-4.1575	2.359692	0.88755

Sirretta series Macro aggregates: C:N ratio

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-2.2002124	-15.9041	11.50371	0.982249
250-25	-14.6535096	-28.3574	-0.94958	0.035089
350-25	-24.110938	-37.8149	-10.407	0.001275
450-25	-54.4337618	-68.1377	-40.7298	1.01E-06
250-150	-12.4532972	-26.1572	1.25063	0.079552
350-150	-21.9107256	-35.6147	-8.2068	0.002622
450-150	-52.2335494	-65.9375	-38.5296	1.49E-06
350-250	-9.45742847	-23.1614	4.246499	0.230656
450-250	-39.7802522	-53.4842	-26.0763	1.86E-05
450-350	-30.3228237	-44.0268	-16.6189	0.0002

Sirretta series Macro aggregates: d13C

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.113888893	-1.54124	1.769019	0.999308
250-25	0.085272733	-1.56986	1.740403	0.999779
350-25	0.723166673	-0.93196	2.378297	0.619639
450-25	2.98029167	1.325161	4.635422	0.001066
250-150	-0.02861616	-1.68375	1.626514	0.999997
350-150	0.60927778	-1.04585	2.264408	0.745599
450-150	2.866402777	1.211272	4.521533	0.00144
350-250	0.63789394	-1.01724	2.293024	0.714754
450-250	2.895018937	1.239888	4.550149	0.001334
450-350	2.257124997	0.601995	3.912255	0.008003

Sirretta series Macro aggregates: d15N

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.55944444	-2.95605	1.837161	0.934147
250-25	0.743060607	-1.65355	3.139666	0.840555
350-25	-0.87633333	-3.27294	1.520272	0.749913
450-25	1.135666667	-1.26094	3.532272	0.551248
250-150	1.302505051	-1.0941	3.699111	0.429528
350-150	-0.31688889	-2.71349	2.079717	0.991365
450-150	1.695111111	-0.70149	4.091717	0.2131
350-250	-1.61939394	-4.016	0.777212	0.246305
450-250	0.39260606	-2.004	2.789212	0.980896
450-350	2.012	-0.38461	4.408606	0.112589

Sirretta series Macro aggregates: N concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.03236913	-0.11609	0.051347	0.712497
250-25	-0.00660222	-0.09032	0.077114	0.998819
350-25	-0.0709283	-0.15464	0.012788	0.108344
450-25	-0.10835297	-0.19207	-0.02464	0.011266
250-150	0.025766914	-0.05795	0.109483	0.843895
350-150	-0.03855917	-0.12228	0.045157	0.575667
450-150	-0.07598383	-0.1597	0.007733	0.079998
350-250	-0.06432608	-0.14804	0.01939	0.159564
450-250	-0.10175075	-0.18547	-0.01803	0.016709
450-350	-0.03742467	-0.12114	0.046292	0.600802

Sirretta series Micro aggregates: C concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	1.236855733	-5.11914	7.592849	0.967047
250-25	-0.18508938	-6.54108	6.170904	0.999979
350-25	-3.45460138	-9.40009	2.490886	0.381225
450-25	-5.27996687	-11.636	1.076026	0.12021
250-150	-1.42194511	-7.77794	4.934048	0.946556
350-150	-4.69145711	-10.6369	1.25403	0.148002
450-150	-6.5168226	-12.8728	-0.16083	0.043749
350-250	-3.269512	-9.215	2.675975	0.430857
450-250	-5.09487749	-11.4509	1.261116	0.1391
450-350	-1.82536549	-7.77085	4.120122	0.853193

Sirretta series Micro aggregates: C:N ratio

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	2.03141261	-4.5687	8.631529	0.852107
250-25	-13.5095151	-20.1096	-6.9094	0.00029
350-25	-22.0128718	-28.1867	-15.839	1.41E-06
450-25	-34.8223055	-41.4224	-28.2222	2.54E-08
250-150	-15.5409277	-22.141	-8.94081	8.15E-05
350-150	-24.0442845	-30.2181	-17.8704	5.69E-07
450-150	-36.8537181	-43.4538	-30.2536	1.43E-08
350-250	-8.50335676	-14.6772	-2.32951	0.006894
450-250	-21.3127904	-27.9129	-14.7127	3.85E-06
450-350	-12.8094337	-18.9833	-6.63559	0.000257

Sirretta series Micro aggregates: d13C

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.08194445	-0.70475	0.868634	0.99679
250-25	0.320272733	-0.46642	1.106962	0.687394
350-25	0.63008334	-0.1058	1.365964	0.105612
450-25	2.830958337	2.044269	3.617648	1.29E-06
250-150	0.238328283	-0.54836	1.025018	0.858884
350-150	0.54813889	-0.18774	1.28402	0.183615
450-150	2.749013887	1.962324	3.535703	1.73E-06
350-250	0.309810607	-0.42607	1.045691	0.661936
450-250	2.510685603	1.723996	3.297375	4.33E-06
450-350	2.200874997	1.464994	2.936756	8.24E-06

Sirretta series Micro aggregates: d15N

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.563944445	-4.91702	6.044906	0.996938
250-25	2.411060607	-3.0699	7.892022	0.627024
350-25	1.903500001	-3.22347	7.03047	0.751251
450-25	0.783	-4.69796	6.263961	0.98932
250-150	1.847116162	-3.63385	7.328078	0.808182
350-150	1.339555556	-3.78741	6.466526	0.91074
450-150	0.219055556	-5.26191	5.700017	0.999926
350-250	-0.50756061	-5.63453	4.619409	0.997363
450-250	-1.62806061	-7.10902	3.852901	0.866967
450-350	-1.1205	-6.24747	4.00647	0.950649

Sirretta series Micro aggregates: N concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.027743667	-0.17509	0.230578	0.990927
250-25	0.056249765	-0.14658	0.259084	0.892228
350-25	-0.0335457	-0.22328	0.156188	0.976604
450-25	-0.12886447	-0.3317	0.07397	0.303657
250-150	0.028506098	-0.17433	0.23134	0.989955
350-150	-0.06128937	-0.25102	0.128445	0.829799
450-150	-0.15660813	-0.35944	0.046226	0.160894
350-250	-0.08979547	-0.27953	0.099939	0.565389
450-250	-0.18511423	-0.38795	0.01772	0.079
450-350	-0.09531877	-0.28505	0.094415	0.512664

