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The main chemical, rare earth and trace elements and minerals formation of mountain soil as an indicator of source and treatment pedogenetic in the Palestinian mountain soil

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“The main chemical, rare earth and trace elements and minerals formation of mountain soil as an indicator of source and treatment pedogenetic in the Palestinian mountain soil”

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1438/2017

Dedication:

"To Our Profit Mohammad (Peace be upon him)"

To my family

To my friends

To you

Declaration

I Certify that this thesis submitted for the degree of Master of Science is the result of my own research, except where otherwise acknowledged, and that this thesis (or any part of the same) has not been submitted for a higher degree to any other university or institution.

Signed:

Mahmoud Salahdeen Zaid

Date: / / 2017

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Abstract

The purpose of this study was to explore the pedogenesis processes and to examine the source (parent material) of Mediterranean mountain soil; especially Terra Rossa, Rendzina and other associated soils through chemical (major, trace and Rare Earth Elements (REEs)), grain size and mineralogical compositions. Forty soil samples were collected form 13 pedons from different areas in Palestine that represent different soil types, lithology, elevation and precipitation along a climatic transect to demonstrate variability between south, north sections and west east transects. The north section around Nablus consists of: western and eastern transect. The western one in turn consists of Qusin pedon which was Terra Rossa, and Bait Eba pedon which was Rendzina. While the eastern one in turn consists of Tubas pedon which was Rendzina, and Tayaseer pedon which was Terra Rossa. The south section, which was Bethlehem and Jerusalem mountains, consists of: western and eastern transect, the western one in turn consists of Battir1, Battir2 and AlQbu, which is Karstic, pedons which were Terra Rossa, while Ishwa and Ishwa (the road) pedons which were Rendzina soil. In other hand, the eastern one in turn consists of Teqo’a east and Teqo’a west pedons which were Terra Rossa, While Beit Sahour and Bayth Ta'amar pedons which were Rendzina. Two dust samples from Al-Quds University and seven rock samples from different pedons were collected also. From grain size, chemical compositions (major, trace and REEs), and mineralogical compositions results, dust was found to be the dominant parent material in studied soils.

Leaching was dependent on rainfall amount and bedrock and soil permeability. Ca, Sr and U elements leached more than these trace elements Fe, K, Mg, Na, Al, Ba, Co, Cr, Cu, Mn, Ni, Rb, Sb, V, Zn and Zr and REEs. Some Terra Rossa samples were alike Typical Terra Rossa but with relatively high calcite content but mineralogical and chemical characteristics were similar to Pale Rendzina as in Qusin pedon. On the other hand, Brown Rendzina resembles Typical Terra Rossa as in Beit Sahour and Bayth Ta'amar pedons. The east transect samples leached less than the western, but the difference in leaching was low.

Battir 2 profile has two soil layers deep layer, layers were composed of one on top of the other

Dust samples were polluted with these trace elements Al, Cu, Pb, Sb and Zn, and this may be due to industrial or construction sources. Vanadium element found to be affected by rain and this is similar to Aluminum which considered to be well retained in soil.

A baseline of grain size, major and trace elements, REEs and minerals was added to soil science in Palestine in general and Mediterranean virgin mountain soil (Terra Rossa and Rendzina).

التركيب الكيميائي (العناصر الرئيسة والنزرة والترابية النادرة) والمعدني للتربة الجبلية في منطقة البحر المتوسط كمؤشر لمصادر التربة وتكونها(pedogenetic) في فلسطين

اعداد: محمود صلاح الدين زيد

المشرف: الاستاذ الدكتور معتز علي قطب

الملخص

الغرض من هذه الدراسة هو دراسة عمليات تكون التربة ودراسة مصدرها (المادة الأم) في التربة الجبلية لمنطقة البحر الأبيض المتوسط وخاصة التربة الحمراء (Terra Rossa)،والتربة البنية (Rendzina) وغيرها من التربة المرتبطة بهذة التربة. عن طريق دراسة التركيب الكيميائية (العناصر الرئيسية ، والعناصر النزرة العناصر الترابية النادرة(REEs))، وحجم حبات التراب والتراكيب المعدنية للتربة. تم اخذ أربعين عينة من عينات من التربة في 13 موضع (pedons) في مناطق مختلفة في فلسطين التي تمثل مختلف نوعي التربة ، والخصائص الصخرية، والارتفاع وهطول الأمطار على طول القطع المناخية لإظهار التباين بين الجنوب والشمال والمقاطع العرضية شرقا وغربا. القسم الشمالي حول نابلس يحتوي على: القطاع الغربي من القسم الشمالي قوصين وهي تربة حمراء (Terra Rossa)، وبيت إيبا وهي تربة بنية (Rendzina) . بينما كان القطاع الشرقي من القسم الشمالي ممثلا في طوباس وهي تربة البنية (Rendzina)، وتياسير وهي تربة الحمراء (Terra Rossa). اما القسم الجنوب، الذي كان في جبال القدس وبيت لحم ويشمل على: القطاع الغربي بتير 1، بتير 2 والقبو- وهي تربة كارستية- تربة حمراء (Terra Rossa)، في حين إشوع وإشوع (الشارع) وهي من التربة البنية (Rendzina). في جهة أخرى القطاع الشرقي من الجزء الجنوبي ممثلا في طقوع الشرق و طقوع الغرب وهي من التربة الحمراء(Terra Rossa) ، بينما بيت ساحور وبيت تعمر هي من التربة البنية (Rendzina).اضافة الى ذلك تم جمع عينتين من الغبار وتم أخذ سبعة عينات الصخور من مختلف العينات.

من خلال حجم حبات التراب، والتراكيب الكيميائية (العناصر الرئيسية ، والعناصر النزرة العناصر الترابية النادرة(REEs)) والتراكيب المعدنية ، وجد ان الغبار هو المصدر الاهم و المادة الأم المسيطرة في التربة التي تم دراستها مقارنة مع الصخور.

كان غسل التربة او الرشح (Leaching) يعتمد على كمية الأمطار ونفاذية التربة وكانت بعض العناصر كانت أكثر رشحا(كالكالسيوم والاسترنتيوم واليورانيوم) بينما عناصر (كالحديد والبوتاسيوم والمغنيسيوم والصوديوم والالمنيوم والباريوم والكوبالت والنحاس والمنغنيز والنيكل والروبيديوم والأنتيمون والفاناديوم والزنك والزركون والعناصر الأرضية النادرة) ترشح بكمية اقل او تبقى في التربة وقتا اكثر.

بعض عينات التربة الحمراء (Terra Rossa) تبدو مثل تربة حمراء معتادة ولكن تحتوي نسبة اكبر نسبيا من الكالسيت بحيث تكون الخصائص المعدنية والكيميائية مماثلة للتربة البنية (Rendzina) كما هو الحال في

عينات قوصين. من ناحية أخرى، التربة البني الغامق (Brown Rendzina) يشبه التربة الحمراء المعتادة كما هو الحال في تربة موقع بيت ساحور وبيت تعمر وهي بعيدة عن التربة البني الفاتح (Pale Rendzina).

كان المقطع الترابي في موقع بتير 2 اكثر من طبقة من التراب, بحيث تكونت طبقة عميقة قديمة واخرى سطحية اقل عمرا. كما تعرضت عينات الغبار للتلوث في بعض العناصر ، مثل الابمنيوم والنحاس والرصاص والزنك والأنتيمون ، وربما يرجع ذلك إلى الصناعة او الحفر.

يتأثر الفاناديوم بالامطار وكانه مماثل لالمنيوم بحيث يحفظ بشكل جيد في التربة. كما كانت التربة في القطع الشرقي أقل رشح من القطع الغربي ولكن الفرق في الترشيح ليس بكل كبير.

بما انه علم التربة وتكونها في فلسطين في بدايته فان هذه الدراسة تساعد في اضافة اساسا للتربة الحمراء والبنية الجبلية المتوسطية الطبيعية في فلسطين.

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Chapter One:

Introduction

Soil is the surface layer of the earth's crust. It is a mixture of mineral particles, organic matter, water, air and living organisms. Soil formation is a relatively slow process, therefore soil can be considered essentially as a non-renewable resource. Soils have horizons, roughly parallel to the earth's surface, that indicate the degree to which materials have been altered and redistributed by gravity, organisms and water. Individual soils occupy distinct places in the landscape.

Soil develops when there is a continuous and effective interaction between atmosphere, biosphere, lithosphere and hydrosphere (Fig. 1.1). The pore space between the soil particles is either filled by water (hydrosphere) or by air (atmosphere), while particles consist of minerals and other nonliving components (lithosphere), and living organisms (biosphere). Soil is a foundation for life in earthly ecosystems and affects the energy budget, water exchange, and nutrient cycling and ecosystem productivity (Ugolini and Spaltenstein, 1992).

The science of pedology deals with the formation of soils, their physical, chemical and biological composition, their classification and distribution (Bridges, 1997). Soil formation is a complex processthat occurs on mineral or organic substrates (parent materials) that are either in place or have been displaced from their source of origin, like dust (Ficklin, 2008).

Soil formation and weathering are affected by the following factors (Fig 1.2): Climate, Topography, Biotic Activity, Parent Material and Time. (Hans, 1941).

The current study investigates the composition and formation of soils from local parent materials derived from bedrock and from dust.

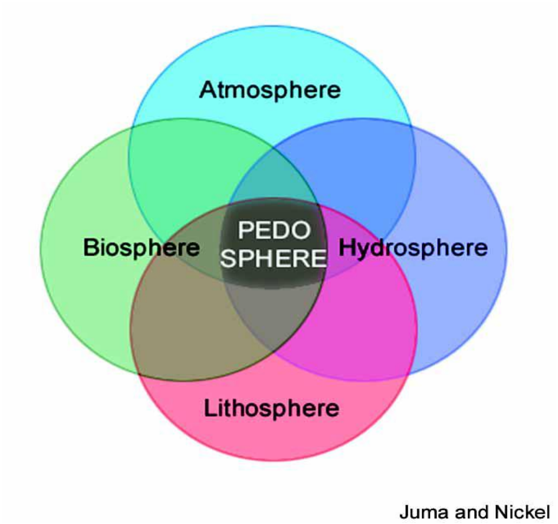


Figure 0.1 The relationships between pedosphere, atmosphere, hydrosphere, lithosphere and biosphere

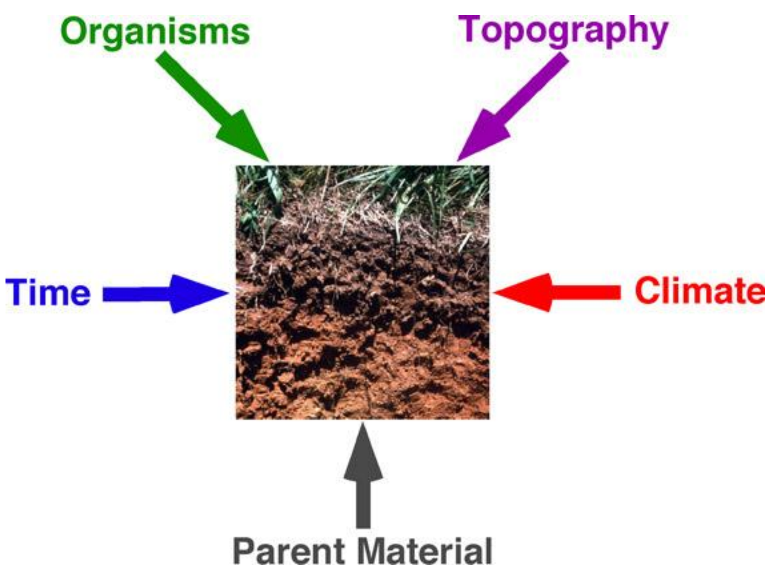


Figure 0.2 Factors affecting soil formation

1.1 Soil types in Palestine

The soil types in Palestine, which is a part of the Levant, are affected by a diversity of factors. The parent material in this area derives from both bedrock and dust. Recent studies expect that more than 50% of soils in the region derive from dust (Sandler, 2013).

Three different climate regimes occur in Palestine: Mediterranean climate in the center of the area, semi-arid (steppe climate) and arid climates in the south of this area. Humans have been intervening with the landscape and affect soil since thousands of years before Present (Yaalon, 1997).

The main soil types in Palestine are: lithosols and desert soils, terra rossa, Pale Rendzina, Brown Rendzina and grumusol (vertisol) (Fig. 1.3). Terra Rossa are developed on hard calcareous rocks, mainly limestone, dolomite, while Rendzina types are developed on soft calcareous rocks, mainly chalk, chert, and calcrete. (Reifenberg, 1947).

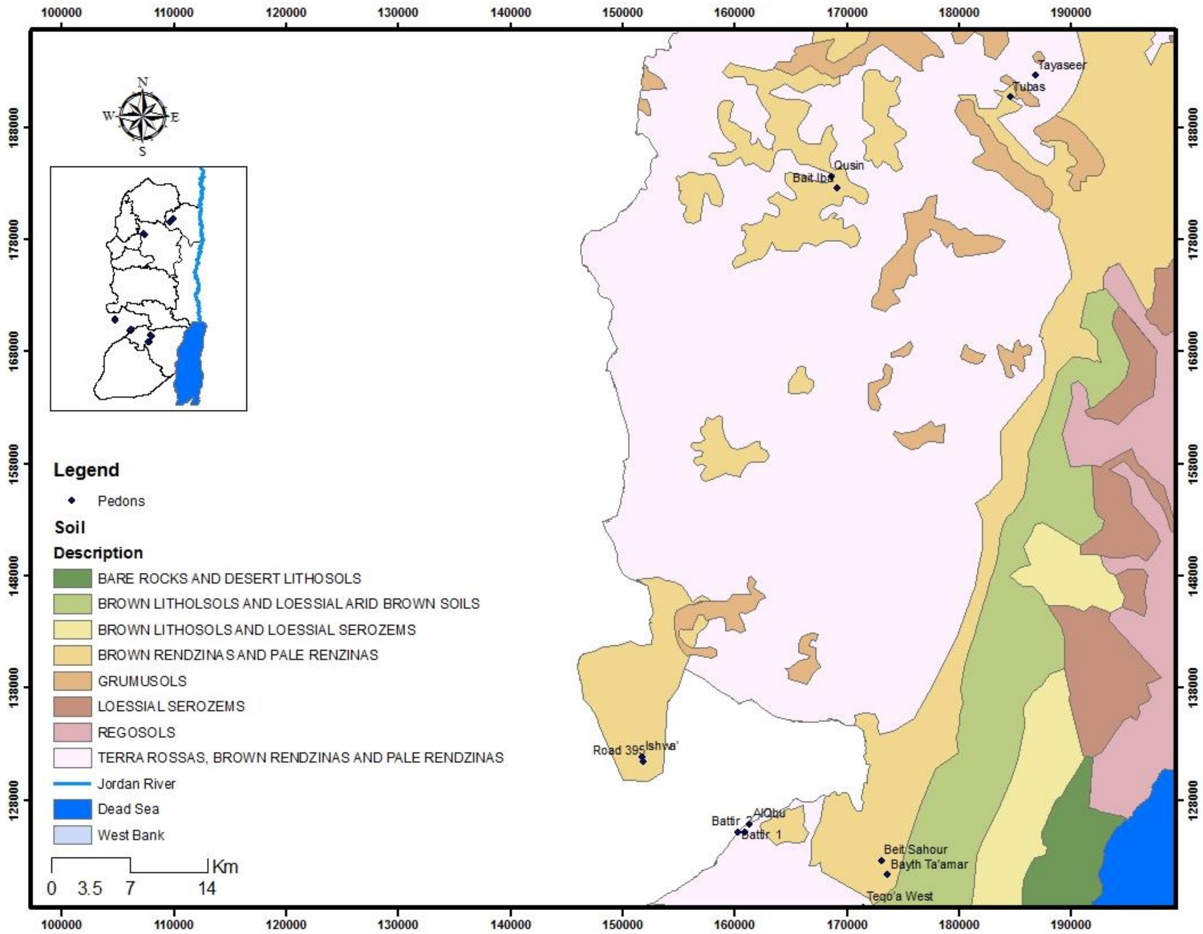


Figure 0.3 Soil types in study area. (Created in GIS Lab by Husam Utair)

1.2 Soil types in the mountains of the Palestine

Most Typical soils in the mountains are Terra Rossa and Rendzina soil, which develop under Mediterranean climate.

1.2.1 Terra Rossa

Terra Rossa soil is heavy and clay-rich, with silty-clay to clayey texture, and strong reddish color. The bedrock of Terra Rossa is mainly hard dolomite and limestone rocks. Terra Rossa is a local name for Rhodustalfs (Bronger, 1997).

Many theories had explained the formation of Terra Rossa in Mediterranean area. The most accepted theory was derivation from the insoluble residue of the underlying limestone during the dissolution of carbonate minerals by rain. Limestone sediments contained clay with other insoluble substances or rock fragments, forming discontinuous residual layers variable in depth. Iron oxide, which produces the characteristic red color under oxidizing conditions. Moreover, formation of the Mediterranean Terra Rossa is closely related to the properties of the limestone substrate (Muhs, 2010).

1.2.2 Rendzina

Pale Rendzina is a grayish to Brown soil. It usually forms by weathering of soft calcareous rock as soft dolomite, chalk and marl. Brown (Dark) Rendzina forms on calcrete (locally called Nari), which mostly develops on chalk, but also on chert. It is one of the soils most closely associated with the bedrock type and is an example of initial stages of soil development. (Avery, 1980)

1.3 Dust in the Middle East region

The Levant is influenced by many dust storms each year. In spring, this region is influenced by Khamaseen storms; Khamaseen is an Arabic word means fifty. Dust storms are repeated several times during a period of around 50 days. Khamaseen can be triggered by cyclones that move eastwards along the southern parts of the Mediterranean or along the North African coast from February to June (Fig.1.4) (Pye, 1992).

When a storm passes over an area, lasting several hours, it carries large quantities of sand and dust from the deserts with approximately speed 140 kilometers per hour, and the humidity may drop below 5%. (Avila et al., 1997).

Only in Sahara, millions of tons of dust were gone out annually. 260 million tons per year of dust were gone westward to the Atlantic Ocean, some of it reached America's coasts. Eastward, about 100 million tons yearly from Algeria, Western Sahara, Morocco, Libya, and western Egypt reach the eastern Mediterranean region (Bergametti et al., 1989; Ganor et al., 1991).

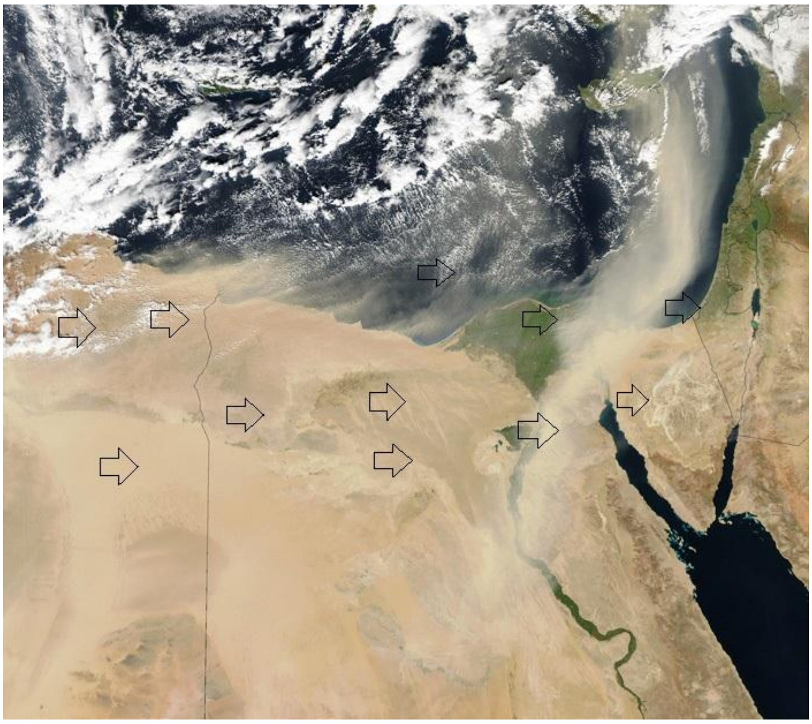


Figure 0.4 Khamaseen dust storm from Sahara toward the Levant

Dust is one of soil sources in Levant (Engelstaedter et al., 2006). The Levant is also influenced by dust storms from the Arabian Desert (Fig. 1.5). Palestine was influenced by dust from southern sites too.

Palestine was influenced by ten dust storms events in the fifties of the last century; but the events increased to nineteen in the nineties of the same century (Ganor and Foner, 1996). Another source of dust, but not frequent, is from the north (Syria and Iraq), as the dust storm in September, 2015.