Sirretta series Silt-clay size aggregates: C concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.9467624	-7.19029	5.296761	0.985609
250-25	-0.83180152	-7.07532	5.411722	0.991116
350-25	-4.34145313	-10.585	1.90207	0.225188
450-25	-7.26176213	-13.5053	-1.01824	0.021765
250-150	0.114960883	-6.12856	6.358484	0.999996
350-150	-3.39469073	-9.63821	2.848832	0.429142
450-150	-6.31499973	-12.5585	-0.07148	0.047159
350-250	-3.50965162	-9.75317	2.733871	0.399467
450-250	-6.42996062	-12.6735	-0.18644	0.042923
450-350	-2.920309	-9.16383	3.323214	0.562497

Sirretta series Silt-clay size aggregates: C:N ratio

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	1.919425763	-5.22963	9.068481	0.896619
250-25	-8.72296771	-15.872	-1.57391	0.016316
350-25	-18.8934871	-26.0425	-11.7444	4.30E-05
450-25	-28.571779	-35.7208	-21.4227	9.54E-07
250-150	-10.6423935	-17.7914	-3.49334	0.004386
350-150	-20.8129129	-27.962	-13.6639	1.81E-05
450-150	-30.4912048	-37.6403	-23.3421	5.17E-07
350-250	-10.1705194	-17.3196	-3.02146	0.006012
450-250	-19.8488113	-26.9979	-12.6998	2.77E-05
450-350	-9.67829187	-16.8273	-2.52924	0.008402

Sirretta series Silt-clay size aggregates: d13C

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.101611117	-0.71541	0.918635	0.993148
250-25	0.421272733	-0.39575	1.238297	0.476648
350-25	0.539500007	-0.27752	1.356524	0.263924
450-25	2.45229167	1.635268	3.269316	1.37E-05
250-150	0.319661617	-0.49736	1.136686	0.704148
350-150	0.43788889	-0.37914	1.254913	0.442003
450-150	2.350680553	1.533657	3.167705	2.01E-05
350-250	0.118227273	-0.6988	0.935251	0.9879
450-250	2.031018937	1.213995	2.848043	7.36E-05
450-350	1.912791663	1.095768	2.729816	0.000124

Sirretta series Silt-clay size aggregates: d15N

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.553611111	-2.26968	3.376905	0.96367
250-25	1.49839394	-1.3249	4.321688	0.450789
350-25	0.636666667	-2.18663	3.459961	0.941315
450-25	1.877333334	-0.94596	4.700627	0.258528
250-150	0.944782829	-1.87851	3.768077	0.802314
350-150	0.083055556	-2.74024	2.90635	0.999976
450-150	1.323722222	-1.49957	4.147016	0.560432
350-250	-0.86172727	-3.68502	1.961567	0.847652
450-250	0.378939394	-2.44435	3.202233	0.990865
450-350	1.240666666	-1.58263	4.063961	0.614953

Sirretta series Silt-clay size aggregates: N concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.04034257	-0.25586	0.17517	0.969147
250-25	0.040276619	-0.17524	0.255789	0.969325
350-25	-0.01795333	-0.23347	0.197559	0.998537
450-25	-0.19406237	-0.40957	0.02145	0.082948
250-150	0.080619186	-0.13489	0.296132	0.735052
350-150	0.022389233	-0.19312	0.237902	0.996555
450-150	-0.1537198	-0.36923	0.061793	0.207256
350-250	-0.05822995	-0.27374	0.157283	0.894555
450-250	-0.23433899	-0.44985	-0.01883	0.031997
450-350	-0.17610903	-0.39162	0.039404	0.125766

Vista series Macro aggregates: C concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.404955033	-0.28215	1.092064	0.357931
250-25	0.301721333	-0.38539	0.988831	0.615554
350-25	-0.45279093	-1.1399	0.234318	0.265509
450-25	-0.73538493	-1.42249	-0.04828	0.034916
250-150	-0.1032337	-0.79034	0.583876	0.986092
350-150	-0.85774597	-1.54486	-0.17064	0.014165
450-150	-1.14033997	-1.82745	-0.45323	0.001988
350-250	-0.75451227	-1.44162	-0.0674	0.030291
450-250	-1.03710627	-1.72422	-0.35	0.003977
450-350	-0.282594	-0.9697	0.404515	0.667343

Vista series Macro aggregates: C:N ratio

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.553308053	-4.26823	5.374846	0.994954
250-25	-2.29517432	-7.11671	2.526364	0.547298
350-25	-1.700433	-6.52197	3.121105	0.772329
450-25	-9.60122439	-14.4228	-4.77969	0.000478
250-150	-2.84848237	-7.67002	1.973056	0.355842
350-150	-2.25374105	-7.07528	2.567797	0.563053
450-150	-10.1545324	-14.9761	-5.33299	0.000302
350-250	0.59474132	-4.2268	5.416279	0.993358
450-250	-7.30605007	-12.1276	-2.48451	0.003867
450-350	-7.90079139	-12.7223	-3.07925	0.002186

Vista series Macro aggregates: d13C

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.154500003	-1.54334	1.852341	0.997936
250-25	0.6489394	-1.0489	2.34678	0.720505
350-25	0.485166673	-1.21267	2.183008	0.874757
450-25	3.438625003	1.740784	5.136466	0.000417
250-150	0.494439397	-1.2034	2.19228	0.867406
350-150	0.33066667	-1.36717	2.028508	0.964526
450-150	3.284125	1.586284	4.981966	0.000605
350-250	-0.16377273	-1.86161	1.534068	0.997413
450-250	2.789685603	1.091845	4.487527	0.002143
450-350	2.95345833	1.255617	4.651299	0.001392

Vista series Macro aggregates: d15N

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	2.379166667	-0.61044	5.368774	0.139664
250-25	2.69339394	-0.29621	5.683001	0.082759
350-25	3.541000001	0.551393	6.530607	0.019535
450-25	2.557333334	-0.43227	5.54694	0.104021
250-150	0.314227273	-2.67538	3.303834	0.996397
350-150	1.161833334	-1.82777	4.15144	0.708922
450-150	0.178166667	-2.81144	3.167774	0.999608
350-250	0.847606061	-2.142	3.837213	0.87771
450-250	-0.13606061	-3.12567	2.853546	0.999865
450-350	-0.98366667	-3.97327	2.00594	0.811325

Vista series Macro aggregates: N concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.0297982	-0.02213	0.081728	0.381279
250-25	0.0440657	-0.00786	0.095995	0.107633
350-25	-0.03510887	-0.08704	0.016821	0.245879
450-25	-0.06014427	-0.11207	-0.00821	0.022312
250-150	0.0142675	-0.03766	0.066197	0.888941
350-150	-0.06490707	-0.11684	-0.01298	0.014054
450-150	-0.08994247	-0.14187	-0.03801	0.001439
350-250	-0.07917457	-0.1311	-0.02724	0.003701
450-250	-0.10420997	-0.15614	-0.05228	0.000449
450-350	-0.0250354	-0.07696	0.026894	0.53623

Vista series Micro aggregates: C concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.86752723	-3.44223	1.707173	0.798566
250-25	-1.0243825	-3.59908	1.550318	0.692066
350-25	-1.89303363	-4.46773	0.681666	0.186937
450-25	-2.32680403	-4.9015	0.247896	0.081597
250-150	-0.15685527	-2.73156	2.417845	0.999572
350-150	-1.0255064	-3.60021	1.549194	0.691266
450-150	-1.4592768	-4.03398	1.115423	0.392173
350-250	-0.86865113	-3.44335	1.706049	0.797853
450-250	-1.30242153	-3.87712	1.272278	0.493718
450-350	-0.4337704	-3.00847	2.14093	0.978848

Vista series Micro aggregates: C:N ratio

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.045772117	-3.38885	3.480395	0.999999
250-25	-3.53286687	-6.96749	-0.09824	0.0432
350-25	-3.98992029	-7.42454	-0.5553	0.021921
450-25	-7.72922016	-11.1638	-4.2946	0.000173
250-150	-3.57863899	-7.01326	-0.14402	0.040355
350-150	-4.03569241	-7.47032	-0.60107	0.02049
450-150	-7.77499228	-11.2096	-4.34037	0.000165
350-250	-0.45705342	-3.89168	2.97757	0.991154
450-250	-4.19635329	-7.63098	-0.76173	0.016183
450-350	-3.73929987	-7.17392	-0.30468	0.031777

Vista series Micro aggregates: d13C

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.792833337	-1.3864	2.972064	0.753132
250-25	0.881606067	-1.29762	3.060837	0.679779
350-25	0.850166673	-1.32906	3.029398	0.706201
450-25	2.63229167	0.453061	4.811523	0.017354
250-150	0.08877273	-2.09046	2.268004	0.999913
350-150	0.057333337	-2.1219	2.236564	0.999985
450-150	1.839458333	-0.33977	4.018689	0.110061
350-250	-0.03143939	-2.21067	2.147792	0.999999
450-250	1.750685603	-0.42855	3.929917	0.134605
450-350	1.782124997	-0.39711	3.961356	0.125386

Vista series Micro aggregates: d15N

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.940833333	-1.93705	3.818721	0.814674
250-25	2.060727273	-0.81716	4.938615	0.204585
350-25	2.516666667	-0.36122	5.394555	0.094544
450-25	2.226	-0.65189	5.103888	0.155679
250-150	1.11989394	-1.75799	3.997782	0.70799
350-150	1.575833334	-1.30205	4.453721	0.422833
450-150	1.285166667	-1.59272	4.163055	0.601685
350-250	0.455939394	-2.42195	3.333827	0.983094
450-250	0.165272727	-2.71262	3.043161	0.999661
450-350	-0.29066667	-3.16855	2.587221	0.99691

Vista series Micro aggregates: N concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.06358493	-0.23964	0.112474	0.75775
250-25	-0.0357695	-0.21183	0.140289	0.958891
350-25	-0.12633983	-0.3024	0.049719	0.203112
450-25	-0.1674802	-0.34354	0.008578	0.064106
250-150	0.027815433	-0.14824	0.203874	0.983265
350-150	-0.0627549	-0.23881	0.113304	0.765886
450-150	-0.10389527	-0.27995	0.072163	0.356818
350-250	-0.09057033	-0.26663	0.085488	0.478706
450-250	-0.1317107	-0.30777	0.044348	0.175858
450-350	-0.04114037	-0.2172	0.134918	0.93392

Vista series Silt-clay size aggregates: C concentration

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.05221837	-0.72541	0.620976	0.998893
250-25	-0.10195657	-0.77515	0.571238	0.985674
350-25	-0.9931553	-1.66635	-0.31996	0.004673
450-25	-1.51343107	-2.18663	-0.84024	0.000175
250-150	-0.0497382	-0.72293	0.623456	0.999085
350-150	-0.94093693	-1.61413	-0.26774	0.006782
450-150	-1.4612127	-2.13441	-0.78802	0.000235
350-250	-0.89119873	-1.56439	-0.218	0.009734
450-250	-1.4114745	-2.08467	-0.73828	0.000313
450-350	-0.52027577	-1.19347	0.152919	0.15616

Vista series Silt-clay size aggregates: C:N ratio

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	1.058695713	-0.13612	2.253515	0.089193
250-25	-1.48427128	-2.67909	-0.28945	0.014603
350-25	-1.94021746	-3.13504	-0.7454	0.002338
450-25	-3.89270782	-5.08753	-2.69789	6.48E-06
250-150	-2.54296699	-3.73779	-1.34815	0.000277
350-150	-2.99891318	-4.19373	-1.80409	6.77E-05
450-150	-4.95140354	-6.14622	-3.75658	6.78E-07
350-250	-0.45594618	-1.65077	0.738873	0.721606
450-250	-2.40843654	-3.60326	-1.21362	0.000433
450-350	-1.95249036	-3.14731	-0.75767	0.002231