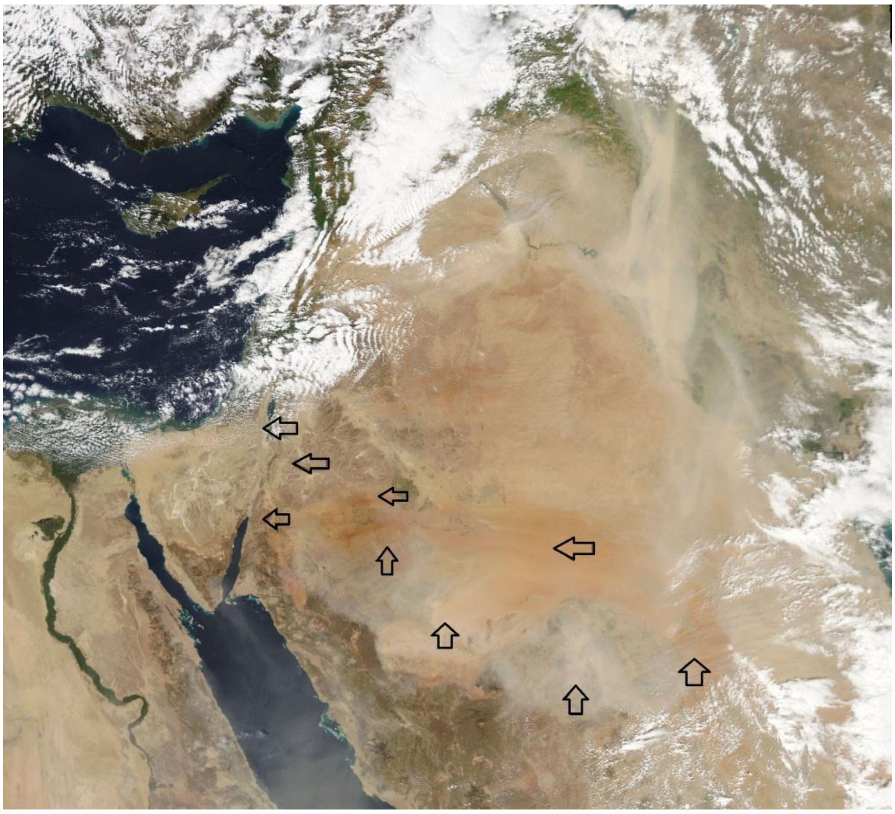


Figure 0.5 Dust storm from Arabian Peninsula toward the Levant

1.4 Soil color

Soil color is one of soil obvious properties that can be used to describe horizonation and soil morphology. Over 170 different soil colors were officially recognized. Most of these are brown, red, black, gray and white. The soil color does not affect the behavior of the soils, but provides insights into environmental conditions, formation processes, and other influences on the soil (Brady, 2006).

Soil color is affected by the parent material, soil mineralogy, chemical and biological weathering and redox reactions. The primary minerals in soil parent material weather, some elements combine into new and colorful compounds. It is an indicator of the composition of the soil and gives evidence to the conditions that the soil has been subjected to (Muhs, 2010).

Top soil is generally darker than the subsoil due to organic matter from the surface (Brady, 2006).

1.5 Soil pH

Soil pH generally ranges from an extremely acidic pH of 3 to a very alkaline pH of 10, but mostly between 5.5 and 8.5 (Perry,2016). The pH of a soil will change over time influenced by factors including current parent material, climate, vegetation and agricultural practices. Some rocks and sediments produce soils that are more acidic than others: quartz-rich sandstone is acidic; limestone is alkaline. Some types of vegetation, particularly conifers, produce organic acids, which lower soil pH values. (Peech, M., 1948)

1.6 Soil mineralogy

Minerals are generally compose 40-50 % of a soil, along organic matter and amorphous material. Soil is formed by the process of weathering of rocks, which has great variability in its mineralogical and chemical compositions. Therefore, it is expected that soil properties are also bound to the chemical variability of its constituents. (Berkowitz et al. 2008)

Primary minerals are those which are not altered chemically since the time of formation and deposition. This group includes quartz (SiO_2), alkali-feldspars (Na, K) $AlSi_3O_8$, micas (muscovite, biotite), amphibole, etc. Secondary minerals are formed by the decomposition and chemical alteration of primary minerals.

1.7 Soil grain size and texture

Soil texture is the size of the particles that make up the soil, using the terms sand, silt, and clay. Texture is generally used to reference the proportions of sand, silt, and clay. The particle sizes in each of these three soil fractions range between specific limits. The distinctions among the size groups are more or less arbitrary. They have been arrived at after many trials in developing classes that can be used consistently, conveniently, and best describe the nature of the separates. (Ficklin, 2008). It is highly correlated with a range of soil chemical and physical properties. Fine textured soils with high clay contents generally have higher nutrient and water holding capacities than do coarse textured soils. Fine textured soils often do not have good drainage

Maintaining good soil structure is important for plant growth. Texture can change over a period of only a couple of hundred years or so, but structure can change rapidly, especially through management practices.

1.8 Chemical composition:

1.8.1 Major elements:

Major elements are rock-forming elements Ca, Fe, K, Mg, Na, Al, and Si minor elements are Mn, P, S, and Ti. Typically, major and minor element concentrations are presented in weight percents of their oxides.

1.8.2

The trace elements Typically studied are Ag, Al, As, Ba, Ca, Cd, Co, Cr, Cu, Fe, Hg, K, Mg, Mn, Na, Ni, P, Pb, Sb, Se, Si, Sr, Th, Ti, V, and Zn. These elements are usually described in terms of their total content and availability.

Trace elements retention in soil is dependent on several soil characteristics that include pH, cation exchange capacity (CEC), particle size distribution, organic matter content, and oxide content. These characteristics cause trace elements to either accumulate in the soil, or leave the soil for other components of the environment. When parent materials have high trace element concentrations, the soils that develop over them have high or even higher trace element concentrations. Concentrations of trace elements in soil are important to soil scientists not only for environmental purposes, such as quantifying contamination, but also to help solve problems associated with human and plant toxicity.

The effects of soil characteristics on trace element concentrations in soils have been studied by many soil scientists and have been reviewed by Adriano (1986). Soil pedologists can perform predictive modeling of soil formation using trace element concentrations in soil and parent material. By comparing the soil and parent material data, using a normalization element, overall soil loss or soil formation can be assessed. Certain elements are enriched during the weathering of parent material and soil formation, while other elements are lost (Middelburg et al., 1988).

1.8.3 Rare Earth Elements

Rare Earth Elements (REEs) are members of the group IIIB in the periodic table and defined as the 14 naturally-occurring elements of the lanthanide series. Therefore, their use as proxies progressively developed in different disciplines of earth sciences, such as hydrology, geochemistry or geology, notably to trace origin and processes. REEs occur in more than 200 minerals distributed in a wide variety of mineral classes, thus in most primary and secondary minerals in soils. (Bockheim and Gennadiyev, 2000)

The large variations of total REE contents in soils are highly dependent on the types of soil and of parent material from which they are issued. Other REE sources in soils are atmospheric depositions (atmospheric particles, rainwater and snow) and anthropogenic (waste samples, irrigation and sewage waters, and especially fertilizers). (Bockheim and Gennadiyev, 2000)

1.9 Total organic carbon:

Total organic carbon (TOC) is the carbon that stored in soil from organic matter source. The organic carbon enters the soil by decomposition of plant and animal residues, root exudates, living and dead microorganisms, and soil biota.

1.10 Geology

The rock formations of the study area range in age from Cretaceous to Tertiary, consisting mainly of marine carbonate rocks as limestone, dolomite, chalk and marl, frequently interspersed with chert. (Fig. 1.6). The formations are named according to Palestinian terminology (Sameer Shadeed, 2008).

Ramali Formation of Lower Cretaceous age consists mainly of sandstone Cretaceous. It is more calcareous at the top than the bottom and contains bands of marl and limestone.

Cenomanian-Turonian formations of Upper Cretaceous age consists mainly of Cretaceous rocks. It is mainly consist of dolomite and limestone, with some marl and chalk layers and chert. The Upper Cretaceous rock sequence is divided into: Lower Beit Kahil Formation forms the lower part of the Lower Cenomanian. It consists of grey marly and dolomitic limestone. And Upper Beit Kahil formation forms the upper part of the Lower Cenomanian. It consists of dolomitic and sometimes chalky and marly limestone. This formation has a small outcrop area because of its steep dips. The top of the formation is more massive, exhibiting karstic features.

Yatta formation of the lower part of the Middle Cenomanian age exposed as a sequence of marl, chalky limestone, clay and thin interceded dolomitic limestone.

Hebron formation of the upper part of the Middle Cenomanian period composed mainly of limestone and dolomitic limestone. Sometimes, chalky bands and chert nodules exist.

Bethlehem formation of Upper Cenomanian age consists mainly of dolomite, limestone, chalk and marl while at the top it becomes hard, coarse crystalline dolomite.

Jerusalem formation of the Turonian period consists mainly of massive limestone and dolomite and sometimes chalky and silicified limestone.

Abu Dies Formation of Senonian to Palaeocene period contains Chalk is the major component of this formation. It sometimes has interceded silicified limestone, hard phosphoric limestone, marl, chert, and shales.

Jenin Subseries of Eocene period consists mainly of chalk. It five faces of limestone and chalk are described: chalk with minor chert, chalk with inter-bedded limestone, limestone with minor chalk, massive limestone and reef limestone.

Alluvium formation of Pliocene period consists of unconsolidated, laminated marl with some siliceous sand known as alluvium rocks. It has a red color and fine texture which is due to its derivation from limestone (Rofe and Raffety, 1965).

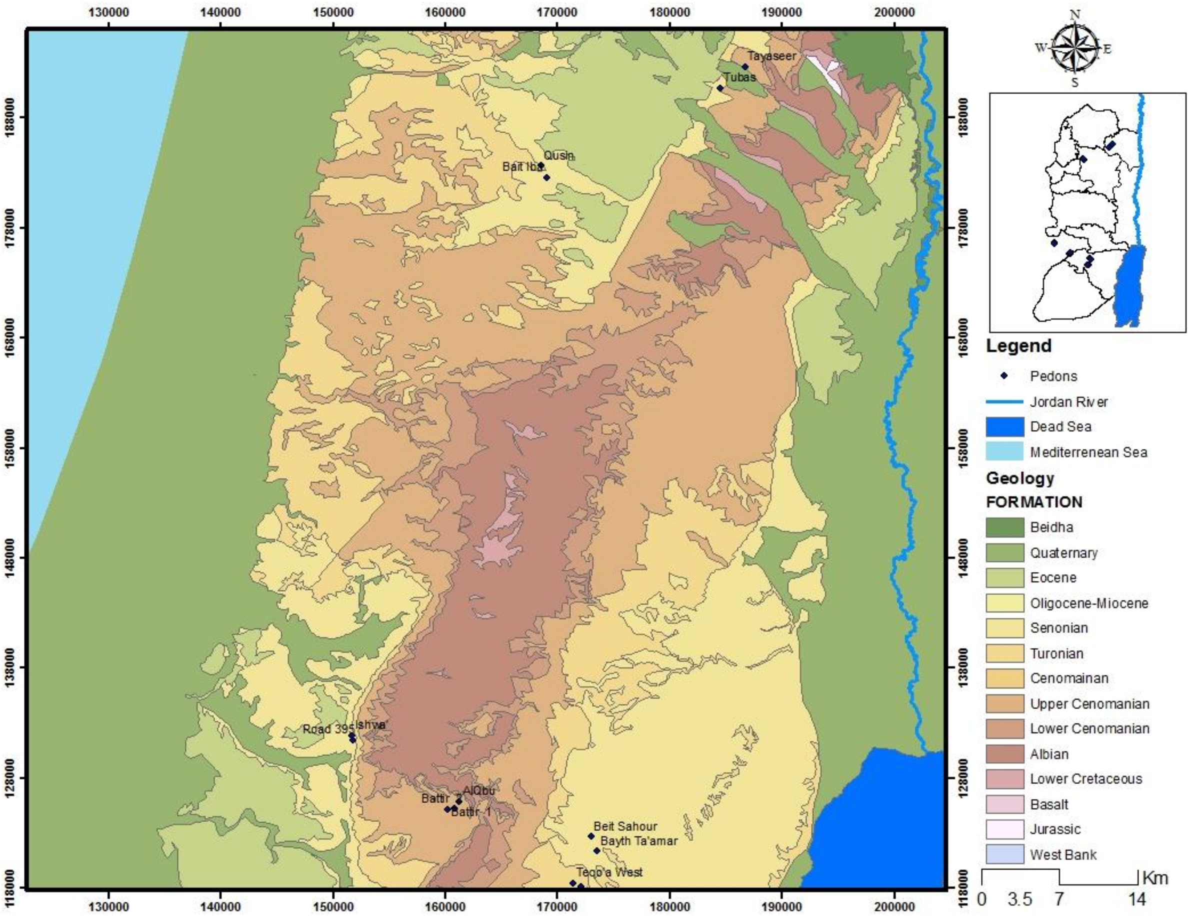


Figure 0.6 A Geologic map of the study site (Created in GIS Lab by Husam Utair)

Research Goals

The goal of this study is to know the sources of Palestinian mountains soils and their pedogenic processes according to their chemical major, rare and trace elements and mineral composition, along with other parameters as pH, color and grain size.

Main objective

1. Quantitative analysis of various elements and minerals in some mountain soil from the Palestinian region.
2. Studying the leaching of elements from the selected soil samples.
3. Make a base study of chemical major, rare and trace elements for Palestinian mountain soil.
4. Determine the parent material for Palestinian soil.
5. Understanding the pedogenic processes of Palestinian mountain soil.
6. Adding essential knowledge on trace elements, including REE, about the Palestinian soil.

Chapter Two:

Literature review

Soil science in Palestine is only in its first steps; there is almost very little information about this science. There is no study on soil sources and pedogenetic processing in Palestine, except a few studies which studied the soil types and soil sorting.

The first soil survey of the country was made in 1927-28 by Strahorn. He surveyed almost 4.9 million dunams of the lowlands of Palestine. Strahorn used the American system of soil series as the primary unit for soil classification and for mapping purposes. Twenty-six soil series were defined and given the geographical names of the first place where they were identified.

Reifenberg and Whittles (1947) studied in details the chemical properties of most soil types occurring in Palestine, and compared their composition to that of subjacent rocks. The soils were classified according to the identified climatic regions. In combination with the parent material, he considered climate as the dominant factor in the differentiation of the soils, and there were grouped into 4 climatic zones, which are differentiated by specific rainfall conditions.

(Dan et al. 1962) described the soils of Palestine and mapped them on the basis of soil associations. A map having a scale of 1:250,000 was published. The soil associations on the map were defined as geographical associations of the listed soil units. There are 17 soil associations included in the map. They are divided into two major groups: those of subdued mountains and agricultural areas. According to this study, the soil associations which are existing in the West Bank and Gaza are: Terra Rossa, Brown and Pale Rendzina, bare rock and desert lithosols, grumosols, dark brown, sandy regosols and arid brown, sand dunes, and calcareous serozem soils, which are loess and/or loess like soils.

(Amiel 1965) described the soils in the southwestern heights of the West Bank (southern Shfela) and those of the coastal plain, which include also the Gaza Strip.

Early studies in these area considered Terra Rossa as a residual product of the bedrock (Reifenberg, 1947; Gal, 1974), while other studies recognized and emphasized the significant contribution of dust (Yaalon and Ganor, 1973). Based on clay-to-silt ratios in dust and on the insoluble fraction of limestone in soils, the dust contribution to Terra Rossa soils was estimated as one-third to two-fifths (Yaalon and Ganor, 1973). By comparing rates of dust accretion to hard limestone dissolution it was estimated that eolian material makes up to 50% of the fine fraction in soils on hard limestone rocks (Yaalon, 1997).

Several works were carried out in nearby countries. Singer et al. (2003) studied the amount and composition of the dust particles that deposited over the Dead Sea during the period 1997–1999. Ganor and Foner (1996) identified that the annual amount of the Saharan dust that leaves North Africa towards the East Mediterranean region is w100 million tons, and that the number of dust storms in the area west of the Dead Sea has increased from 10 events per year in 1958 to 19 events per year in 1991. Kubilay and Saydam (2001) studied the major and trace element geochemistry of the dust in the southeast and northeast of the Eastern Mediterranean, respectively. Both studies identified the enrichment of certain elements such as Cd, Pb, Cu, and Zn due to human activities.

Geographers, by emphasizing the distinctiveness of the Mediterranean climatic type have associated it with a specific soil type, and thereby developed a myth of Red Mediterranean Soils (or Terra Rossa) as the dominant type, which is not really substantiated in surveys (Eswaran et al., 1997). The region is probably more diverse in soils than other climatic regions (Ibanez et al., 1995). Therefore, it is worthwhile to review the distinctiveness of soils in the Mediterranean region, which I shall do briefly in the following sections.

Chapter Three:

Location and study area

The selected sampled sites represent south-north and west-east sections to follow possible differences that originate by location as annual precipitation and distance from dust sources. The north section was taken in the Nablus area from Bait Iba, Qusin Tubas and Tayaseer. The south section was taken in the Jerusalem area from Ishwa’, Battir, AlQbu, Bait sahour and Tequa. In the eastern side of both sections the precipitation was less than the western side of the section (Fig.3.1).

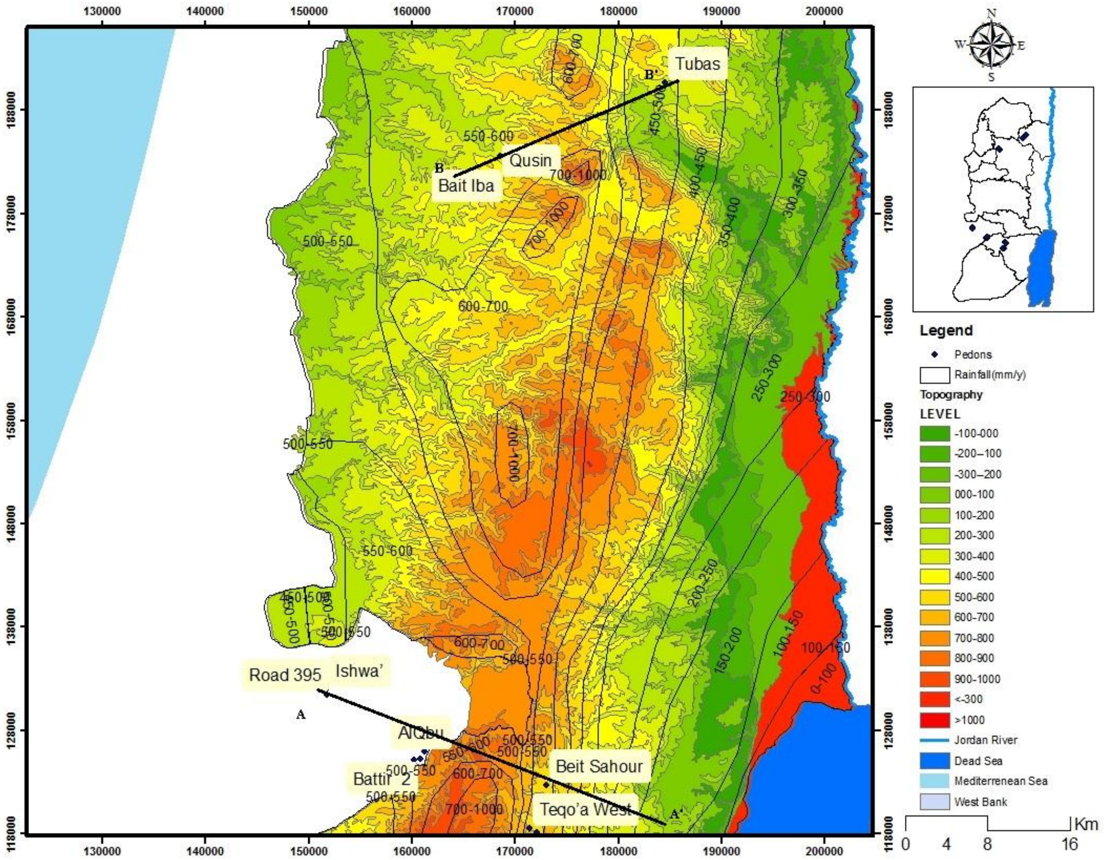


Figure 00.1 Topographical and precipitation map. (Created in GIS Lab by Husam Utair)
Pedons and cross sections was located.

1.11 Southern section

Jerusalem-Bethlehem section was between Ishwa' village in the west and Teko'a village in the east (Fig.3.2). Terra rossa, Pale Rendzina soil types were sampled in both sides, whereas dark Rendzina was sampled in the east.

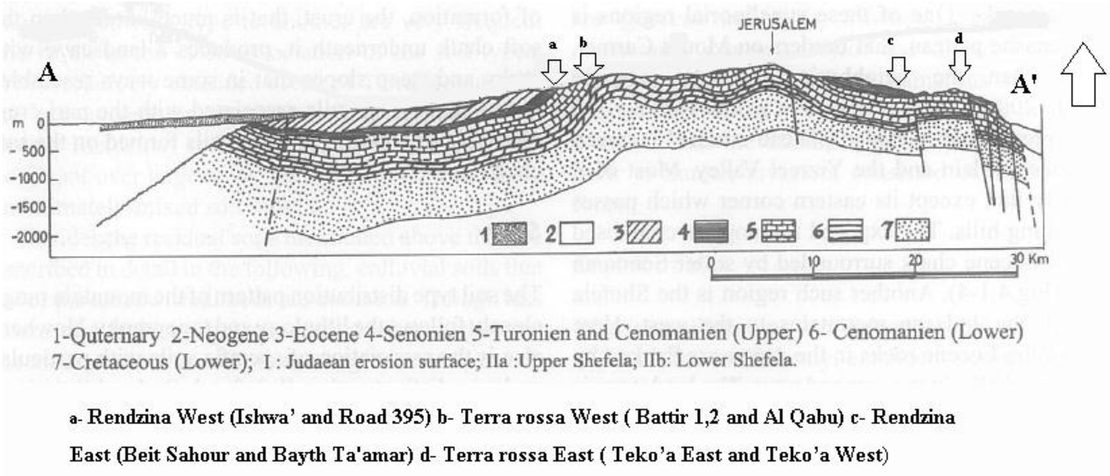


Figure 0.2 A scematic geological cross section that includes the southern section studied (after Singer, 2007)

1.11.1 Terra Rossa west

Variable occurrences of apparently well-developed Terra Rossa in a region of relatively high mean annual precipitation (590 mm) and intensive karstic processes within the substrate rocks was Terra Rossa west. Three pedons were sampled: Battir 1, Battir 2 and Al Qabu.

1.11.1.1 **Battir 1**

Battir (N699654.56, E3511155.68) is 756 m above sea level. The vegetation was mixed: Cypress and pine trees along with seasonal plants and grasses.
The brown-reddish soil was generally shallow and well-leached, which was defined as Terra Rossa. It formed on dolomite rocks of the Bethlehem Formation and filled karst depressions. The depressions walls are coated by pedogenic calcite. Pedogenic calcite is also observed as white lamina filling semi-horizontal cracks in the dolomitic rock. The sampled soil profile, which is 170 cm thick within a depression, was exposed by a road-cut (Fig. 3.3.A). The soil texture is granular all along. An A1 horizon is darker due to higher content of organic matter and is 15 cm thick. It gradually changes to the lower A2 horizon (Fig. 3.3.B). Five samples were taken from this pedon (Table 3.1).