Vista series Silt-clay size aggregates: d13C

Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.618500003	-0.52994	1.76694	0.437669
250-25	0.491272733	-0.65717	1.639713	0.636691
350-25	0.389500007	-0.75894	1.53794	0.794944
450-25	1.894958337	0.746518	3.043399	0.002076
250-150	-0.12722727	-1.27567	1.021213	0.99559
350-150	-0.229	-1.37744	0.91944	0.96148
450-150	1.276458333	0.128018	2.424899	0.028294
350-250	-0.10177273	-1.25021	1.046668	0.998138
450-250	1.403685603	0.255245	2.552126	0.016145
450-350	1.50545833	0.357018	2.653899	0.010378

Vista series Silt-clay size aggregates: d15N

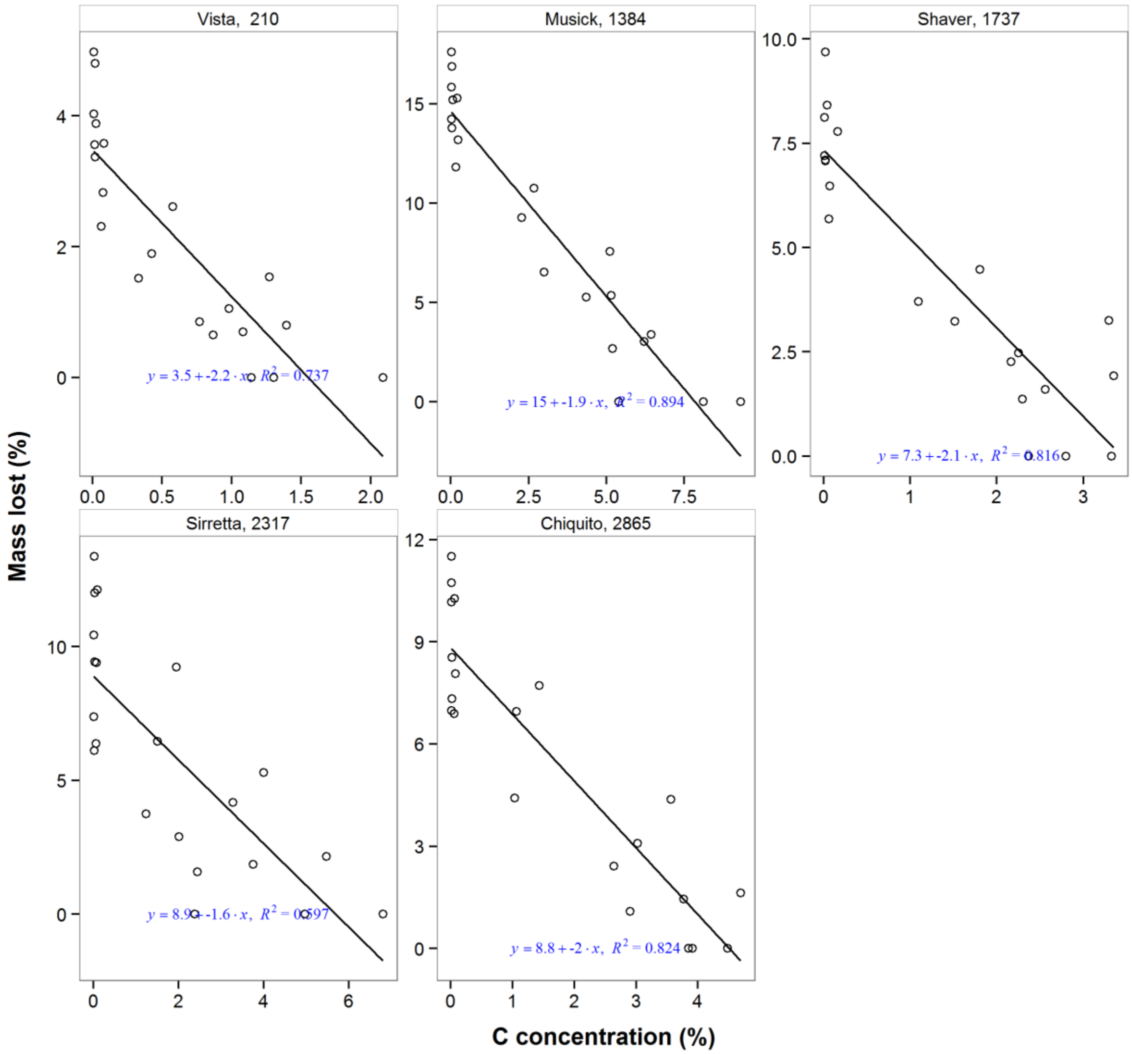
Temp. Comparison	Difference	Lower	Upper	p adj
150-25	0.469833333	-1.12718	2.066849	0.863313
250-25	1.05839394	-0.53862	2.65541	0.2611
350-25	1.498666667	-0.09835	3.095683	0.068439
450-25	1.114333334	-0.48268	2.711349	0.222708
250-150	0.588560607	-1.00846	2.185576	0.744855
350-150	1.028833334	-0.56818	2.625849	0.283414
450-150	0.6445	-0.95252	2.241516	0.681592
350-250	0.440272727	-1.15674	2.037289	0.887767
450-250	0.055939394	-1.54108	1.652955	0.999952
450-350	-0.38433333	-1.98135	1.212683	0.927187

Vista series Silt-clay size aggregates: N concentration

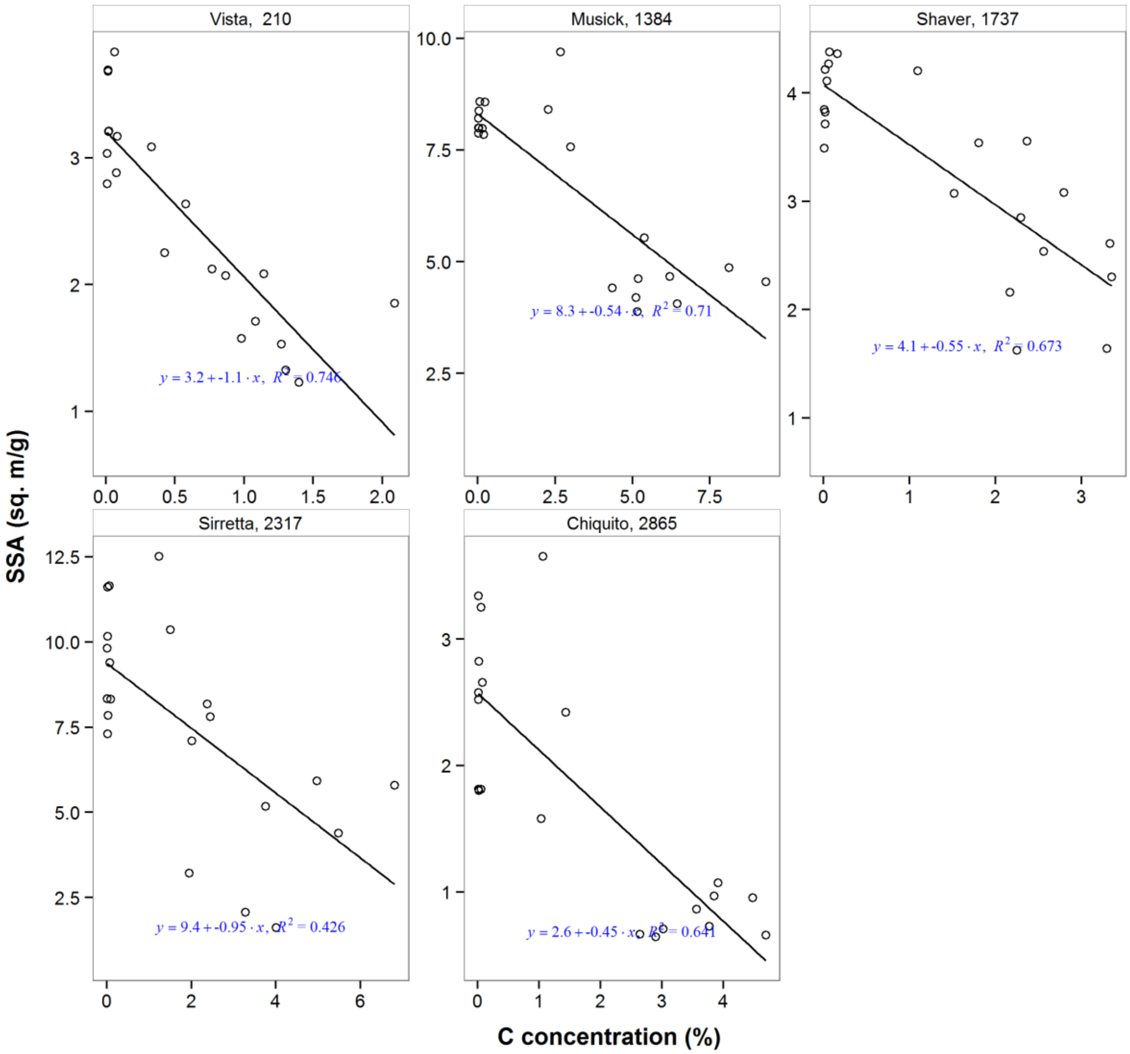
Temp. Comparison	Difference	Lower	Upper	p adj
150-25	-0.02111843	-0.085	0.042767	0.808867
250-25	0.015396233	-0.04849	0.079281	0.926848
350-25	-0.08601697	-0.1499	-0.02213	0.00871
450-25	-0.14323003	-0.20712	-0.07934	0.000179
250-150	0.036514667	-0.02737	0.1004	0.384741
350-150	-0.06489853	-0.12878	-0.00101	0.046107
450-150	-0.1221116	-0.186	-0.05823	0.000665
350-250	-0.1014132	-0.1653	-0.03753	0.002764
450-250	-0.15862627	-0.22251	-0.09474	7.44E-05
450-350	-0.05721307	-0.1211	0.006672	0.085028

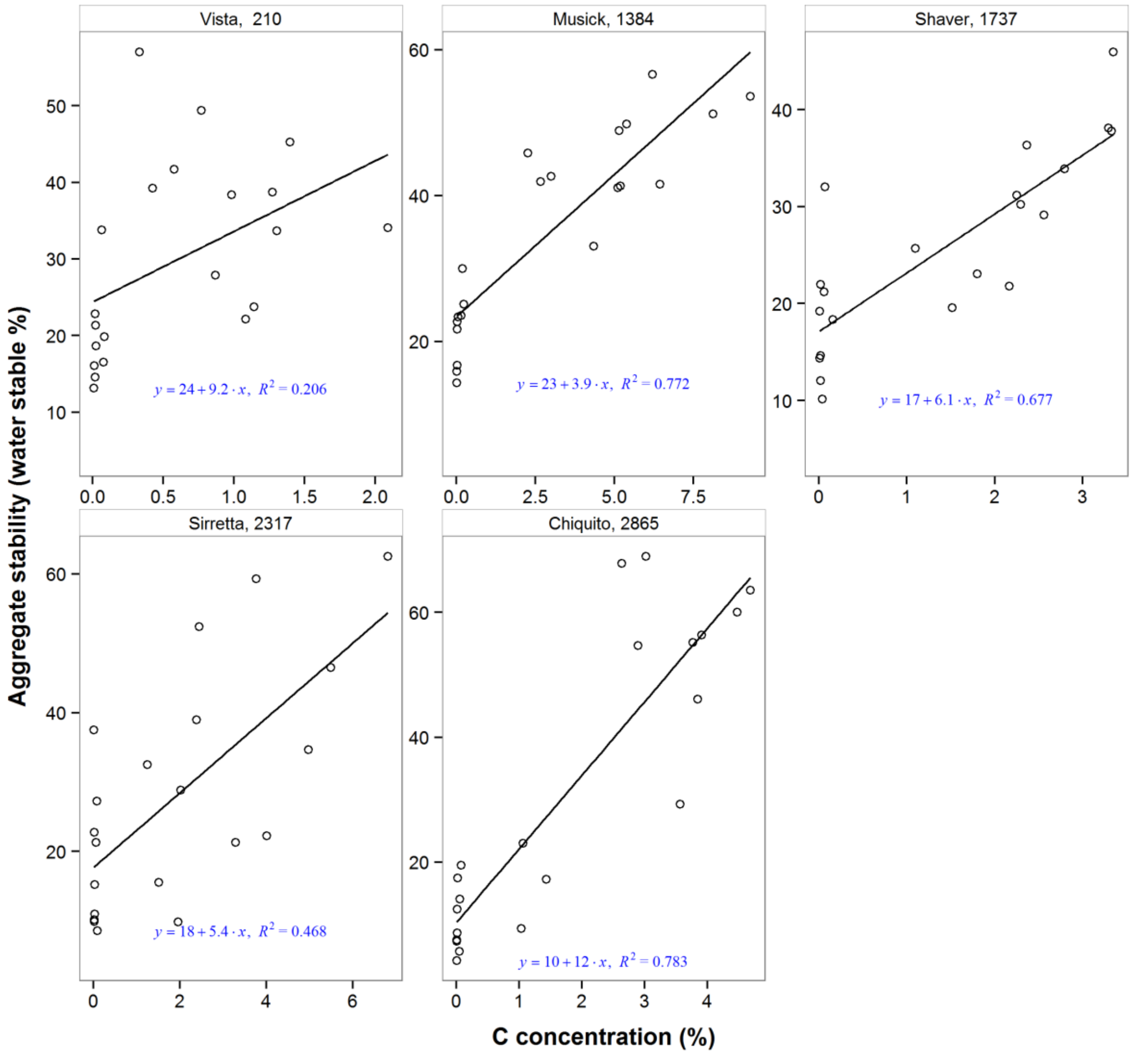
Appendix III: Linear regression of soil properties with C concentration during heating