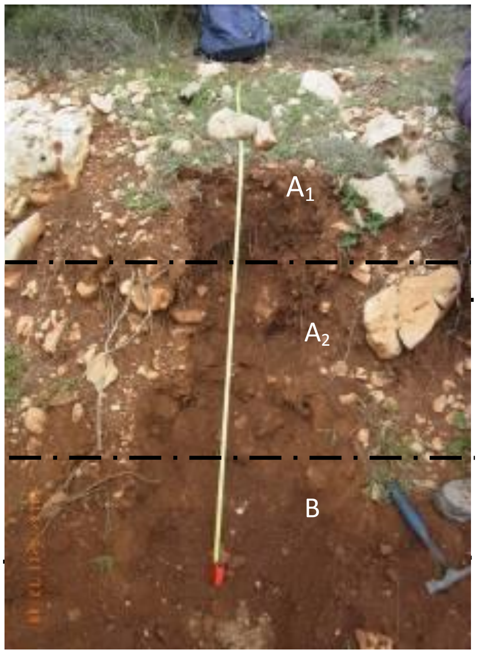


Figure 00.3 Battir1 pedon A. A general view of the sampling site a road-cut B. Soil profile in Battir1 which show the deferent horizon.

A karstic depression, a few meters away from profile 1 displays weathering of dolostone into fine-sand dolomitic grains, associated with the karst activity. The fifth sample was taken from the bottom of that depression.

Table 0.1 Five samples from Battir1 pedon

Horizon	Depth (cm)	Description	Sample Name
O	5	Leaves, pine needles and roots	------------------
A_1	30	Brown/red soil, granular structure, small rock fragments, gradual transition, some roots.	JS-4 Depth: 0-15cm
	80	Soil from the bottom of the fracture depression, red soil, granular structure, small rock fragments, some roots.	JS-3 Depth: 65-80 cm
A_2	120	red soil, granular structure, small rock fragments	JS-2 Depth: 95-110 cm
A_3	180	red soil, granular structure, small rock fragments	JS-1 Depth:160-175cm
B	>180	Soil from the bottom of the karstic depression	JS-5 Depth :~180 cm

1.11.1.2 Battir 2

Battir 2 (N700310.64, E3511220.15) is located about 50 m from the Battir1 profile at about 750 m above sea level. The vegetation was mainly Cypress and Pine trees and some seasonal grasses (Fig. 3.4).

The soil pedon is similar to that Battir 1. The soil fills a ~150 cm karst depression in dolomite of the Bethlehem Formation. The soil profile consisted of A1 horizon (10 uppermost cm), A2 horizon (upper 100 cm, lighter color, stony) and B horizon (the lower part, darker soil with more clays). Four samples were taken from this pedon (Table. 3.2)

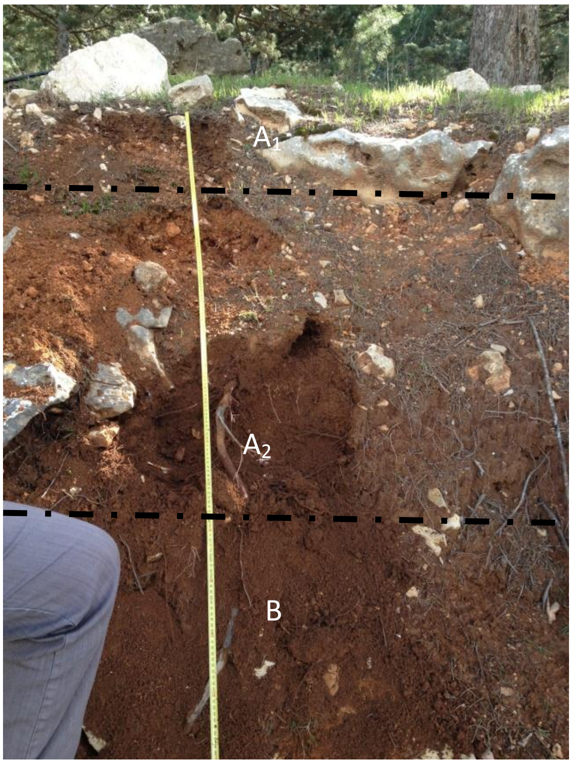


Figure 00.4 A soil profile in Battir2 pedon which show the deferent horizons

Table 0.2 Four samples from Battir2 pedon

Horizon	Depth (cm)	Description	Sample Name
O	5	Leaves, pine needles and roots	------------------
A	20	Brown/red soil, granular structure, small rock fragments, gradual transition, some roots.	JS-9 Depth: 0-15cm
	50	Soil from the bottom of the fracture depression, red soil, granular structure, small rock fragments, some roots.	JS-8 Depth: 30-45cm
A2	120	red soil, granular structure, small rock fragments	JS-7 Depth:80-95cm
B	150	red soil, granular structure, small rock fragments	JS-6 Depth:135 -150cm

1.11.1.3 Al Qabu (Karstic field)

A few hundred meters from Battir1 pedon, at similar elevation and precipitation, AlQabu (N700704.4 , E3511935.8), shallow brown-reddish soil form on the limestone member of the generally dolomitic Bethlehem Formation. The color of the soils are more reddish. The limestone terrain is highly karstic and locally the outer parts of the limestone are friable due to weathering. The exceptional karstic topography includes pinnacles of up to 3 m high. The vegetation is a pine forest with some seasonal plants and grasses (Fig. 3.5).

The soils are topped by a 5-10 cm thick O horizon, mostly pine needles. Three profiles were sampled (Table. 3.3).

Table 0.3 Samples from Al Qabu pedon

Horizon	Depth (cm)	Description	Sample Name
O	5	Leaves, pine needles and roots	------------------
Topsoil	30	Dark Brown/red soil, granular structure, small rock fragments, gradual transition, some roots, pine needles	JS-11 Depth:0-15 cm
Subsoil	50	Brown/red soil, granular structure, small rock fragments, gradual transition, some roots, pine needles	JS-10 Depth:30-45cm
O	5	Leaves, pine needles and roots	------------------
Topsoil	25	Brown/red soil, granular structure, small rock fragments, gradual transition, some roots, pine needles	JS-13 Depth: 0-15cm
Subsoil	40	Brown/red soil, granular structure, small rock fragments, gradual transition, some roots, pine needles	JS-12 Depth: 25-40cm
O	5	Leaves, pine needles and roots	------------------
Topsoil	15	Brown/red soil, granular structure, small rock fragments, gradual transition, some roots, pine needles	JS-14 Depth: 0-15cm

Figure 00.5 AlQabu pedons A. AlQabu I: JS-10 and JS-11 samples B. AlQabu II: JS-12 and JS-13 samples C. AlQabu III: JS-14

1.11.2 Pale Rendzina west

Pale Rendzina soils were sampled on the western flank of Jerusalem Bethlehem Mountains. The sampled sites receive mean annual precipitation of 550 mm.

1.11.2.1 Ishwa'

Ishwa' (N691007.27, E3517733.33) is Pale Rendzina, 283 m above sea level, is filling shallow depressions on weathered calcrete (Nari). A thicker soil profile fills a deeper depression above broken calcrete. The calcrete is overlying chalk of the Santonian Abu Dis Formation. The vegetation is mixed: seasonal grasses and plants, pine, oak, and cherub trees. The soil profile consists of A and AR horizons as in (Fig. 3.6) and (Table 3.4).

Figure 00.6 A. Ishwa' profile, which show the different horizons

Table 0.4 Soil profile and samples

Horizon	Depth (cm)	Description	Sample Name
O	5	Leaves, pine needles and roots	-----------------
A	40	Dark brown, granular structure, rock (calcrete) fragments, roots, gradual transition to AR horizon.	JS-26 Depth: 0-15 cm
AR	70	Dark brown, granular structure, large rock fragments, roots, gradual transition	JS-27 Depth: 40-55 cm
R		Calcrete	JS-28

1.11.2.2 Ishwa' (The Road)

Ishwa' (The road) (N691089.45, E3517286.79) isPale Rendzina, 334 m above sea level, is developed on talus that covers a slope built of chalk of the Santonian Abu Dis Formation. The talus consists mainly of chalk with some chert fragments. No Calcrete is developed here. The vegetation is seasonal grass, pine and oak trees.

The soil profile described in (Table 3.5) and (Fig. 3.7).

Figure 00.7. Road profile which shows the horizons

Table0.5. Soil profile and samples in Ishwa' (Road) pedon

Horizon	Depth (cm)	Description	Sample Name
O	5	Leaves, pine needles and roots	-----------------
A	35	Pale brown, granular structure, small rock fragments, gradual transition, some roots.	JS-30 Depth: 0-15cm
	70	Pale brown, granular structure, rock fragments,	JS-31 Depth: 35-50 cm
R		Chalk	JS-29

1.11.3 Brown and Pale Rendzina east

Brown and Pale Rendzina soils were sampled on the eastern flank of the Jerusalem-Bethlehem Mts., where mean annual precipitation is ~400 mm, less than on the western flank.

1.11.3.1 Beit Sahour

Beit Sahour (N712513.02, E3508923.92) is Shallow Brown Rendzina, 570 above sea level, is filling local depressions on weathered calcrete (Nari). The calcrete, ~0.5m thick, is overlying chert of the Campanian Abu Dis Formation (Fig. 3.8.A). The seasonal vegetation is short grass and some scattered plants.

The soil profile consists of A and AR horizons as described in Fig.4.8 and Table. 4.6.

Figure 0.8. Bait Sahour pedon A.The calcrete on top of chert and chalk rocks around sampling location B. A general view of the sampling site. C. Beit Sahour profile. Measuring tape’s length is 0.41 m

Table 0.6 Soil profile and samples in Beit Sahour pedon

Horizon	Depth (cm)	Description	Sample Name
O	5	Leaves, pine needles roots	________
A	20	Color: dark brown, granular structure, no .gradual transition ,rock fragments	JS-16 Depth:0-15cm
A	40	rock ,color: dark brown, granular structure fragments, sharp transition	JS-15 Depth:25-40cm
A		Calcrete fragment in AR	JS-17
R		Calcrete	JS-18

1.11.3.2 Bayth Ta'amar

Bayth Ta’amar (N713083.31, E3507639.42) is a road-cut along street, which is 512 m above sea level, exposes a 60 cm soil profile; that fills a local karstic depression in weathered calcrete (Nari). The calcrete is capping chalk of the Santonian Abu Dis Formation. The soil is Brown colluvial soil and is mostly 0 – 0.3 m thick. The vegetation is seasonal: short grass and some scattered plants.

The soil profile consists of horizons A1, A2 and R, described in (Fig.3.9) and (Table 3.7).

Figure 0.9 Bayth Ta'amar pedon A. The sampled soil profile that fills a local karstic depression in weathered calcrete . B. profile which show the horizons

Table 0.7 Soil profile and samples Bayth Ta'amar pedon

Horizon	Depth (cm)	Description	Sample Name
O	5	Leaves, pine needles and roots	________
A2	25	Brown, granular structure, no rock fragments, gradual transition.	JS-20 Depth:0-15 cm
A1	60	Brown, granular structure, no rock fragments, gradual transition.	JS-19 Depth:30-45 cm
R		Calcrete on chalk	

1.11.4 Terra Rossa east

1.11.4.1 Teko’a East

Teko’a East (N711696.8 , E3504339.86) is a shallow brown-red Terra Rossa, 645 m above sea level, is developed on dolomite of the Turonian Jerusalem Formation**.** The soil profile is 0.35m thick and consists of A horizon, as described in (Fig.3.10) and (Table 3.8). Vegetation is mainly seasonal Graminae.

Figure 0.10. The sampled soil profile in Teko’a East. Measuring tape is 0.35 m

Table 0.8 Soil profile and samples in Teko’a East

Horizon	Depth (cm)	Description	Sample Name
O	5	leaves and pine needles and roots	--------------
A_1	15	color red , bed rock dolomite	JS-22 Depth:0-15 cm
A_2	40	color red , bed rock dolomite	JS-21 Depth:20-35 cm

1.11.4.2 Teko’a West

Teko’a West (N711018.29, E3504708.57) is 600 m above sea level, is 0.5 m thick (bedrock not reached) and consists of O, A1 and A2 horizons, as described in (Fig.3.11) and (Table 3.9) . Vegetation is a mixture of dwarf shrubs, seasonal plants and recently planted pines.

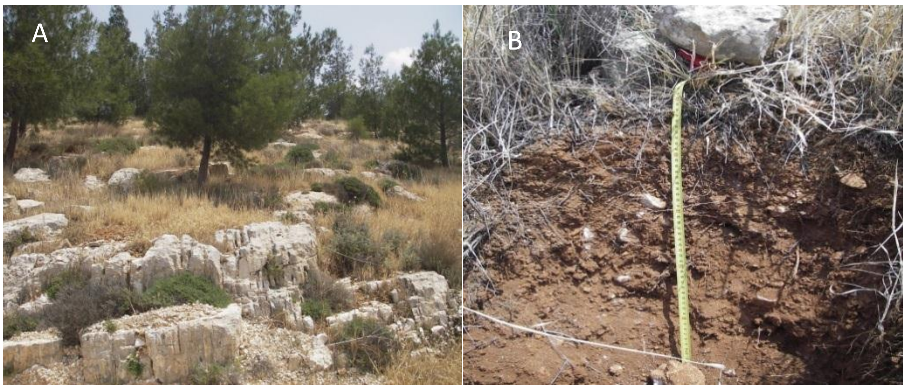


Figure 00.11. Teko’a West pedon A. the limestone rocks, and view on this pedon B.The sampled soil profile and horizons.

Table 0.9 Soil profile and samples in Teko’a West pedon

Horizon	Depth (cm)	Description	Sample Name
O	5	Leaves, pine needles and roots	--------------
A1	10	color brown-red soil	JS-23 Depth:0-10 cm
	25	color brown-red soil	JS-24 Depth:15-25 cm
A2	45	color brown-red soil	JS-25 Depth:25-45 cm

1.12 Northern section

Brown and Pale Rendzina and Terra Rossa soils on the western and eastern flanks of the Nablus Mountains section (Fig.3.12). The region receives mean annual precipitation of 550 mm in the west and 400 mm in the east.

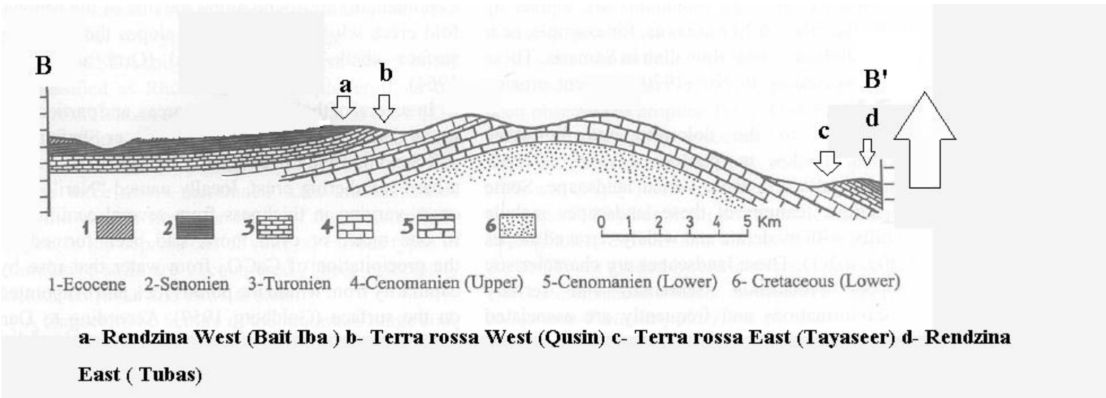


Figure 00.12. A scematic geological cross section that includes the northern section studied (after singer, 2007)

1.12.1 Rendzina wast (Bait Iba)

Bait Iba (N707322, E3568748) is Pale Rendzina, 390 m above sea level, is developed on talus that covers a slope built of chalk of the Santonian Abu Dis Formation. The talus consists mainly of chalk with some chert fragments. The vegetation is seasonal grass, and Prickly Shrubby Burnet. The topograghy slope is steep on the east-west flake in Bait Iba. The profile was sampled in an agriculture area that has not been cultivated for many years. The profile is not disturbed and the horizons are distinctive. There are some roots.

The soil profile consists of A, B and C horizons (Fig.3.13) and (Table 3.10).

Figure0.13 Bait Iba pedon A. the area of Bait Iba pedon and the vegetation B. Bait Iba profile and horizons

Table 0.10 Soil profile and samples in Bait Iba pedon

Horizon	Depth (cm)	Description	Sample Name
O	5	Leaves, pine needles and roots	--------- -----
A	40	Pale brown, granular structure, roots, gradual transition to B horizon.	JS-32 0-15 cm
B	80	Brown, granular structure, large rock fragments, gradual transition	JS-33 40-55 cm
	110	Brown, granular structure, large rock fragments, gradual transition	JS-34 77-100 cm
R		Chalk	JS-35

1.12.2 Terra Rossa west (Qusin)

Qusin (N706773, E3569815) is Shallow reddish-Brown Terra Rossa, 320 m above sea level, developed on limestone of the Jerusalem Formation. The vegetation is seasonal grass and Prickly Shrubby Burnet. There are some roots. A wide fracture is filled with thicker soil.

The soil profile consists just of A horizon (Fig. 3.14) and (Table 3.11).

Figure 00.14 Qusin pedon A. over view of Qusin pedon B. Qusin profile

Table 0.11 Soil profile and samples

Horizon	Depth (cm)	Description	Sample Name
O	5	Leaves, pine needles and roots	--------------
A	30	Brown/red soil, granular structure, small rock fragments, gradual transition, some roots. Soil from the bottom of the fracture depression	JS-36 0-15cm
	70	Brown/red soil, granular structure, small rock fragments, gradual transition, some roots.	JS-37 Depth: 40-55 cm
	120	Soil from the bottom of the fraction depression	JS-38 Depth: 80-100 cm
R		Limestone	JS-39

1.12.3 Terra Rossa east (Tayaseer)

Tayaseer (N724781, E3579177) is Shallow and well- leached reddish-Brown Terra Rossa, 358 m above sea level, is developed on dolomite of the Jerusalem Formation. The vegetation is seasonal grass, and Prickly Shrubby Burnet. There some roots

The soil profile consists of just A horizon (Fig.3.15) and (Table 3.12).

Figure 0.15 Tayaseer pedon A. A general view of the sampling area and sampling B. Tayaseer profile

Table 0.12 Soil profiles and samples in Tayaseer pedons

Horizon	Depth (cm)	Description	Sample Name
O	5	Leaves, pine needles and roots	--------------
A	30	Red soil, granular structure, small rock fragments, gradual transition, some roots.	JS-40 Depth: 0-15cm
R		Limestone	JS-41
A	30	Soil from the bottom of the fraction depression	JS-42 Depth: 0-15 cm
	70	Soil from the bottom of the fraction depression	JS-43 Depth: 35-50 cm

1.12.4 Rendzina east (Tubas)

Tubas (N722646, E3577195) is Pale Rendzina, 260 m above sea level, is developed on talus that covers a slope built of chalk of the Santonian Abu Dis Formation. The talus consists mainly of chalk with some chert fragments. No Nari is developed here. The vegetation is seasonal grass. There are some roots. The soil profile consists of A and B horizons (Fig.3.16) and (Table 3.13).

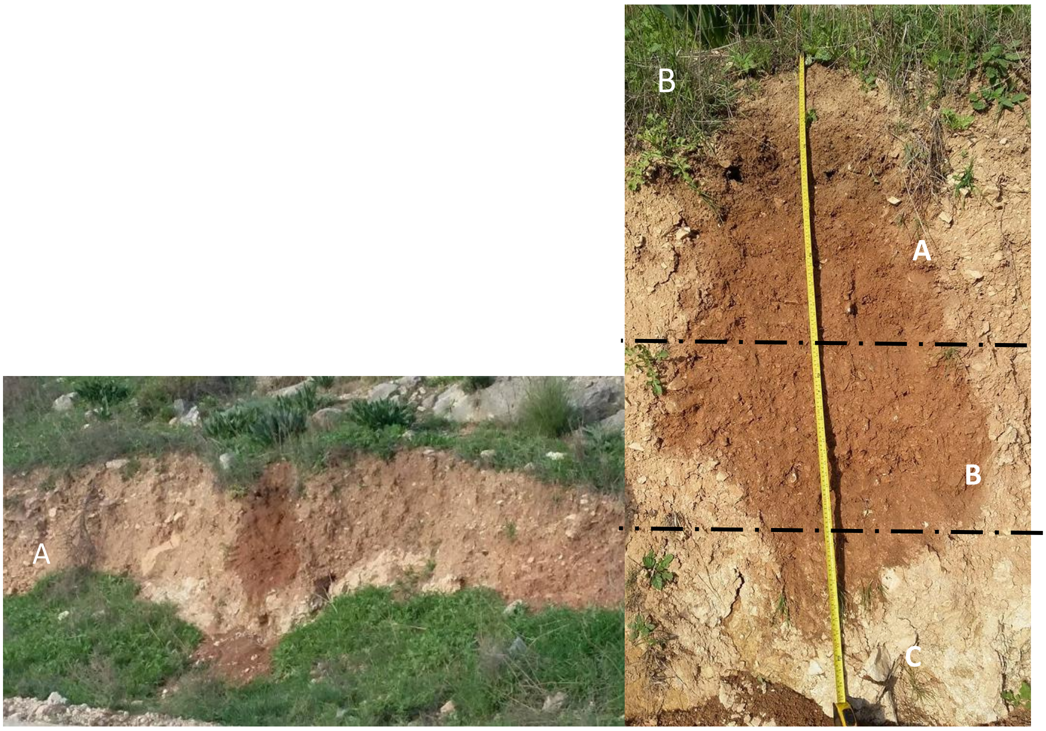


Figure 0.16 A. over view of Tubas pedon B. Tubas profile and horizon

Table 0.13 Soil profile and samples in Tubas pedon

Horizon	Depth (cm)	Description	Sample Name
O	5	Leaves, pine needles and roots	--------------
A	30	Pale brown, granular structure, roots, gradual transition to B horizon.	JS-44 0-15 cm
B	70	Brown, granular structure, large rock fragments, gradual transition	JS-45 35-50 cm
	100	Brown, granular structure, large rock fragments, gradual transition	JS-46 75-90 cm
	140	Brown, granular structure, large rock fragments, gradual transition	JS-47 110-125 cm
R		Chalk	JS-48

Chapter Four:

Sampling and Methodology

1.13 Sampling and processing

40 soil samples, of ~2 kg weight each, were sampled in 13 pedons in different areas in Palestine. Soil pedons were selected to represent different soil types and lithology along a climatic transect and to demonstrate variability between south and north.

The pedons and soil samples represent two type of soil which was Terra Rossa and Rendzina in different precipitation with the same elevation and lithology in both transects of each section.

Table 0.1 The reasons of choice each pedon

site Name	The reasons of choice each pedon
Battir 1	Terra Rossa in higher rainfall in south section over dolomite rock
Battir 2	Terra Rossa in higher rainfall in south section over limestone rock
AlQbu	Terra Rossa in higher rainfall in south section over karstic rock
Ishwa'	Rendzina in higher rainfall in south section over calcrete rock
Road 395	Rendzina in less rainfall in south section over calcrete rock
Beit Sahour	Rendzina in less rainfall in south section over chert rock
Bayth Ta'amar	Rendzina in less rainfall in south section over calcrete rock
Teqo'a East	Terra Rossa in less rainfall in south section over dolomit rock
Teqo'a West	Terra Rossa in less rainfall in south over section limestone rock
Bait Iba	Rendzina in higher rainfall in north section over chert rock
Qusin	Terra Rossa in higher rainfall in north section over limestone
Tayaseer	Terra Rossa in less rainfall in north section over limestone
Tubas	Rendzina in less rainfall in north section over limestone

The north section around Nablus contains: western transect of the northern section is Qusin pedon is in Terra Rossa soil, limestone rock and Bait Eba pedon is in Rendzina soil, chert rock. While the eastern transect of northern section is Tubas pedon is in Rendzina soil, chert rock; and Tayaseer pedon is in Terra Rossa soil, dolomite rock. The south section, which is Bethlehem and Jerusalem, contains: the western transect of southern section is Battir1, Battir2 and AlQbu, which is Karstic, pedons are in Terra Rossa soil, limestone and dolomite rocks; While Ishwa and Ishwa (the road) pedons are in Rendzina soil, chert and Calcrete rocks which are in western transect. In other hand the eastern transect of southern section is Teqo'a east and Teqo'a west pedons are in Terra Rossa soil, limestone rock. While Beit Sahour and Bayth Ta'amar pedons are in Rendzina soil and colluvial soil, chert and Calcrete rocks (Table 4.1).

The elevation is between 260 m above sea level (asl) in Tubas to 757 m above sea level (asl) in Battir. While the mean annual precipitation is ~400 mm in the eastern transect of both sections; and 550-600 mm in the western transect of both sections.

In most sites, the sampling included top-soil and sub-soil, where as in some sites only top soil was sampled. Bedrock was sampled as stones within a profile in some samples and from the bedrock in the bottom of the soil profile in other samples.

Soil samples were dried in the laboratory at 50°C until they reached constant weight. The samples were disaggregated and split to two portions. One portion was discarded and the other one was sieved to pass a 2 mm sieve. An aliquot was analyzed for grain size, pH, and water saturation. Another aliquot of about 20 gr was ground by a mullite grinding machine (Fig. 4.1) and was used for mineralogical total organic carbon (TOC) and chemical analyses.

Settled dust (2 samples) was collected in plastic trays covered with three layers of glass marbles (Fig.4.2), on the roof of College of Science and Technology building in AlQuds University. The dust samples were collected in November 2015 and in March 2016.

After the soil samples were sieved to pass a 2 mm sieve, each sample was taken parts: One part for pH, Water absorption, color analysis; other for TOC analysis; other for grain size analysis; and last one for mineralogy analysis, chemical composition (Fig.4.3).

Table 0.2 Soil pedons in southern and northern sections in Palestine

Location	Samples Name	Horizon	Elevation	Soil Type	Formation	Lithology	MAP (mm)
Battir 1	JS-4	Ah	756m	Terra Rossa	Bethlehem	Dolomite	590 mm
	JS-3	A					
	JS-2	A					
	JS-1	A					
	JS-5	B					
Battir 2	JS-9	Ah	750m	Terra Rossa	Bethlehem	Limestone	590 mm
	JS-8	A					
	JS-7	A					
	JS-6	B					
AlQbu (Karstic)	JS-11	Topsoil	750m	Terra Rossa	Bethlehem	Karstic	590 mm
	JS-10	Subsoil					
	JS-13	Topsoil					
	JS-12	Subsoil					
	JS-14						
Ishwa	JS-26	Topsoil	283 m	Rendzina	Abu Dis	Calcrete	550 mm
	JS-27	Subsoil					
	JS-28	Rock					
Ishwa (main road)	JS-29	Rock	283 m	Rendzina	Abu Dis	Chert	540 mm
	JS-30	Topsoil					
	JS-31	Subsoil					
Beit Sahour	JS-16	Topsoil	570m	Rendzina	Abu Dis	Chert	400 mm
	JS-15	Subsoil					
	JS-17	Rock					
	JS-18	Rock					
Bayth Ta'amar	JS-19	Topsoil	512 m	colluvial	Jerusalem	Calcrete	400 mm
	JS-20	Subsoil					
Teqo'a East	JS-21	Topsoil	645 m	Terra Rossa	Jerusalem	Dolomite	400 mm
	JS-22	Subsoil					
Teqo'a West	JS-23	Topsoil	600 m	Terra Rossa	Jerusalem	Limestone	400 mm
	JS-24						
	JS-25	Subsoil					
Bait Iba	JS-32	A	390 m	Rendzina	Abu Dis	Chert	550 mm
	JS-33	Ah					
	JS-34	B					
	JS-35	rock					
Qusin	JS-36	Topsoil	320 m	Terra Rossa	Jerusalem	Limestone	550 mm
	JS-37	Subsoil					
	JS-38	fraction					
	JS-39	rock					
Tayaseer	JS-40	Topsoil	358 m	Terra Rossa	Jerusalem	Dolomite	400 mm
	JS-41	Topsoil					
	JS-42	Subsoil					
	JS-43	rock					
Tubas	JS-44	A	260 m	Rendzina	Abu Dis	Chert	400 mm
	JS-45	B					
	JS-46						
	JS-47						
	JS-48	Rock					

Figure 00.1 mullite grinding machine

Figure 0.2 A. Dust sample preparing B. three layers of glass marbles in a plastic trays

Rocks and dust samples were analyzed for just mineralogical and chemical compositions.

Figure 00.3 Preparing samples for analysis

1.14 Grain size

An aliquot of a few grams of each sample was taken for grain size analysis. Organic carbon was removed by H_2O_2 at 60°C, followed by a low-intensity ultrasonic treatment for a few minutes. This procedure was repeated three times and the samples were washed. A few samples were measured two times: with organic carbon and without organic carbon. The samples were analyzed by (AS-2011 Laser Particle Size Analyzer) (Fig. 4.4) that utilizes diffraction patterns of a laser beam passed through the sample ranging from 100 nanometers to 2 millimeters (Wayne, 2000). Laser diffraction analysis is based on the Fraunhofer diffraction theory, stating that the intensity of light scattered by a particle is directly proportional to the particle size (Mudroch, 1997).

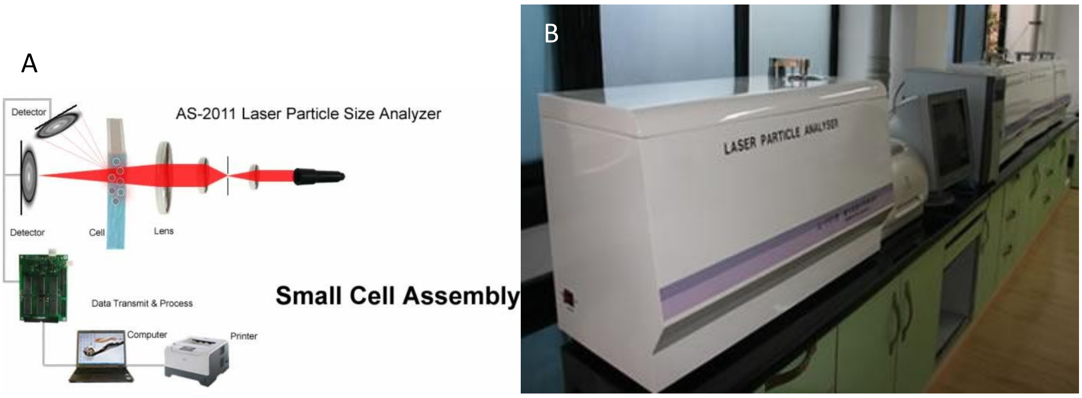


Figure 0.4 A. Laser Particle Size Analyzer Work principle B. Laser Particle Size Analyzer machine

1.15 Water saturation and pH

A 30 g of each sample was put in a beaker. Distilled water was gradually added to soil sample and carefully stirred by a glass rod until surface glistens. Each sample was monitored for a few minutes to see if the water remained on the surface. It was left for an hour and checked again to check if glistening disappeared and addition of water is needed (Fig. 4.5.A). Then the beaker was weighted and the difference was calculated; in other hand water saturation in soil range between 0 to 1.

Some distilled water was added to the saturated paste to make the ratio between soil and water 1:1. After magnetically stirring the paste for about an hour pH was measured (Multimeter WTW 2F40110/ pH electrode) (Fig. 4.5. B) (Pawar D. R., 2009).

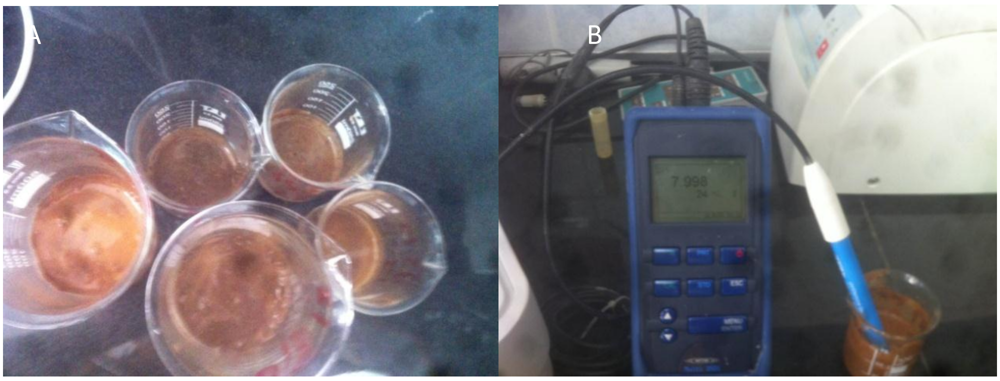


Figure 4. 0.5 A. water saturation test B. pH test by Multimeter

1.16 Color

Color was defined by the Munsell color system (Fig. 4.6), which is a color space that specifies colors based on three color dimensions: hue, value, and chroma. Munsell divides hues into five principal: Red, Yellow, Green, Blue, and Purple, along with 5 intermediate hues. Color charts conventionally specify 40 hues, in increments of 2.5, progressing as 10R to 2.5YR; which R is red and Y yellow. (Cleland, 1921) The color value vertically extends from black (value 0) at the bottom, to white (value 10) at the top. Chroma represents the purity of a color. Munsell noted that there is no intrinsic upper limit to chroma. For instance, light yellow colors have considerably more potential chroma than light purples (Cleland, 1921). Soil color Ranges between 10 YR 1/1 to 5Y 8/8

Figure 04.0.6 Color test by the Munsell system

1.17 TOC

Determination of soil organic carbon is based on the Walkley-Black chromic acid wet oxidation method. Oxidable matter is oxidised by 1 N $K_2Cr_2O_7$ solution. The reaction is assisted by the heat generated when two volumes of H_2SO_4 are mixed with one volume of the dichromate. Potassium dichromate $K_2Cr_2O_2$ and concentrated H_2SO_4 are added to between 0.5 g and 1 g of soil. The remaining dichromate is titrated with ferrous sulfate. The final result g/g ratio this what called the Walkley-Black procedure (ASTM. 2000) (Walkley and Black, 1934)

1.18 Mineralogy

A ground sample was side-loaded into standard aluminum holder and was scanned by a PANALYTICAL X'Pert^3 Powder diffractometer equipped with a PIXcel detector (Fig. 4.7).

Scanning range: 3 – 70° 2θ, step size 0.013°, speed 70.1 s per step. Each sample was loaded and analyzed twice: 1. with an automated divergence slit that kept length of radiated area at 8 mm. This condition enabled a better precision and detection of more low-amount phases; 2. with a fixed divergence slit. This traditional condition enabled a semi-quantitative estimation of mineralogical composition by the use of the known factors practiced in the XRD lab. Cupper lab use to make X ray source, the result as in (Fig. 4.8)

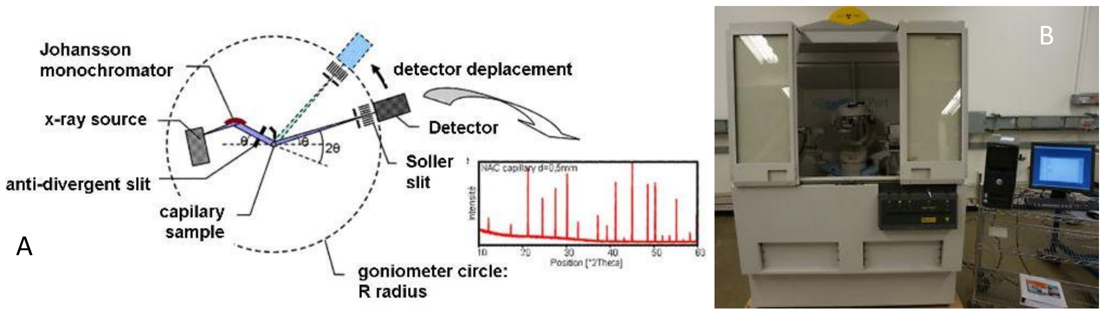


Figure 4.0.7 PANALYTICAL X'Pert3 Powder diffractometer

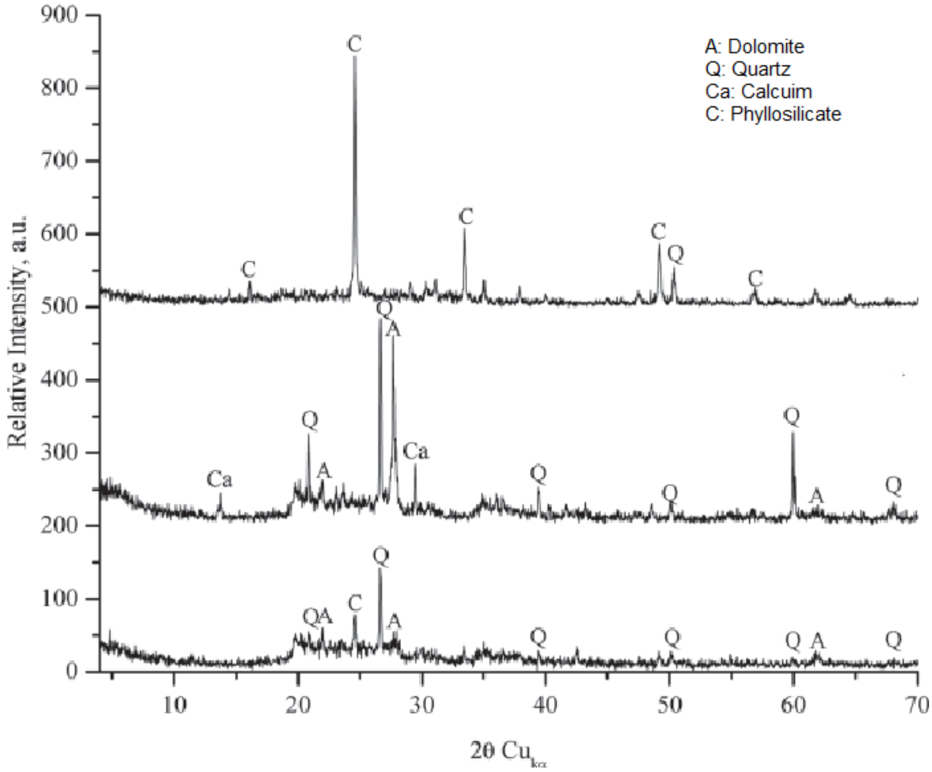


Figure 0.8 X-ray diffraction (XRD) patterns

1.19 Chemical composition

1.19.1 Major elements

Major elements, reported as oxides, and Sr, Ba and Sr were determined by inductively coupled plasma optical/atomic emission spectroscopy (ICP-OES) (Fig. 4.9). Emission spectroscopy uses the inductively coupled plasma to produce excited atoms and ions that emit electromagnetic radiation at wavelengths characteristic of a particular element. (Mermet, J. M. 2005). 1.25 g of Lithium metaborate (Li2B2O4) was added to 0.25 g of a sample. Each run included repeated determinations of two of the international standards SO-3, BE-N, BHVO-1, SCo-1, NIM-L, and NIM-G every ten samples (Mermet, J. M. 2005).

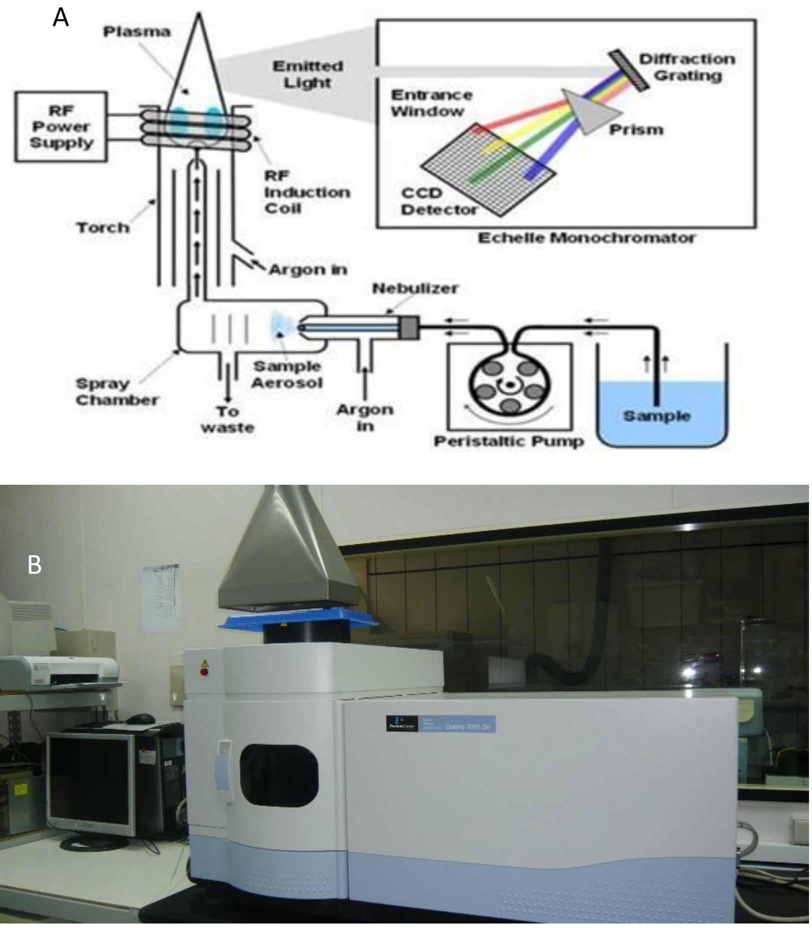


Figure 00.9 ICP-OES instrument

1.19.2 Trace elements

Trace elements, including REE were determined by inductively coupled plasma mass spectrometry (ICP-MS) (Fig. 4.10). This equation was used, $(mg/kg) = [(mg/L) \text{ X } (mL)] / [(kg) \text{ x } 1000]$, to change mg/L to mg/kg.

The sample is typically introduced as an aerosol, produced by passing the liquid sample through a simple pneumatic nebulizer. Larger aerosol droplets are removed from the gas stream by a spray chamber, and the remaining smaller droplets are swept into the central channel of the argon plasma.

500 mg of a sample is mixed with 2.0 g of Na_2O_2 (sodium peroxide) in zircon crucible and heated in a furnace at 500◦ C for 40 minutes. The hot crucible is put into a plastic beaker with distilled water. After cooling 20 ml HNO3 (3N) are added rapidly using a magnet stirrer until dissolution is completed. The solution is transformed into volumetric flask. (Hutting, G.F, 1943).