Physical properties (mass loss, specific surface area and aggregate strength)



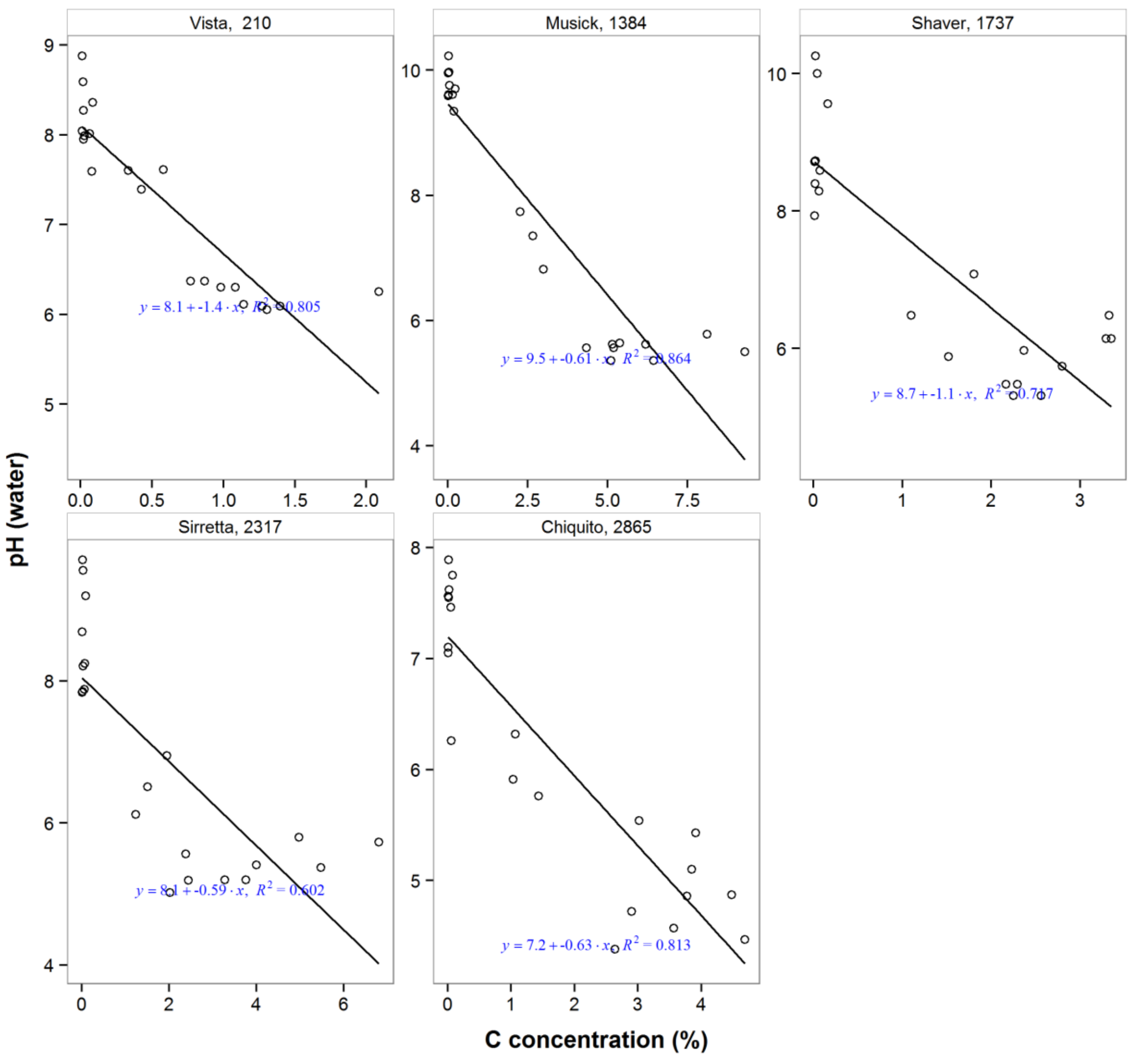
Vista, 210
Musick, 1384
Shaver, 1737
Sirretta, 2317
Chiquito, 2865
Mass lost (%)
C concentration (%)