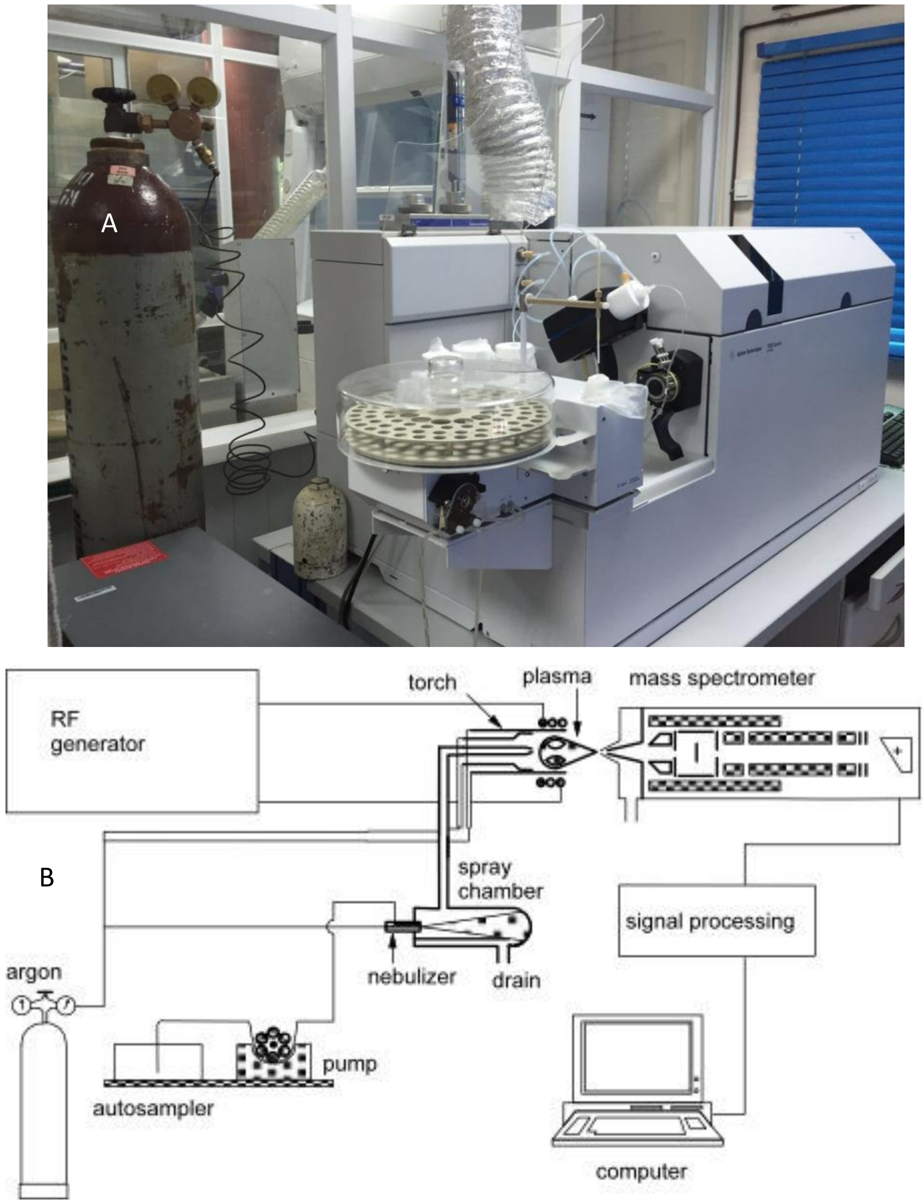


Figure 00.10 Inductively coupled plasma mass spectrometry (ICP-MS) machine

Chapter Five:

Results and interpretation

Through the sampling and by followed the methodology that described before. To achieve the objectives and the goal of this study; the following result was resulted.

1.20 Color, pH, Water absorption, and soil TOC

Color: The Terra Rossa soils Munsell colors were mostly from 5 YR 4/3 to 5 YR 5/8 and Rendzina soils were from 7.5YR 6/2 to 7.5YR 6/6. The hue of the Terra Rossa was 5 degrees of Yellow Red (5YR), while the value degrees (lightness) were from 3 to 6 and chroma degrees were from 3 to 8. The hue of the hue Rendzina soils was 7.5 degrees of Yellow Red (7.5YR) and value degrees from 4 to 7 with chroma degrees from 2 to 6 (Table 5.1).

This difference in color is mainly due to the mineralogical composition: Terra Rossa is enriched by iron minerals and depleted by calcite relative to Rendzina. This makes Terra Rossa color darker than Rendzina. Soil color is also affected by soil texture and grain size. Terra Rossa has more clay, while Rendzina has more silt, as described below. Soils color is affected also by organic matter, the topsoil is darker than subsoil.

pH: The range of values in all samples was between 7.68 and 8.34, which indicates alkaline soils. There was not a clear difference between soil types (Table 5.1) (Appendix A).

Water absorption: The range of values was between 0.52 and 0.69, with no difference between soil types.

Total organic carbon: The range of concentrations was between 0.4 and 2.4, with an exceptional value of 6, and no difference between soil types. Variations among pedons (sites) reflect the amount of vegetation. The top soil in most pedons had the highest values along a profile (Table 5.1) (Appendix A).

Table 0.1 Color, pH, TOC, water absorption and texture in 40 soil samples

Soil Site	Location	Sample No.	Color	pH	Water saturation (g/g)	TOC %
Terra Rossa West-South	**Battir 1**	**JS1**	5 YR 4/6	8.03	0.59	1.0
		JS2	5 YR 5/8	8.01	0.68	0.9
		JS3	5 YR 4/4	8.02	0.56	1.5
		JS4	5 YR 4/6	8.02	0.62	2.0
		JS5	5 YR 4/6	8.01	0.68	-
	Battir 2	**JS6**	5 YR 5/4	7.88	0.66	0.8
		JS7	5 YR 4/4	7.98	0.67	0.9
		JS8	5 YR 6/6	8.10	0.55	0.7
		JS9	5 YR 4/3	7.70	0.58	2.8
	AlQbu (Karstic)	**JS10**	7.5 YR 4/3	7.83	0.68	2.4
		JS11	7.5 YR 4/3	7.80	0.79	6.0
		JS12	7.5 YR 5/4	7.92	0.64	-
		JS13	7.5 YR 4/3	7.82	0.67	-
		JS14	7.5 YR 5/6	7.89	0.57	-
Rendzina East-South	**Beit Sahour**	**JS15**	7.5 YR 4/4	7.87	0.54	1.2
		JS16	5 YR 4/6	7.94	0.63	1.3
	Bayth Ta'amar	**JS19**	7.5 YR 5/3	8.11	0.62	0.4
		JS20	7.5 YR 5/4	7.94	0.60	1.4
Terra Rossa East-South	**Teqo’a East**	**JS21**	5 YR 4/8	7.97	0.52	0.6
		JS22	5 YR 4/6	7.89	0.65	1.5
	Teqo’a West	**JS23**	5 YR 5/4	7.88	0.61	1.8
		JS24	5 YR 4/8	7.97	0.69	1.2
		JS25	5 YR 4/4	7.97	0.60	-
Rendzina West-South	**Ishwa**	**JS26**	7.5YR6/3	7.68	0.60	2.4
		JS27	7.5YR6/2	7.77	0.59	1.1
	Ishwa (the main road)	**JS30**	7.5YR7/2	8.01	0.61	1.9
		JS31	7.5YR7/2	8.23	0.63	1.2
Rendzina West-North	**Bait Iba**	**JS32**	7.5YR7/3	7.94	0.58	1.4
		JS33	7.5YR6/4	8.11	0.62	0.5
		JS34	7.5YR6/3	7.84	0.56	0.5
Terra	**Qusin**	**JS36**	5 YR 4/3	8.14	0.62	1.7

Rossa West-North		**JS37**	5 YR ¾	8.25	0.61	1.2
		JS38	5 YR 3/3	8.24	0.54	0.9
Terra Rossa East-North	**Tayaseer**	**JS40**	5 YR ¾	7.88	0.55	1.6
		JS42	5 YR ¾	7.94	0.59	1.6
		JS43	5 YR 3/6	8.10	0.60	1.6
Rendzina East-North	**Tubas**	**JS44**	7.5YR6/6	8.34	0.64	1.6
		JS45	7.5YR5/4	7.95	0.66	1.0
		JS46	7.5YR4/6	7.99	0.55	0.5
		JS47	7.5YR5/6	8.12	0.60	0.4

1.21 Grain size

Grain size of 40 soil samples was measured (Table 5.2) (Appendix B). Terra Rossa had more clay fraction and less silt fraction, compared to Rendzina which was had more silt and less silt (Fig. 5.2). The mode 3 – 8 µm represent the grain size of clay, while the 30 - 40 µm mode is the silt grain size. The 3-8 µm fine mode should be considered as a clay size, since laser-determined grains of b ~ 5 µm are equivalent to the clay fraction determined by sedimentation. Because not all Terra Rossa and Rendzina soil samples were Typical some of samples and pedons were different in grain size. Brown Rendzina of the east- south pedon was very similar to Terra Rossa soil types (Fig. 5.2). On the other hand, Terra Rossa west-north is very close to Pale Rendzina soil, which was a colluvium terra rossa. A sample (JS13) in Terra Rossa west-south is close to Rendzina may be due not sufficient removal of organic carbon. But two samples (Js33 and Js44) are exceptional, which are silty loam.

Non Typical Terra Rossa is the colluvium Terra Rossa soil with other materials that make these Terra Rossa soil different than Typical Terra Rossa. In other hand Brown Rendzina develop over harder rock than Pale Rendzina; and Brown more colluvium (Darwish,1997).

Most Terra Rossa soils have either clayey or silty clayey texture but a few samples have a silty clay loam texture (Fig. 5.1). This may be due to not sufficient removal of organic carbon by H_2O_2 and the presence of bedrock particles that increase the sand and silt size fractions.

Table 0.2 The percentages of Clay, Silt and Sand in 40 soil samples

Soil Site	Sample	Clay %	Silt %	Sand %	Soil texture
Terra Rossa West-South	**JS1**	36.9	58.0	5.1	**silty clay**
	JS2	42.8	50.8	6.5	**Clay**
	JS3	40.6	53.2	6.2	**Clay**
	JS4	33.6	57.9	8.5	**silty clay**
	JS5	40.9	56.2	2.9	**Clay**
	JS6	47.1	48.8	4.2	**Clay**
	JS7	41.7	55.7	2.6	**Clay**
	JS8	34.7	58.4	6.9	**silty clay**
	JS9	36.0	47.9	16.2	**Clay**
	JS10	38.8	51.2	10.1	**Clay**
	JS11	35.8	46.0	18.2	**Clay**
	JS12	34.2	58.4	7.5	**silty clay**
	JS13	23.2	62.0	14.8	**silty clay loam**
	JS14	33.9	63.5	2.6	**silty clay**
Rendzina East-South	**JS15**	31.8	54.2	14.0	**silty clay**
	JS16	35.5	52.9	11.6	**Clay**
	JS19	40.5	54.5	5.0	**Clay**
	JS20	32.1	55.7	12.3	**silty clay**
Terra Rossa East-South	**JS21**	33.8	58.5	7.7	**silty clay**
	JS22	31.2	56.7	12.1	**silty clay**
	JS23	32.9	49.4	17.7	**Clay**
	JS24	35.8	60.7	3.5	**silty clay**
	JS25	23.9	72.3	3.8	**silty clay loam**
Rendzina West-South	**Js26**	34.1	59.0	6.9	**silty clay loam**
	Js27	35.5	59.7	4.8	**silty clay loam**
	Js30	28.1	64.5	7.4	**silty clay loam**
	Js31	38.1	54.0	7.9	**silty clay loam**
Rendzina West-North	**Js32**	32.8	62.1	5.1	**silty clay loam**
	Js33	23.2	62.4	14.4	**silty loam**
	Js34	36.1	57.3	6.6	**silty clay loam**
Terra Rossa West-	**Js36**	34.5	62.2	3.4	**silty clay loam**
	Js37	42.9	54.2	2.9	**silty clay**
	Js38	33.7	63.9	2.4	**silty clay**
Terra Rossa East-	**Js40**	30.1	63.5	6.4	**silty clay loam**
	Js42	42.6	53.6	3.8	**silty clay**
	Js43	35.2	64.2	0.6	**silty clay loam**
Rendzina East-North	**Js44**	23.9	61.9	14.2	**silty loam**
	Js45	33.1	64.6	2.3	**silty clay loam**
	Js46	27.9	69.0	3.1	**silty clay loam**
	Js47	41.3	51.3	7.4	**silty clay loam**

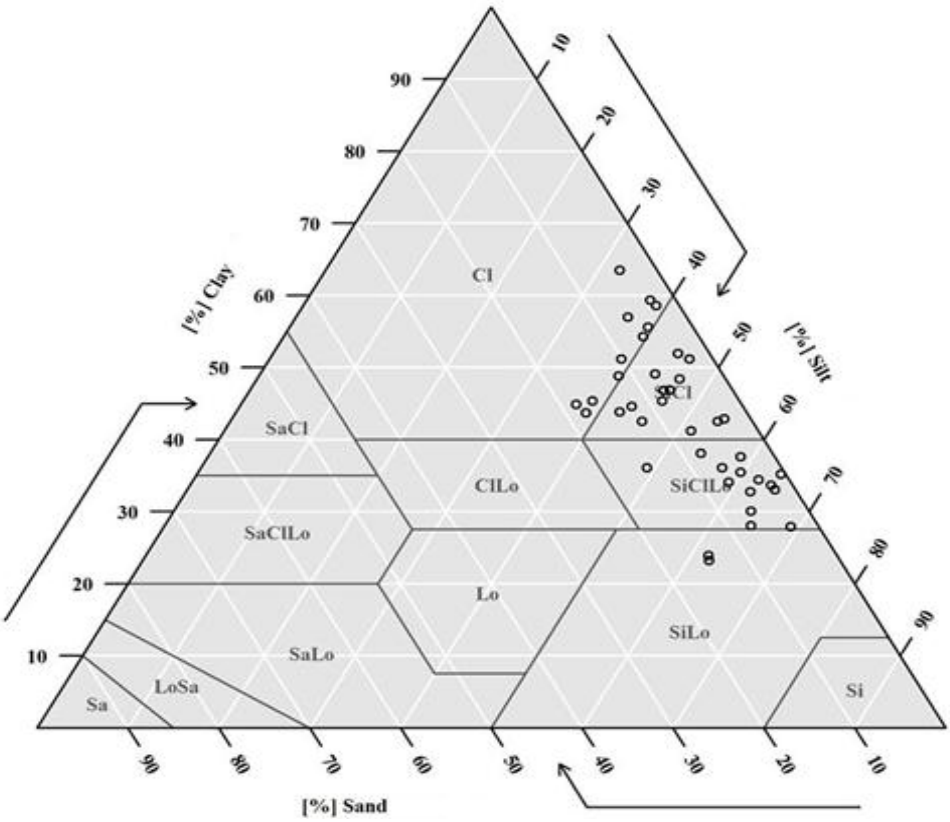


Figure 0.1 Soil texture of 40 soil samples. Cl: Clay, Si: Silt, Sa: Sand and Lo: Loam

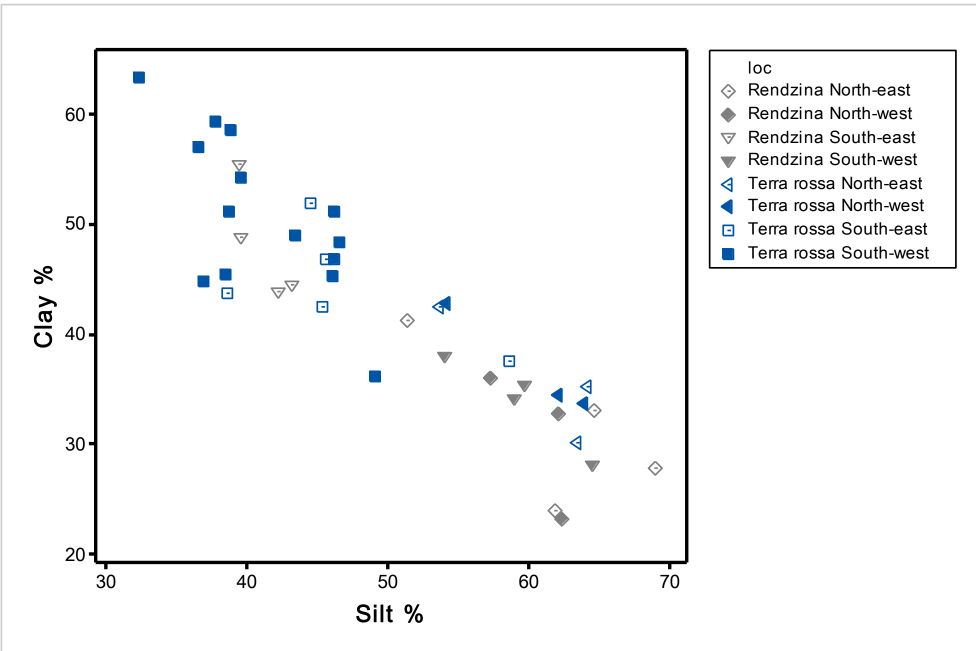


Figure 0.2 The ratio between Clay and Silt percentage

Most samples grain size was between 2 and 60 μm, while an additional mode at around 0.7 μm appears as a shoulder in many samples; but the distribution was different between soil types. Terra Rossa samples grain size mostly focused concentrated in not clay mode this is Typical Terra Rossa (Fig.5.3.A) which was in west south. While some Terra Rossa pedons were not a Typical Terra Rossa as Terra Rossa West-North (Fig. 5.3.B); the ratio of clay silt was (Fig.5.2) was similar to Pale Rendzina soil. On the other hand, the grain size in Terra Rossa West-South, under higher MAP, was finer than Terra Rossa East-South (Fig.5.3.C). This means that the precipitation and leaching affect grain size.

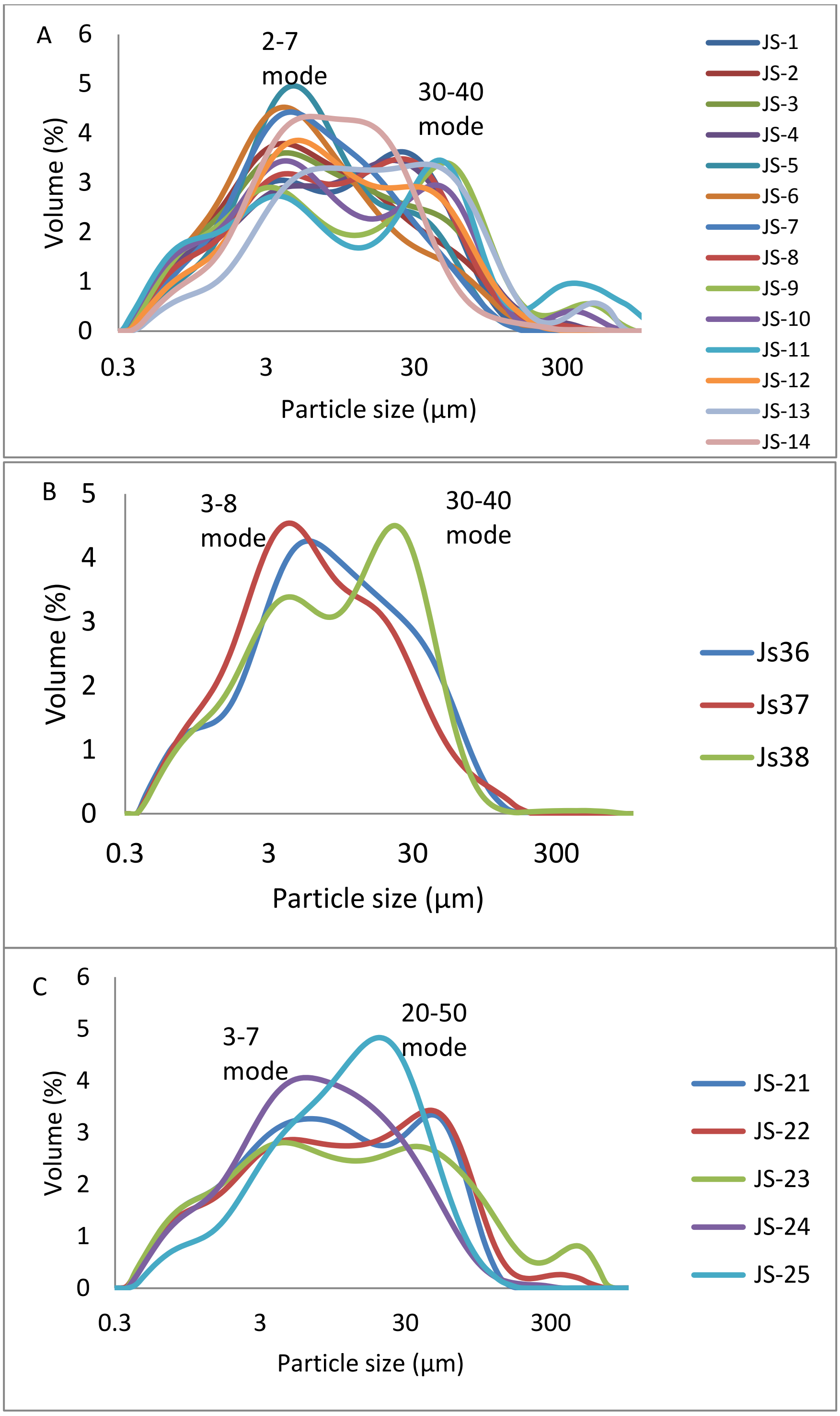


Figure 0.3 Gran size distribution in Terra Rossa soils (µm). A. Western south pedons, B. western north pedons C. eastern south.

Pale Rendzina (West-North, Fig.5.4.A), had higher silt (30-60 mode) than clay (2-7 mode) fraction; the clay/silt ratio was low compared to Typical Terra Rossa. In contrast, in Brown Rendzina pedon (East-South, Fig.5.4.B), the clay/silt ratio was higher than in Pale Rendzina and similar to Terra Rossa. In other hand, the grain size in Rendzina West-North, which was more rain, was big size than Rendzina East-North (Fig.5.4.C), this mean that the precipitation is a factor that affect in grain size, and the leaching is factor of grain size.

Some of the samples in the same pedon were not similar in grain size due to a variable presence of rock particles, there was not enough of removed organic carbon and depth version. The other pedons grain size in the appendices.