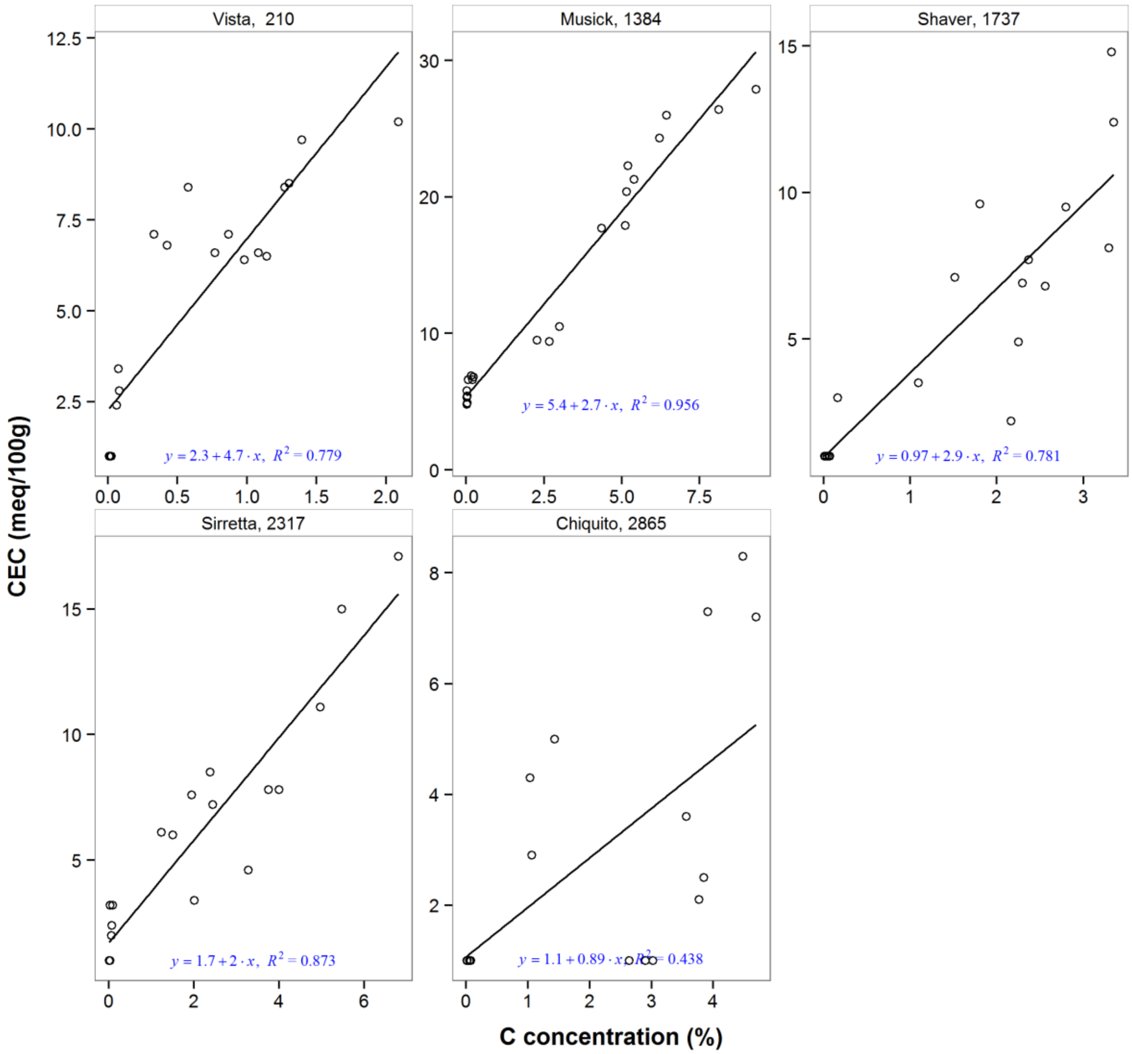

Vista, 210
Musick, 1384
Shaver, 1737
Sirretta, 2317
Chiquito, 2865
y = 3.2 + -1.1 · x, R² = 0.746
y = 8.3 + -0.54 · x, R² = 0.71
y = 4.1 + -0.55 · x, R² = 0.673
y = 9.4 + -0.95 · x, R² = 0.426
y = 2.6 + -0.45 · x, R² = 0.641
SSA (sq. m/g)
C concentration (%)