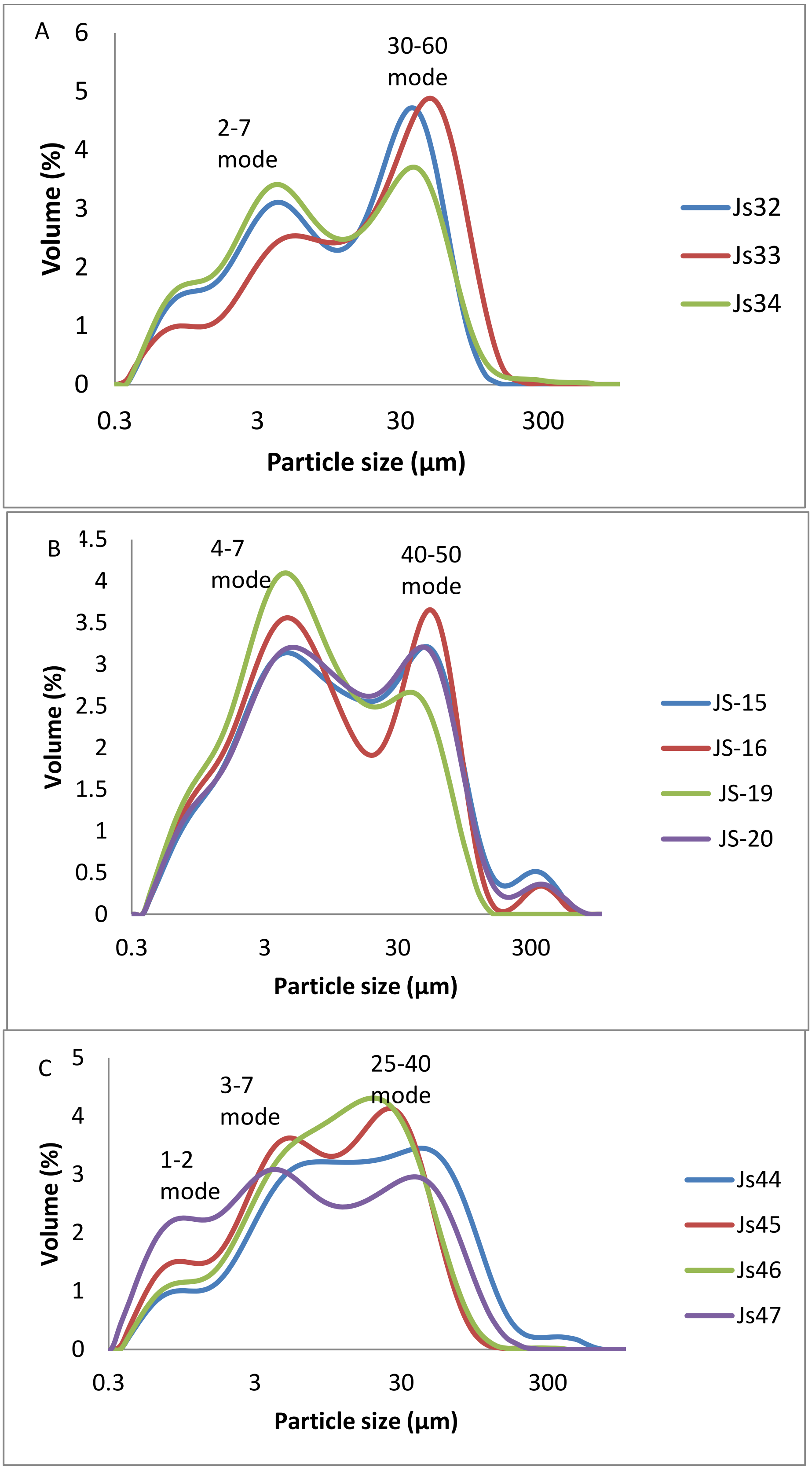


Figure 0.4 Gran size distribution in Rendzina soils (µm) A. Western north pedon B. eastern south pedons C. eastern north.

1.22 Mineralogy

The soil samples were composed of quartz, clay, calcite, dolomite, feldspars, and hematite. Quartz, clay and calcite appear to be the major constituents in most samples, with trace amount of dolomite, feldspars, and hematite (Table 5.3) (Appendix C). The XRD analysis of randomly oriented powder samples, however, tends to mixed large particles of crystalline minerals like calcite, dolomite and quartz, as compared to smaller phyllosilicate minerals as clay.

Soil minerals were different between Terra Rossa, Rendzina (Table 5.3) and dust (Table 5.4). All samples contain large amount of quartz, phyllosilicate (clay) and calcite; while it was contain midtrial amount of dolomite and a few amount of K-feldspare, plagioclase and hematite.

In Typical Terra Rossa 65% -80% of the soil mineral was quartz and clay; as in Terra Rossa West-South (Fig.5.5.A), while in Pale Rendzina pedons 70% -80% was calcite; as in Rendzina West-North (Fig. 5.5.B). On the other hand non Typical Terra Rossa was similar to Rendzina as in Terra Rossa West-North (Fig. 5.5.C). In contrast, dark Rendzina was similar to Typical Terra Rossa as in Rendzina East-South (Fig. 5.5.D).

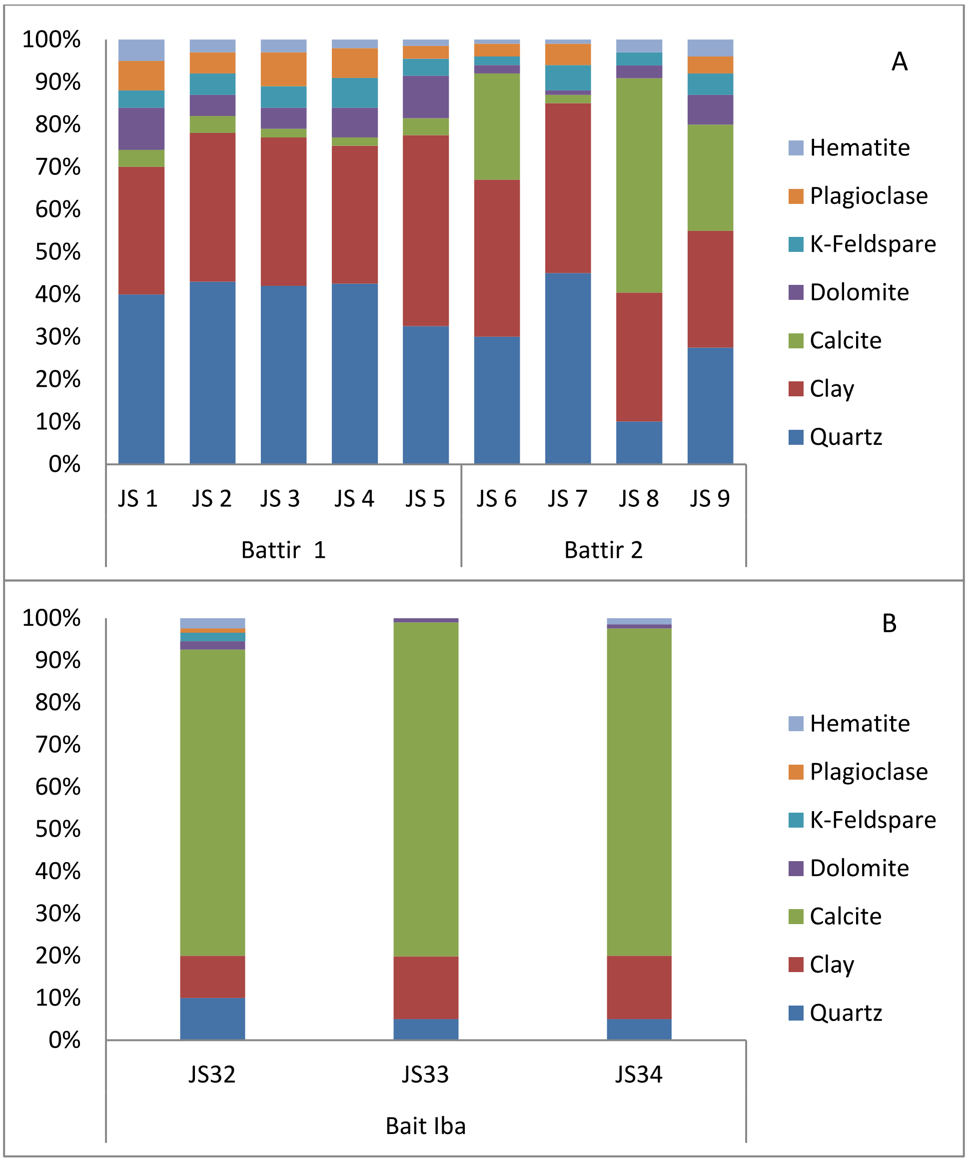
Dolomite presence of dolomite rock (Js 10 and Js 11), was relatively high because these a Terra Rossa soil developed on dolomite rock. In Rendzina JS 31 quartz was relatively high because it was located near a road may be mixed with a more dust.

Table 0.3 Minerals composition of 40 different soil samples

Sample No.	Quartz%	Clay%	Calcite%	Dolomite%	K-feldspar%	Plagioclase%
JS 1	40	30	4	10	4	7
JS 2	40 – 45	35	4	4	4	4
JS 3	40 - 45	35	2	5	6	8
JS 4	40 - 45	30 – 35	>2	7	7	7
JS 5	30 - 35	45	4	10	3	<3
JS 6	30	35 – 40	25	<2	3	3
JS 7	45	40	<2	<1	6	5
JS 8	10	30	50	3	3	-
JS 9	25 - 30	25 – 30	25	7	5	4
JS 10	35	30 – 35	4	20	5	4
JS 11	35	30 – 35	4	20	5	4
JS 12	30 -35	40 – 45	10	<3	5 - 10	5 - 10
JS 13	35	30 – 35	6	9	10	5 - 10
JS 14	27	25	25	8	5	4
JS15	40 - 45	30	3	<3	10	5 - 10
JS16	50	25-30	3	<1	5 - 10	5 - 10
JS19	30 - 35	30	15 - 20	2	10	5
JS20	35-45	20 – 25	15 - 20	<2	5	5 - 10
JS21	45 - 50	25	10 - 15	-	5	5 - 10
JS22	40 - 45	25	10	<2	5 - 10	5 - 10
JS23	30 - 35	25-30	20	<2	5 - 10	5
JS24	35	25	20 - 25	2	5	5
JS25	40 - 45	20	15	3	10	10
JS26	15 - 20	15 – 20	55	<2	5	<2
JS27	10	20	60	<2	<5	<1
JS30	10	10 – 15	65	-	<5	5
JS31	35 - 40	10	45 - 50	-	-	-
JS32	10	10	70 - 75	-	-	<1
JS33	5	15	80	<1	-	-
JS34	5	15	75 - 80	<1	-	-
JS36	15	20 – 25	55	-	<5	<5
JS37	30	30 – 35	30 - 35	-	<3	<5
JS38	30	35 – 40	20 - 25	<2	<5	<5
JS40	45	35	<1	<2	5 - 10	5
JS42	45	35	<2	<2	5	5
JS43	35	45	<1	<2	5	5 - 10
JS44	20 - 25	15	50 - 55	<1	<3	<3
JS45	5	20	60	<1	5	<2
JS46	15	20 – 25	55	5	5	<2
JS47	10 - 15	20	55 - 60	-	5 - 10	5

Table 0.4 Mineral composition of dust sample using XRD

Sample No.	Quartz%	Clay%	Calcite%	Dolomite%	K-feldspar%	Plagioclase%
Dust	25	20	40	5 - 10	<3	5



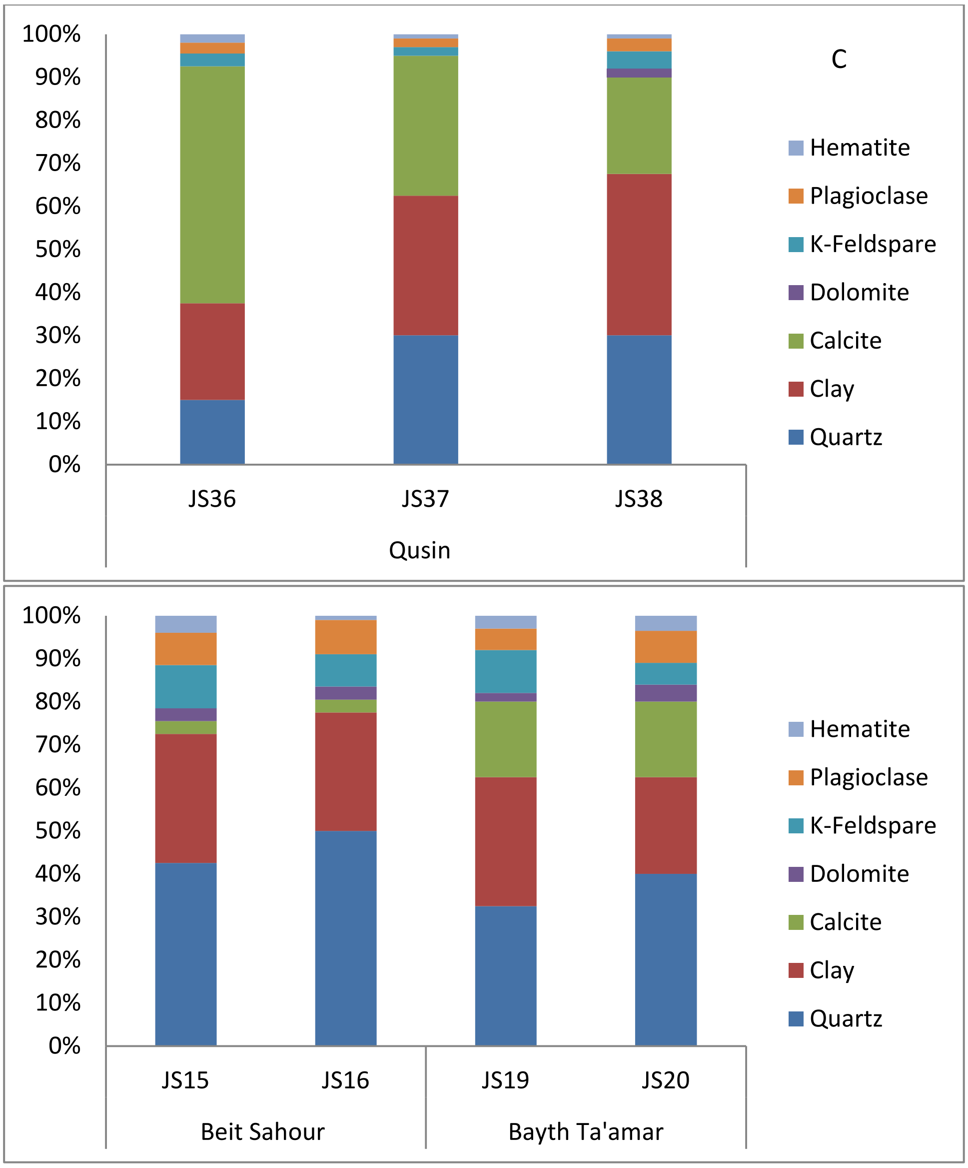


Figure 0.5 Mineralogical compositions A. Typical Terra Rossa West-South, the majority is clay and quartz B. Pale Rendzina West-North, the majority is calcite. C. Non Typical Terra Rossa West-North, some samples the majority quartz and clay, while other the major

In west Typical Terra Rossa samples; under more rain, quartz and clay were more comparing with east Typical terra samples, while calcite was more in east Typical terra samples than, which was less rain, comparing with calcite in west samples. Because calcite more leaching than quartz and clay.

In Battir 1 pedon, a Typical Terra Rossa in the west south (Fig.5.6.A), quartz decreased at the upper 70 cm then increased until 100 cm and decreased again with depth but in small rate. Clay increased until 100 cm then decreased below. In return, calcite seemed no change with the depth.

In Battir 2 pedon, Typical Terra Rossa in the west south (Fig.5.6.B), quartz decreased at the upper 40 cm than increased between 40 and 100 cm, and decreased again with depth. While clay increased at 100 cm then in the deeper layer decreased. In addition, calcite increased due to the leaching at the upper 40 cm than decreased between 40 and 100 cm, and increased again with depth. Quartz, clay and calcite minerals in this Battir 2 pedon were similar to dust.

In Tubas pedon, Pale Rendzina in west north (Fig.5.7.A), quartz decreased at the upper 50 cm than no change with depth. While clay and calcite increased at 50 cm then no clear change decreased. Quartz, clay and calcite minerals in this Bait Iba pedon were close to dust.

In a Pale Rendzina in east north (Fig.5.7.B), quartz decreased at the upper 40 cm than increased between 40 and 80 cm, and decreased again with depth. Clay increased down to 80 cm and then decreased. In addition, calcite increased at the upper 40 cm then decreased between 40 and 80 cm, and increased again with depth. Quartz, clay and calcite minerals in this Tubas pedon were close to dust.

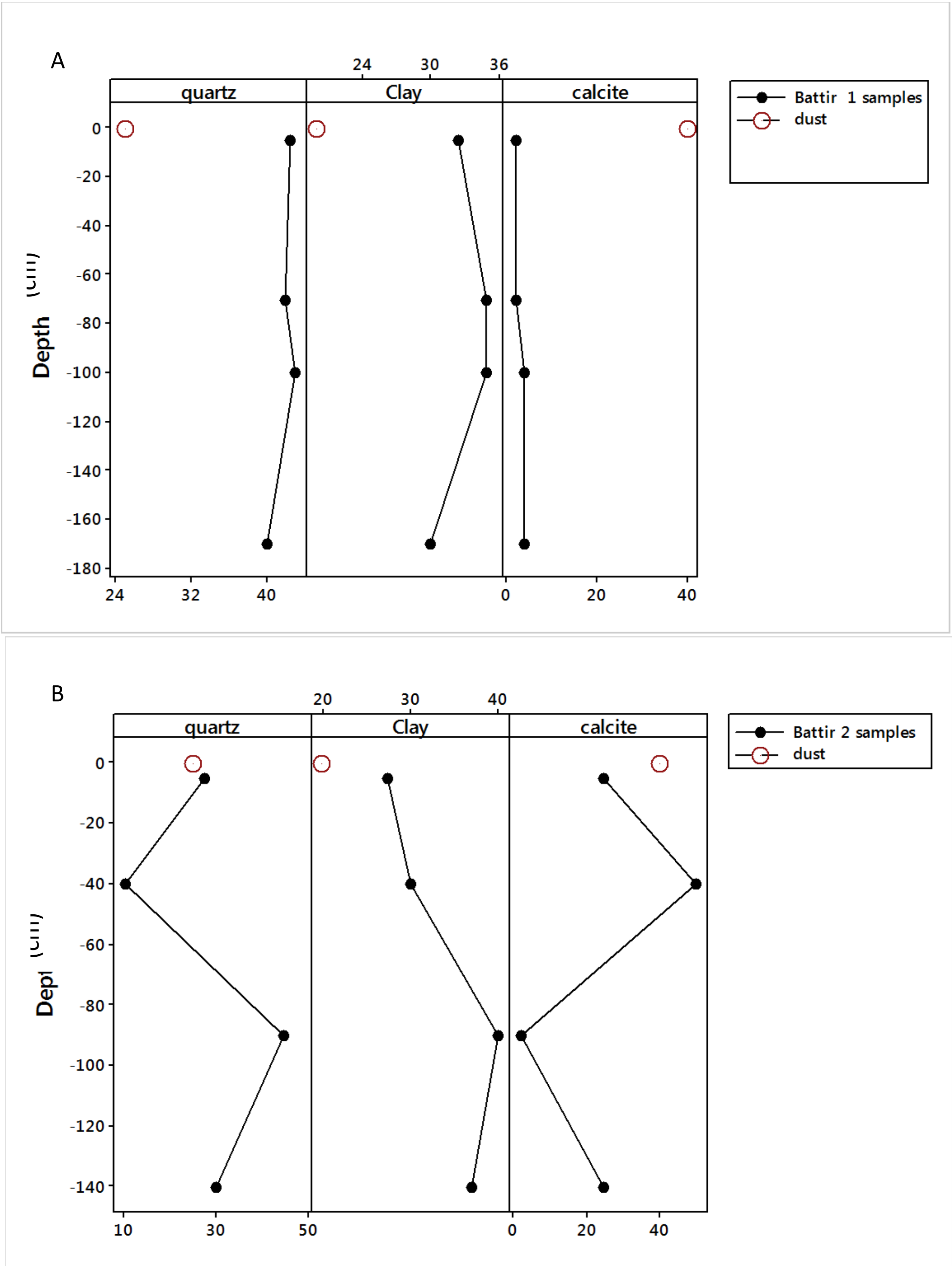


Figure 0.6 Minerals composition (%) in Typical Terra Rossa profiles: A. Battir 1 pedon in west south. B. Battir 2 pedon in in west south too

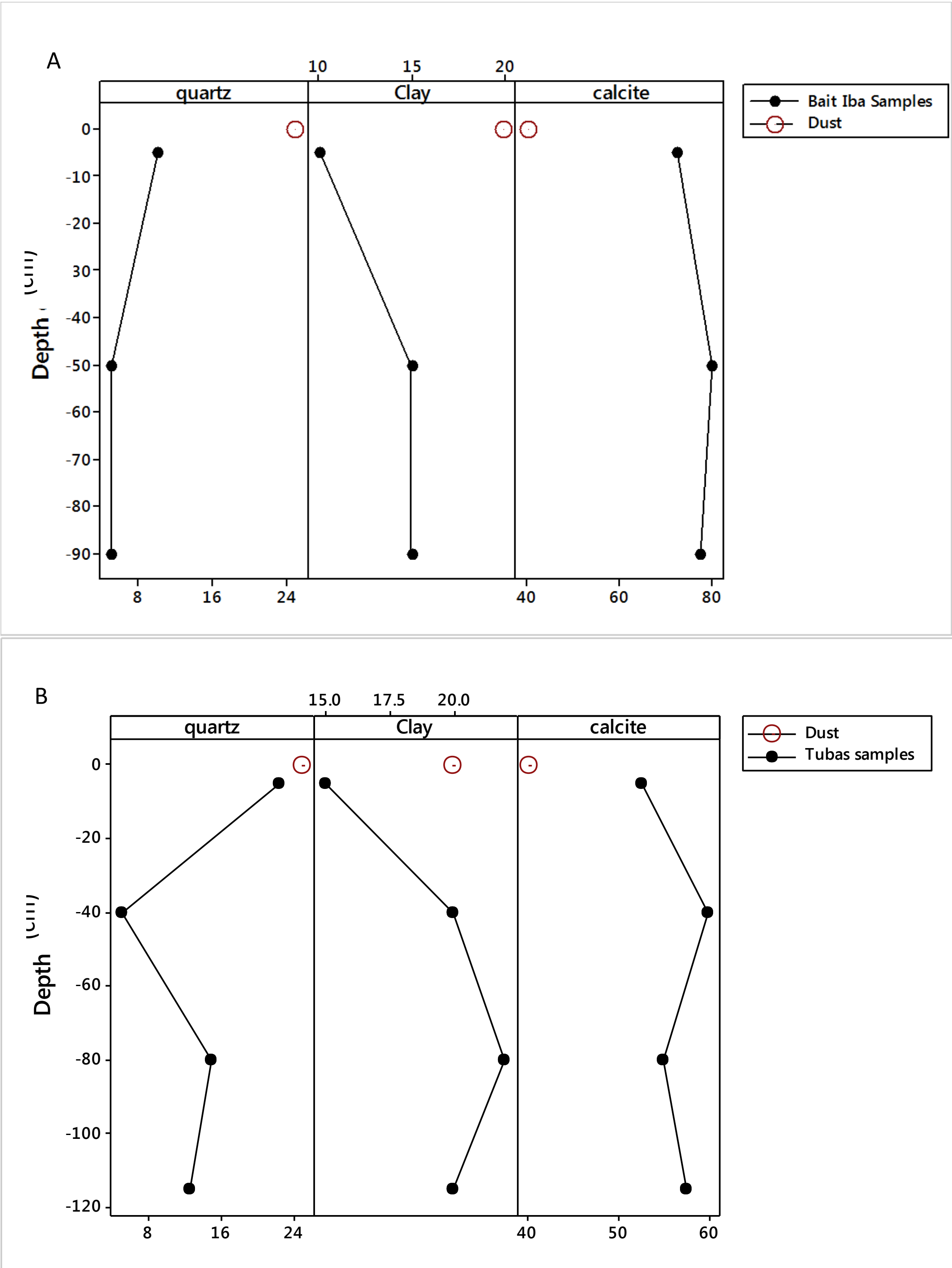


Figure 0.7 Minerals composition (%) in Pale Rendzina profile: A. Bait Iba pedon in west north. B. Tubas pedon in east north

1.23 Chemical composition

1.23.1 Major elements

The following elements: Si, Al, Fe, Ti, Ca, Mg, Mn, Na, K, P and S. reported as oxides, were measured for all soil (Table 5.5) (Appendix D), dust and rock samples (Table 5.6) (Appendix E). Major elements results were heterogeneous and different between terra rossa and Rendzina. Silica which is associated with quartz while calcium associated with calcite and Aluminum associated with clay and quartz, as mentioned in mineralogy section Typical Terra Rossa had more quartz and clay mineral and less calcite, this due to Typical Terra Rossa had more silica and less calcium while Pale Rendzina had more calcium and less silica (Fig.5.8).

West-south Terra Rossa had more silica and less calcium than in the East one (Fig. 5.8). The difference is related to the amounts of precipitation and consequently to leaching in the west, as calcium is leached more than silicate. Rendzina is less leached and is less affected by dust.

Rendzina develops on soft carbonate rocks (mainly chalk) and the dust contributing was relatively less than in Terra Rossa, which develops on hard calcareous rock (limestone and dolostone). Typical Terra Rossa and the Brown Rendzina were similar in major elements, as well as in grain size and mineralogy. Some non-Typical Terra Rossa was different from Typical Terra Rossa and close to Pale Rendzina.

Aluminum was a stable major element in soil; because it do not leached, and need a strong acid water or strong base water, in this study case it was impossible so the aluminum was a stable elements in soil (Bruce R, 1987). Aluminum had a strong positive correlation with iron, titanium and silicon oxides (Fig. 5.9) and a strong negative correlation with calcium. Typical Terra Rossa had more aluminum, iron, titanium and silicon with less calcium. Pale Rendzina had more calcium and less aluminum, iron, titanium and silicon, because Terra Rossa leaching is higher than Rendzina leaching, and silica which is associated with quartz while calcium associated with calcite and Aluminum associated with clay and quartz.

In Battir 1 pedon, a Typical Terra Rossa in the west south, aluminum, Iron and silicon increased at the upper 100 cm and decreased at depth (Fig.5.10.A) while calcium decreased at 100 cm then in the deeper was decreased, due to the leaching. Concentrations of Aluminum, Iron, and silicon in this pedon were similar to dust and not to rock; this means large amount of the soil especially the surface layer was derived from dust.

In Battir 2 pedon, another Typical Terra Rossa in the west south, Aluminum, Iron and silicon displayed a zigzg pattern along the profile (Fig.5.10.B) and in contrast to calcium. This behavior suggests that there was a different soil layer that formed before then a younger layer was formed over and actually this is a composite profile. As in Battir1, the mentions elements were similar to the dust and not to rock, indicating that a large amount of the soil, especially the surface layer, came from dust.

The behavior of elements along Pale Rendzina profiles was similar to Terra Rossa profiles, but less pronounced (Fig.5.11.A and B). Aluminum, Iron and silicon increased at first centimeters then decreased with depth. While Calcium inversely followed due to Pale Rendzina less leaching. As in Terra Rossa profiles, the mentions elements were close to the dust and not to rock, indicating that a large amount of the soil, especially the surface layer, came from dust.

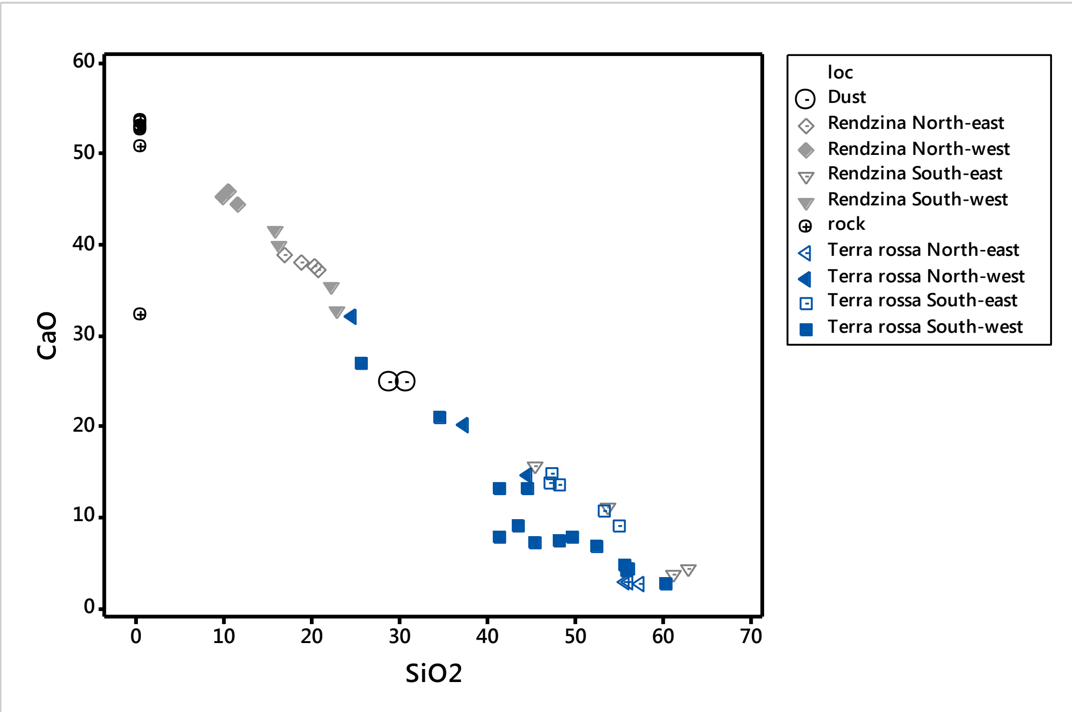


Figure 0.8 Bulk chemical composition of soils: plots of silica and calcite (wt %)

Table 0.5 Major elements in 40 soil samples, reported as oxides

Sample No.	SiO2	Al2O3	Fe2O3	TiO2	CaO	MgO	MnO	Na2O	K2O	P2O5	SO3
					Wt%						
JS 1	52.2	13.0	6.9	1.2	6.9	3.3	0.11	0.3	1.2	0.2	< 0.5
JS 2	55.9	14.9	7.9	1.3	4.4	2.4	0.12	0.3	1.3	≤ 0.1	< 0.5
JS 3	55.6	14.5	7.7	1.3	4.1	2.6	0.12	0.4	1.3	≤ 0.1	< 0.5
JS 4	55.5	13.3	7.1	1.3	4.7	2.7	0.12	0.4	1.3	≤ 0.1	< 0.5
JS 5	48.0	15.2	8.2	1.1	7.4	3.9	0.10	0.3	1.4	≤ 0.1	< 0.5
JS 6	44.5	13.3	7.1	1.1	13.2	1.6	0.09	0.2	1.0	< 0.1	< 0.5
JS 7	60.2	15.1	8.2	1.4	2.6	1.3	0.14	0.3	1.2	< 0.1	< 0.5
JS 8	25.5	10.6	5.5	0.6	27.1	1.6	0.05	0.1	0.7	≤ 0.1	< 0.5
JS 9	41.1	11.2	6.0	1.0	13.3	2.8	0.09	0.2	1.1	0.1	< 0.5
JS 10	43.4	12.5	6.6	1.0	9.0	4.5	0.10	0.3	1.3	≤ 0.1	< 0.5
JS 11	41.1	11.3	5.9	1.0	7.8	3.7	0.09	0.3	1.3	0.2	< 0.5
JS 12	49.5	13.9	7.4	1.2	7.9	2.3	0.10	0.3	1.3	≤ 0.1	< 0.5
JS 13	45.3	12.9	6.8	1.1	7.1	2.7	0.10	0.3	1.3	0.2	< 0.5
JS 14	34.3	10.7	5.7	0.9	21.1	2.0	0.09	0.1	0.7	≤ 0.1	< 0.5
JS15	61.0	12.9	7.0	1.3	3.6	1.7	0.12	0.42	1.3	0.3	< 0.5
JS16	62.7	11.9	6.4	1.3	4.4	1.6	0.12	0.54	1.3	< 0.1	< 0.5
JS19	53.6	11.4	6.1	1.1	11.0	1.6	0.09	0.40	1.3	< 0.1	< 0.5
JS20	45.3	9.6	5.0	0.9	15.7	1.7	0.09	0.36	1.2	0.2	< 0.5
JS21	53.1	11.3	6.2	1.2	10.8	1.7	0.11	0.41	1.2	< 0.1	< 0.5
JS22	54.8	10.7	5.8	1.2	9.1	1.8	0.11	0.50	1.4	< 0.1	< 0.5
JS23	46.9	10.7	5.6	1.0	13.9	1.7	0.10	0.38	1.2	≤ 0.1	< 0.5
JS24	47.1	11.0	5.8	1.0	14.9	1.6	0.10	0.42	1.2	≤ 0.1	< 0.5
JS25	48.1	11.5	6.0	1.0	13.6	1.6	0.10	0.4	1.2	≤ 0.1	< 0.5
JS26	22.6	5.2	2.9	0.5	32.7	1.5	0.05	0.1	0.7	0.5	< 0.5
JS27	22.0	5.1	2.4	0.4	35.4	1.4	0.05	0.1	0.7	0.5	< 0.5
JS30	16.1	3.4	1.6	0.3	40.0	1.0	0.02	0.1	0.3	0.7	< 0.5
JS31	15.7	3.5	1.6	0.3	41.6	1.0	0.03	0.1	0.3	0.8	< 0.5
JS32	9.7	3.2	1.5	0.2	45.4	0.7	0.02	0.1	0.2	0.4	< 0.5
JS33	10.4	3.5	1.6	0.2	46.0	0.6	0.02	0.1	0.2	0.3	< 0.5
JS34	11.4	3.7	1.7	0.2	44.6	0.6	0.02	0.1	0.2	0.3	< 0.5
JS36	24.4	7.1	3.3	0.6	32.2	1.0	0.06	0.1	0.4	0.2	< 0.5
JS37	37.1	11.3	5.7	0.9	20.3	1.1	0.08	0.1	0.6	0.2	< 0.5
JS38	44.4	13.1	6.6	1.1	14.6	1.2	0.10	0.1	0.7	0.2	< 0.5
JS40	57.1	14.4	7.8	1.3	2.6	2.5	0.14	0.3	1.2	0.1	< 0.5
JS42	55.4	14.4	7.8	1.3	2.9	2.6	0.14	0.4	1.3	0.2	< 0.5
JS43	55.9	14.3	8.2	1.3	2.9	2.5	0.13	0.3	1.3	0.1	< 0.5
JS44	16.8	4.9	2.1	0.4	39.0	1.0	0.04	0.1	0.4	0.2	< 0.5
JS45	18.7	5.5	2.9	0.4	38.1	1.0	0.04	0.1	0.4	0.2	< 0.5
JS46	20.2	5.9	2.6	0.5	37.8	1.0	0.04	0.1	0.5	0.2	< 0.5
JS47	20.5	5.8	3.0	0.5	37.4	1.0	0.04	0.1	0.4	0.2	< 0.5

Table 0.6 Major elements in two dust samples and seven rock samples, reported as oxides

Sample no.	SiO2	Al2O3	Fe2O3	TiO2	CaO	MgO	MnO	Na2O	K2O	P2O5	SO3
					wt%						
Dust Nov	30.5	5.8	4.1	0.5	24.9	3.1	0.05	0.6	1.1	0.45	< 0.5
Dust March	28.6	6.2	3.9	0.5	24.9	2.9	0.05	0.4	0.9	0.53	< 0.5
JS4 Rock	< 0.2	0.2	0.13	0.01	53	0.51	< 0.01	< 0.1	0.12	≤ 0.1	≤ 1
JS8 Rock	< 0.2	0.26	0.08	0.01	50.9	0.67	< 0.01	< 0.1	0.11	< 0.1	< 1
JS10 Rock	< 0.2	0.07	0.09	<0.01	32.3	20.6	< 0.01	< 0.1	0.07	<0.1	< 1
JS17 Rock	< 0.2	0.19	0.11	0.01	52.8	0.65	< 0.01	< 0.1	0.08	1.2	≤ 1
JS19 Rock	< 0.2	0.32	0.14	0.01	53.7	0.24	< 0.01	< 0.1	0.1	0.21	≤ 1
JS21Rock	< 0.2	0.13	0.07	0.01	53.9	0.28	< 0.01	< 0.1	0.07	< 0.1	≤ 1
JS25Rock	< 0.2	0.49	0.12	0.02	53.2	0.49	< 0.01	< 0.1	0.1	≤ 0.1	≤ 1

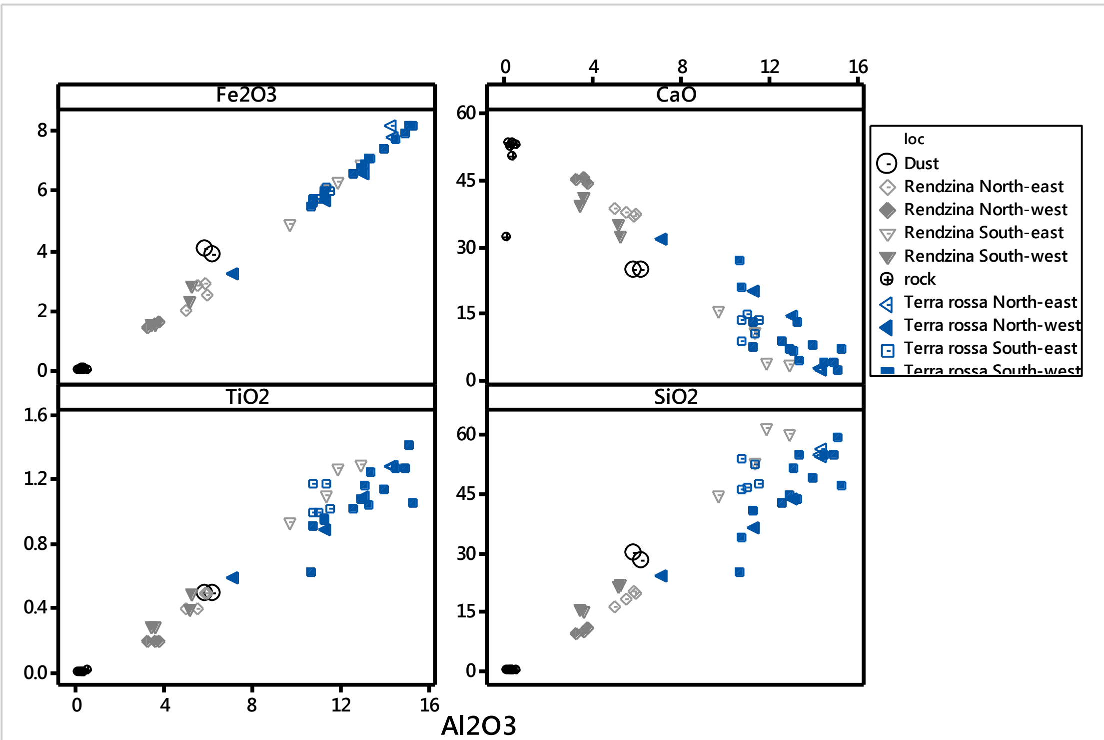
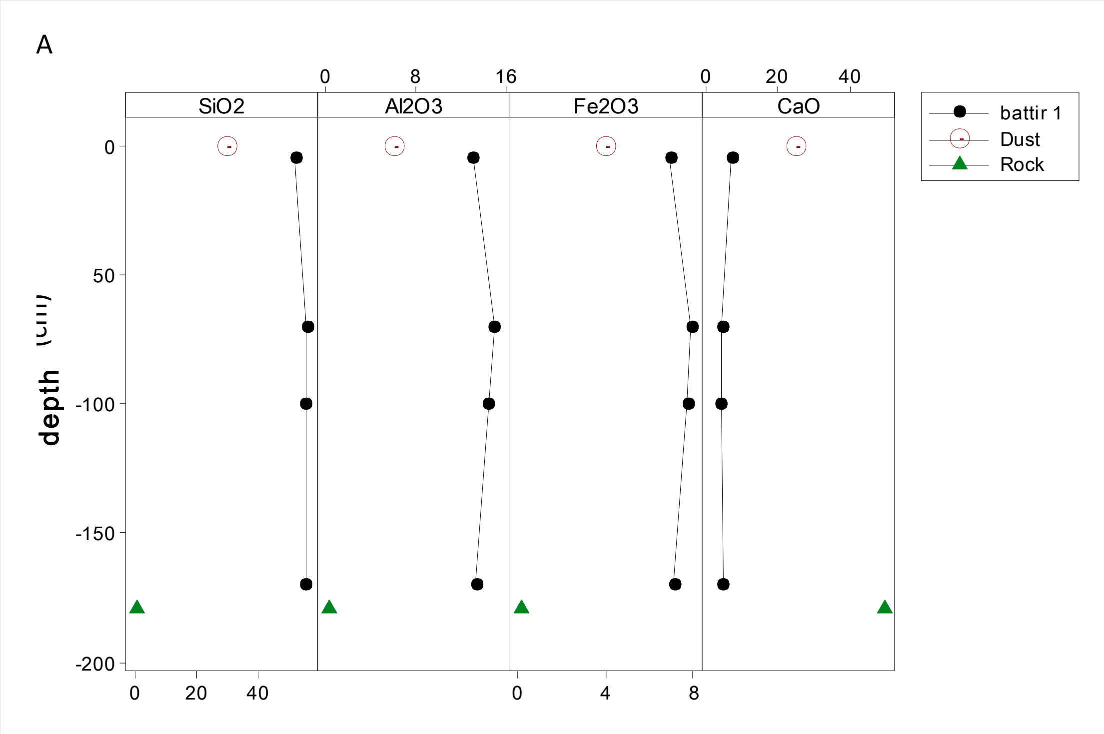


Figure 0.9 Bulk chemical composition of soils: plots of selected major elements in y axis versus aluminum in x axis in (wt %).