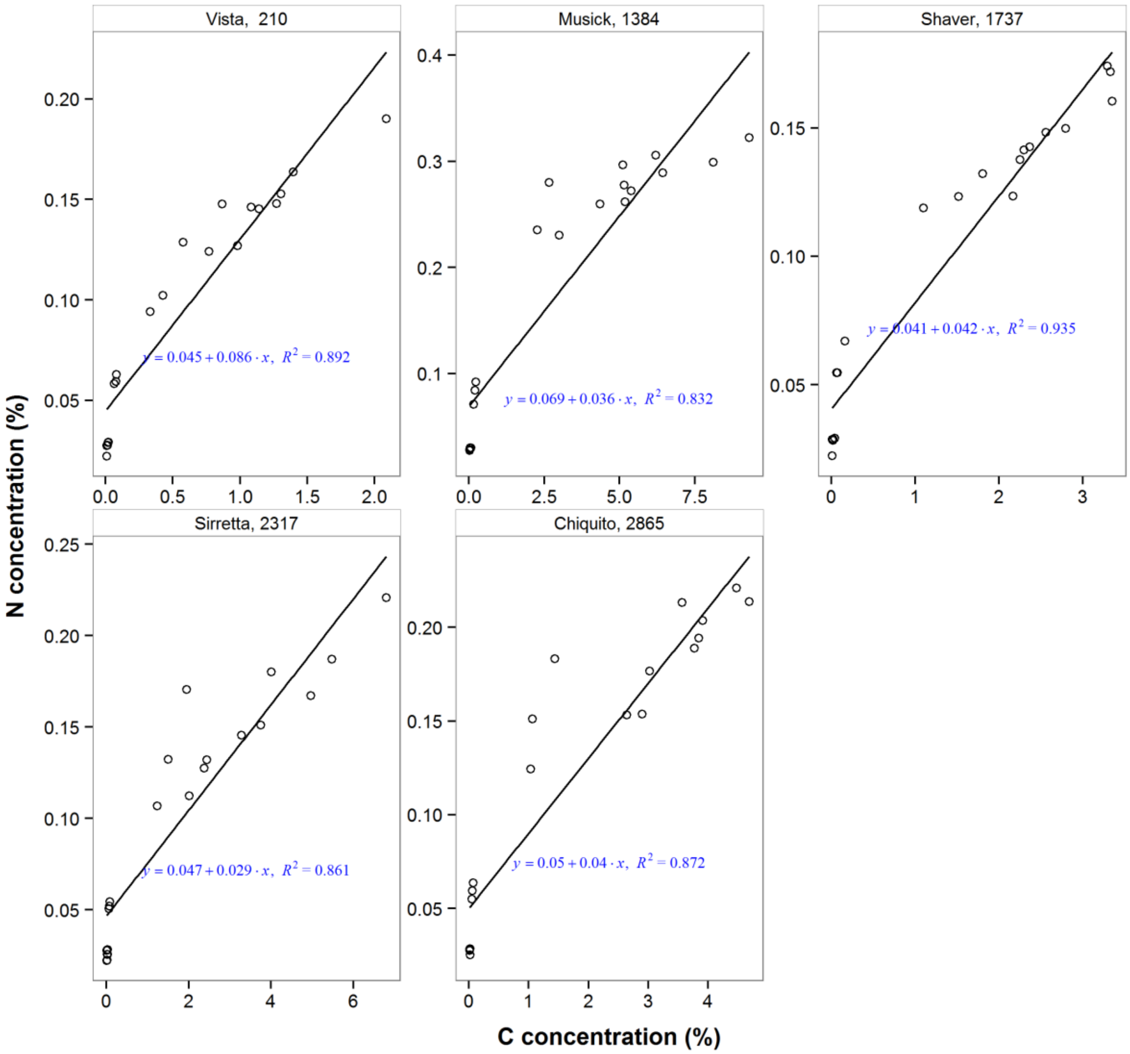


Vista, 210
Musick, 1384
Shaver, 1737
Sirretta, 2317
Chiquito, 2865
Aggregate stability (water stable %)
C concentration (%)
y = 24 + 9.2 · x, R² = 0.206
y = 23 + 3.9 · x, R² = 0.772
y = 17 + 6.1 · x, R² = 0.677
y = 18 + 5.4 · x, R² = 0.468
y = 10 + 12 · x, R² = 0.783

Chemical properties (pH, CEC and N concentration)




Vista, 210
y = 2.3 + 4.7 · x, R² = 0.779
Musick, 1384
y = 5.4 + 2.7 · x, R² = 0.956
Shaver, 1737
y = 0.97 + 2.9 · x, R² = 0.781
Sirretta, 2317
y = 1.7 + 2 · x, R² = 0.873
Chiquito, 2865
y = 1.1 + 0.89 · x, R² = 0.438
CEC (meq/100g)
C concentration (%)



Vista, 210
Musick, 1384
Shaver, 1737
Sirretta, 2317
Chiquito, 2865
y = 0.045 + 0.086 · x, R² = 0.892
y = 0.069 + 0.036 · x, R² = 0.832
y = 0.041 + 0.042 · x, R² = 0.935
y = 0.047 + 0.029 · x, R² = 0.861
y = 0.05 + 0.04 · x, R² = 0.872
N concentration (%)
C concentration (%)

Appendix IV: XRD mineral proportion table

Basic soil minerals groups identified from XRD diagram and their relative amounts (nd means not detected)

Mineral	Relative amount at temperatures (Rietveld, %)					
	25	150	250	450	550	650
Vista						
Amphibole	0.9	0.7	1.5	0.9	11.3	2.2
Feldspar	6.7	4.4	2.4	5.3	0.2	5.7
Kaolinite	3.3	1.2	2	3.3	nd	nd
Mica/ Illite	16.1	16.4	22.2	16.9	15.1	14.5
Phyllosilicate	0.2	0.7	0.3	nd	nd	nd
Plagioclase	42.5	43.2	46.6	43.8	42	48.5
Quartz	30.4	33.4	25.1	29.8	31.4	29.1
Musick						
Amphibole	0.8	1.1	0.9	1.9	0.1	3.8
Feldspar	12.2	17	11.1	13.7	15.1	16.5
Kaolinite	19.1	19.5	17.9	10.2	nd	nd
Mica/ Illite	26.4	20.9	23.3	22.5	20.7	21.4
Phyllosilicate	0.4	0.3	0.3	0.3	nd	nd
Plagioclase	7.4	9.2	7.6	13	9.7	10.2
Quartz	33.7	32	38.9	38.4	54.5	48.1
Shaver						
Amphibole	6.5	8.1	6.7	5.7	6.1	8.7
Feldspar	13.2	13.3	12.6	6.1	16.4	16.8
Gibbsite	1.3	nd	nd	nd	nd	nd
Kaolinite	6.6	9.1	6.7	5.2	nd	nd
Mica/ Illite	25.7	20.8	22.4	37.7	20.1	22
Phyllosilicate	0.6	0.9	0.1	nd	nd	nd
Plagioclase	22.7	22.2	20.6	21.7	22.6	24.6
Quartz	23.4	25.7	30.8	23.6	34.8	27.8
Sirretta						
Amphibole	0.7	1.2	0.6	1.2	3.5	6
Feldspar	14.3	11.7	13.2	14	14.6	15.8
Gibbsite	0.5	0.7	nd	nd	nd	nd
Kaolinite	nd	nd	nd	nd	nd	nd
Mica/ Illite	17.8	21.4	30.8	20.9	18	14.7
Phyllosilicate	0.2	0.3	0.2	nd	nd	nd
Plagioclase	29	28.9	24.7	24.3	30.5	28.6

Mineral	Relative amount at temperatures (Rietveld, %)					
	25	150	250	450	550	650
Quartz	37.4	35.7	30.4	39	33.5	34.9
Chiquito						
Amphibole	3.1	1.7	2.4	3.2	1.7	3.7
Feldspar	10.4	14.3	15.2	15.8	14.3	13
Mica/ Illite	33.7	21.4	18.6	10.1	20	14.6
Phyllosilicate	0.2	0.3	0.3	1.1	0.2	0.1
Plagioclase	30.9	35	38.7	40.5	37.5	40
Quartz	21.4	27.3	24.8	29.3	26.3	28.6