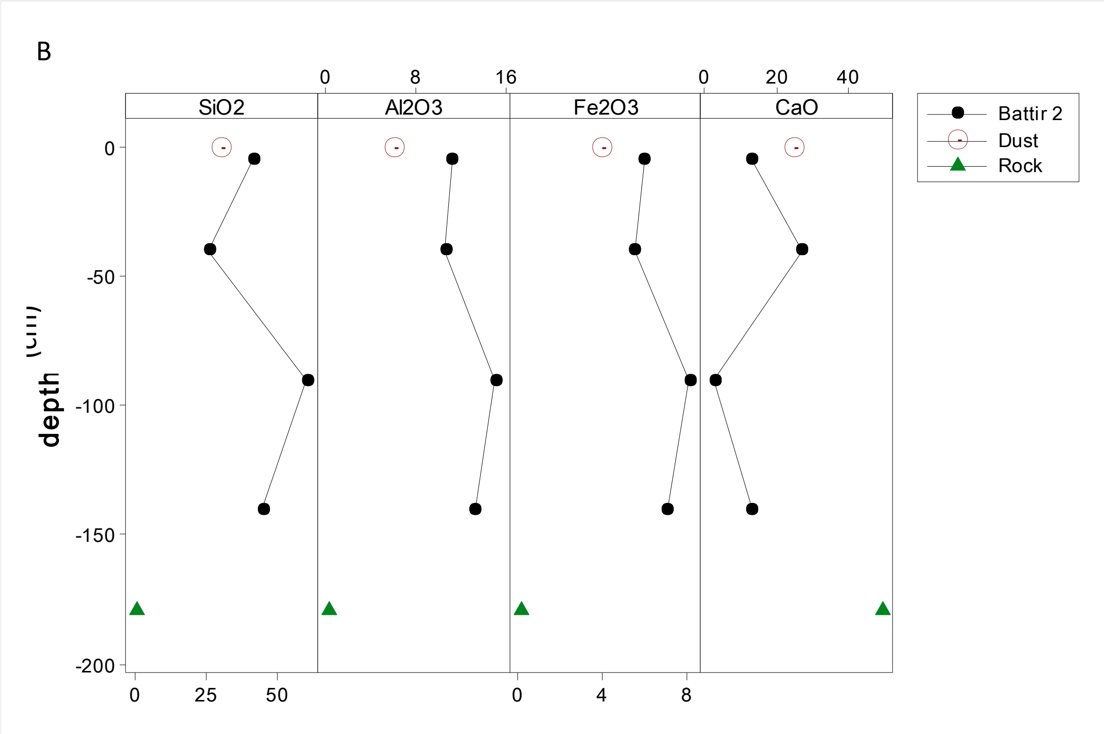


Figure 0.10 Major elements (wt %) in Typical Terra Rossa profiles: A. Battir 1 pedon in west south. B. Battir 2 pedon in in west south too

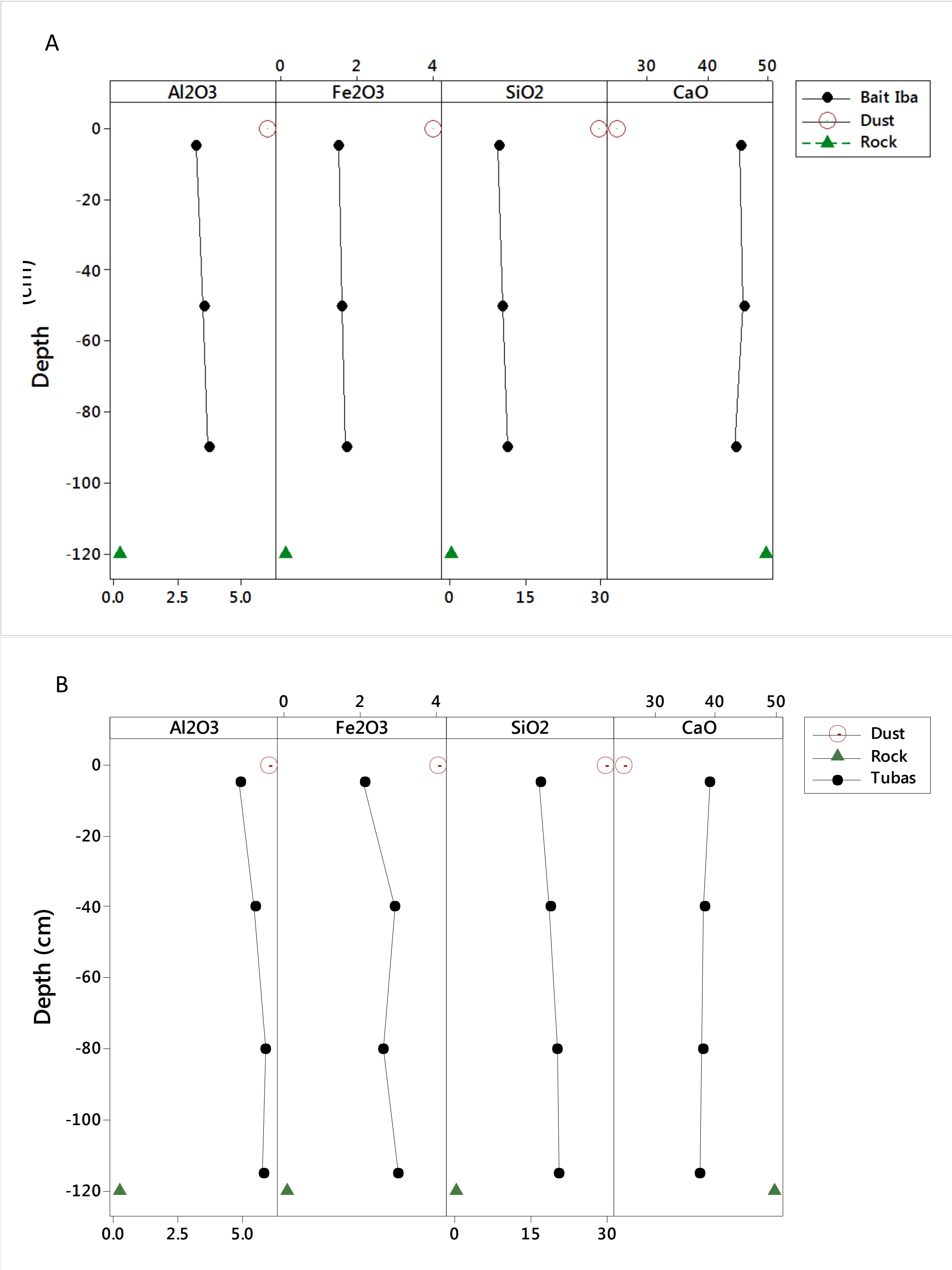


Figure 0.11 Major elements (wt %) in Pale Rendzina profile: A. Bait Iba pedon in west north. B. Tubas pedon in east north

1.23.2 Trace elements

The following trace elements: Ba, Co, Cr, Cu, Mn, Mo, Ni, Pb, Rb, Sb, Sr ,Th, U, V ,Zn and Zr elements were measured for soil samples (Table 5.7), dust and rock samples (Table 5.8) (Appendix F). Trace elements concentrations were heterogeneous and different between Terra Rossa and Rendzina; some were different between east and west, due to the difference in precipitation and liching (Fig.5.12).

As mention before Aluminum was a stable major element in soil; Aluminum had a positive correlation with Ba, Co, Cr, Cu, Mn, Ni, Rb, Sb, V, Zn and Zr. While aluminum had a negative correlation with Sr and U (Fig.5.12). Ba, Co, Cr, Cu, Mn, Ni, Rb, Th, V and Zr concentrations were higher in Typical Terra Rossa than other soil types. While Sr and U concentrations were higher in Pale Rendzina than other types; this means that Sr and U are more leaching. This mean Ba, Co, Cr, Cu, Mn, Ni, Rb, Th, V and Zr associated with quartz and clay, and Sr and U associated with calcite

Some trace elements concentrations displayed variability along the south west- east section. Barium, Zirconium and Thorium concentrations were higher in east; may it more affected by leaching or they are derived from dust. If so it means that that in the east they are not leached as more similar to dust (Fig.5.12). On the other hand, Chromium, Cobalt, Nickel and Vanadium concentrations are higher in the west, apparently due to association with the clay fraction, which is higher there.

High concentrations of trace elements are present in certain minerals and may account for a larger portion of trace element concentrations in certain cases. For example, Pb is found in large amounts in feldspars (Plumlee, 1999).

Trace element concentrations in soils are highly dependent on the trace element concentrations in the parent materials in which they formed. Trace element concentrations vary widely in rocks, and are derived from the rock forming minerals. When measuring trace elements in soils, it is important to consider not only soil properties, but more importantly the underlying parent materials (De Oliveira, 2000).

Dust samples were polluted in some trace elements, like Copper, Lead, Antimony and Zink, probably due to industry. Molybdenum was high in rocks compared to soil and dust with no apparent explanation (Fig.5.12).

Table 0.7 Trace element concentrations in 40 soil samples

Sample No.	Ba	Co	Cr	Cu	Mn	Mo	Ni	Pb	Rb	Sb	Sr	Th	U	V	Zn	Zr
								mg/kg								
JS 1	269	21	718	36	912	1.2	64	14	59	0.5	91	8.8	2.0	302	101	468
JS 2	280	22	622	36	975	1.2	67	14	61	0.5	86	8.5	1.7	283	99	497
JS 3	291	22	718	37	1007	1.4	68	16	64	0.5	93	8.7	1.8	317	140	502
JS 4	297	22	657	38	1030	1.4	65	16	64	0.5	103	9.0	1.9	295	158	515
JS 5	247	23	659	36	856	1.4	76	13	62	0.5	87	8.9	2.0	314	110	298
JS 6	214	20	641	38	785	1.1	70	12	49	0.5	69	7.5	1.3	309	94	311
JS 7	295	25	613	43	1095	1.4	73	14	62	0.6	86	9.0	1.7	305	108	571
JS 8	134	13	629	36	396	0.8	65	8	36	0.5	52	5.1	1.0	290	74	173
JS 9	213	18	583	37	793	1.2	59	15	48	0.7	88	7.0	1.6	273	135	343
JS 10	239	20	563	33	823	1.4	61	15	58	0.5	92	7.9	1.5	265	96	323
JS 11	213	16	528	33	653	1.1	53	19	43	0.6	89	6.4	1.3	232	124	322
JS 12	264	22	563	38	880	1.6	70	40	67	0.7	93	9.2	1.7	281	112	402
JS 13	244	19	605	35	794	1.4	62	18	55	0.7	94	7.8	1.7	276	102	365
JS 14	163	19	565	37	739	1.0	60	11	37	0.6	70	6.3	1.2	263	77	215
JS15	379	21	437	41	1015	1.7	57	14	50	0.7	136	10.1	2.1	217	102	549
JS16	392	18	442	36	1004	1.5	49	15	49	0.7	146	9.6	2.1	209	119	489
JS19	310	17	392	27	784	1.6	49	10	41	0.4	147	8.7	1.6	209	71	483
JS20	299	13	396	35	746	1.8	44	11	39	0.5	208	7.5	1.7	193	75	477
JS21	323	17	368	33	904	1.2	48	11	41	0.4	140	9.6	1.8	201	69	546
JS22	348	16	377	31	942	1.3	46	12	43	0.5	152	9.4	1.8	198	73	599
JS23	343	19	436	36	1022	1.8	55	17	54	0.7	155	10.3	2.0	230	89	454
JS24	309	16	378	31	866	1.5	48	11	45	0.4	140	8.9	1.6	196	74	432
JS25	302	16	350	40	823	1.6	46	11	43	0.7	144	8.9	1.5	177	77	436
JS26	232	10	78	28	419	1.1	28	12	30	0.4	262	4.0	1.8	55	80	156
JS27	221	10	70	27	396	0.8	27	8	27	0.2	240	3.7	1.6	50	69	123
JS30	241	6	87	21	216	2.1	28	8	12	0.5	435	2.7	3.5	51	59	117
JS31	250	6	93	21	207	2.4	28	5	12	0.4	447	2.7	3.4	49	57	90
JS32	109	5	104	23	146	1.7	26	5	11	0.4	346	2.2	2.3	46	67	14
JS33	108	5	102	21	134	1.5	26	4	11	0.4	342	2.3	2.3	47	59	21
JS34	118	6	101	20	137	1.4	24	4	12	0.4	320	2.6	2.2	47	58	26
JS36	192	10	101	25	366	1.2	30	10	23	0.3	214	5.1	1.6	69	65	116
JS37	249	18	96	32	559	1.7	46	12	34	0.5	166	7.7	2.0	108	79	216
JS38	267	21	145	34	631	1.8	52	13	38	0.6	135	8.6	1.9	123	89	291
JS40	333	23	155	29	905	2.2	43	16	61	0.5	103	10.0	1.9	126	89	490
JS42	322	23	133	30	908	2.2	44	15	62	0.5	102	10.2	2.0	130	86	458
JS43	282	18	130	23	737	1.6	35	12	50	0.4	89	7.6	1.4	104	68	460
JS44	118	7	102	20	259	1.6	29	7	17	0.5	362	3.1	2.3	63	55	69
JS45	122	7	84	17	213	1.3	27	5	16	0.2	328	2.9	2.0	55	50	78
JS46	149	10	120	23	305	1.7	35	6	23	0.4	358	4.3	2.8	76	65	96
JS47	144	10	120	22	308	1.6	36	6	22	0.5	382	4.2	2.8	79	64	105

Table 0.8 Trace element concentrations in two dust samples and seven rock samples

Sample No.	Ba	Co	Cr	Cu	Mn	Mo	Ni	Pb	Rb	Sb	Sr	Th	U	V	Zn	Zr
	mg/kg															
Dust Nov	306	13	102	92	411	3.3	40	40	34	4.5	317	5.3	3.1	69	440	149
Dust March	307	12	102	107	403	3.2	52	46	36	12.3	292	4.7	2.6	69	995	125
JS4 Rock	33	6.6	1.8	6	<100	7	0.5	12	0.6	1.4	185	0.3	0.7	4	11	< 100
JS8 Rock	6	8.4	0.6	6	<100	3	<0.2	12	0.9	2.5	7.5	0.4	0.3	9	10	< 100
JS10 Rock	5	7.8	0.8	5	<100	4	0.4	7	1.1	0.7	88	<0.2	1.2	4	12	< 100
JS17 Rock	24	14	2.3	24	<100	9	0.9	15	1.3	0.9	350	0.3	3.3	9	29	< 100
JS19 Rock	11	5.5	0.8	55	<100	14	1.4	21	0.8	2.1	271	0.3	3.6	22	29	< 100
JS21Rock	5	10.1	1.0	16	<100	4	1.3	14	0.5	1.4	100	0.2	0.6	6	12	< 100
JS25Rock	5	7.9	0.6	25	<100	4	0.6	12	2.2	3.5	9	0.5	1.9	22	10	< 100

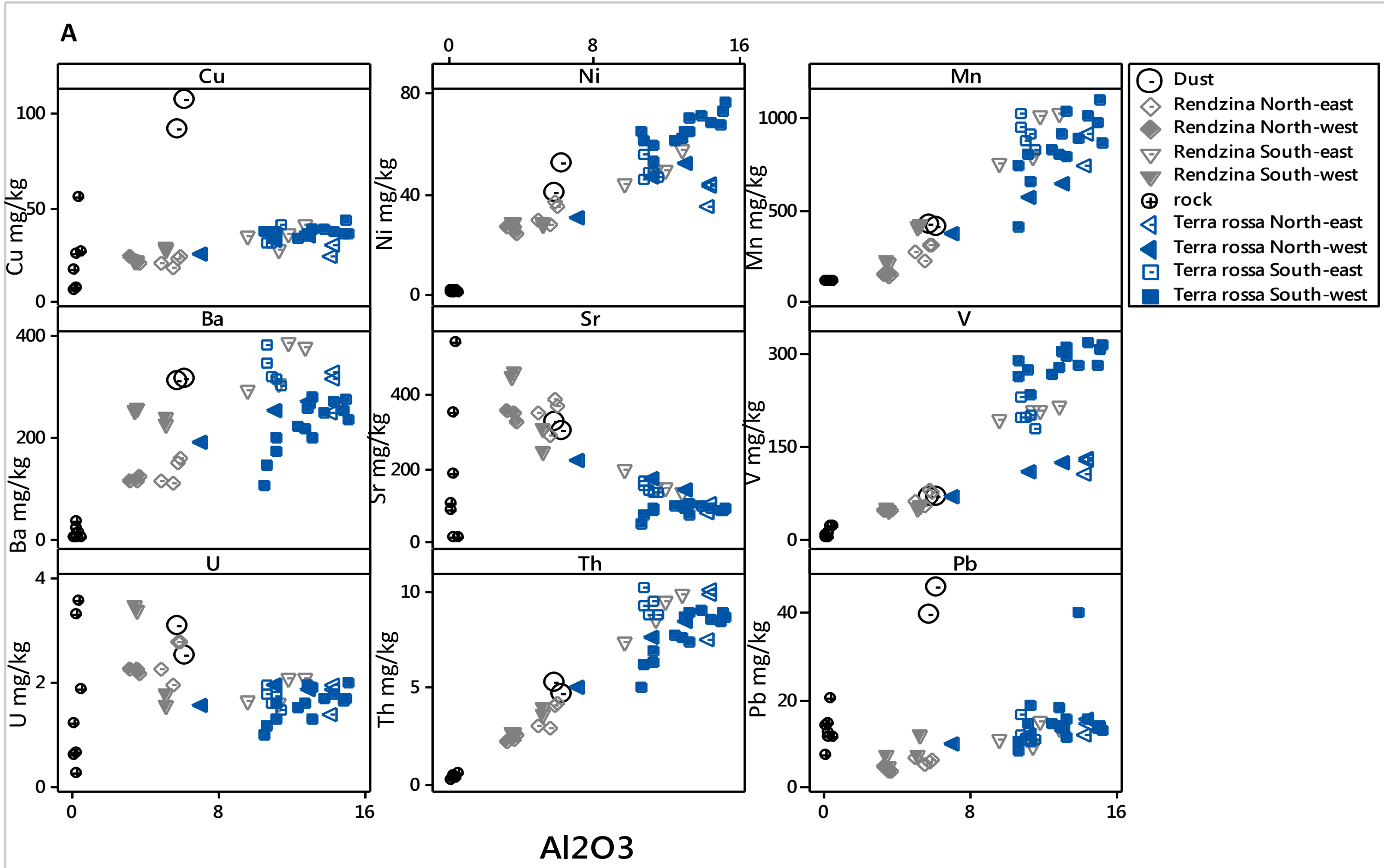


Figure 5.12: continue next page

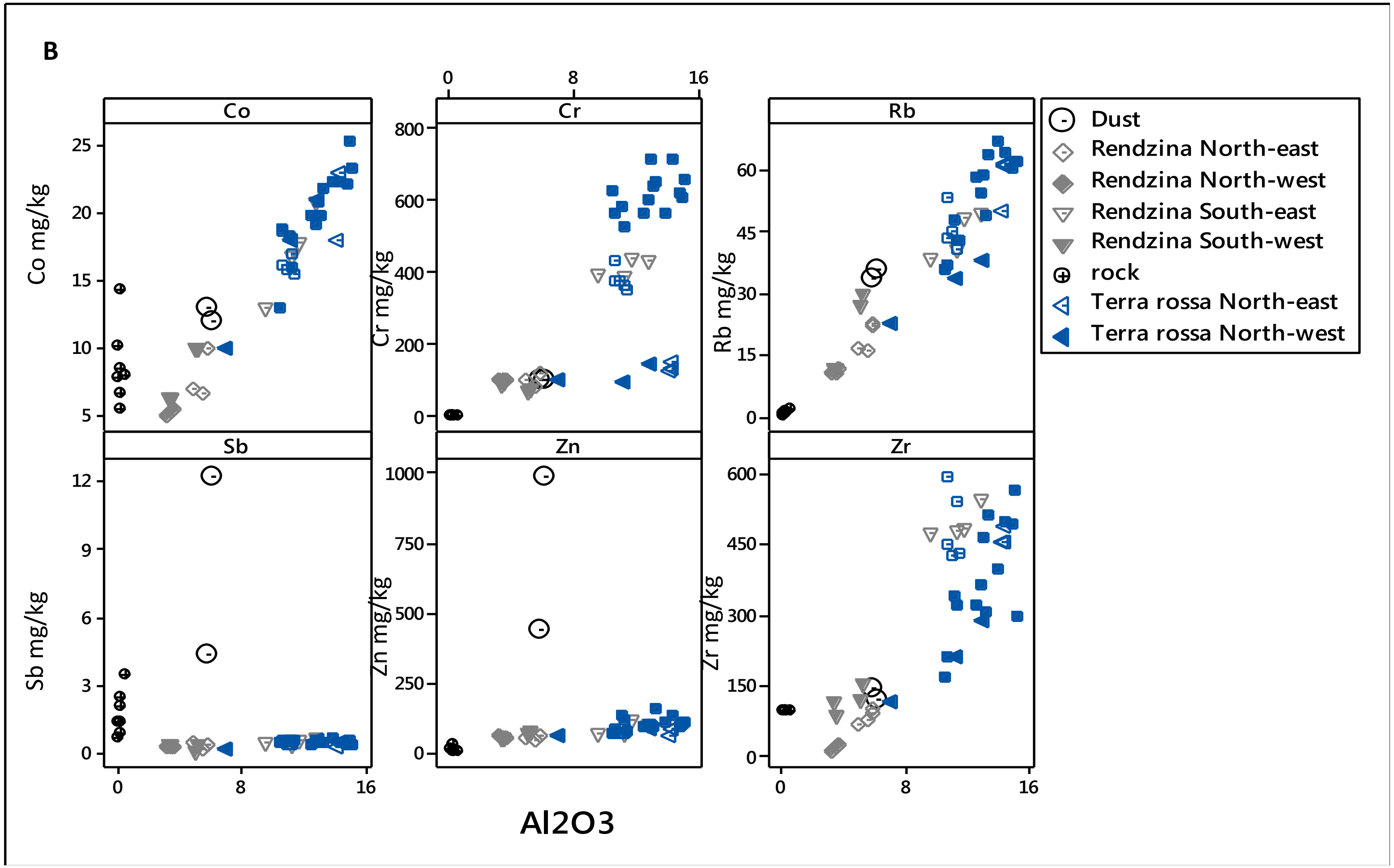


Figure 0.12 Plots between trace elements in mg/kg and Aluminum, Al (wt %) in (x axis) and each trace element (mg/kg) in (y axis). A. Cu, Ni, Mn, Ba, Sr, V, U, Th and Pb vs Al B. Co, Cr, Rb, Sb, Zn and Zr vs Al

In Battir 1 pedon, Barium, Cobalt and Molybdenum were stable all along the profile, except some increase of Barium below 100 cm (Fig.5.13.A). Uranium increased below 70 cm due to the leaching. Ba, Co, Mo and U were very close to the dust more than rock. In other hand uranium was leaching more than barium and other trace elements.

In Battir 2 pedon, Manganese Uranium Nickel and Vanadium (Fig.5.13.B) also indicated a composite profiles as mention before, in the major elements.. Mg, U, Ni and V in Battir 2 bedon were very close to the dust more than rock; this mean large amount of the soil especially the surface layer was come from dust. In addition, Manganese and Uranium more leaching than Nickel and Vanadium that were more staple.

Rendzina was similar to Terra Rossa in changing along the soil profile; (Fig. 5.14.A, Bait Iba and Fig.5.14.B, Tubas) Barium, Cobalt and Molybdenum decreased in a small rate at first 50 cm in Bait Iba and 40 cm in Tubas; then in the deeper increased (Fig.5.14.A). While Uranium decreased at a few surface centimeters then in the deeper decreased in big rate due to the leaching. Barium was leached in Rendzina this will discuss in dissection chapter.

Trace elements iron ratio was substituted trace elements aluminum ratio, because aluminum concentration in rock samples was very low and the ratio will be very high comparing with soil and dust samples and dust samples was polluted in aluminum. In addition, iron had a liner correlation with aluminum which means it was a staple elements in soil.

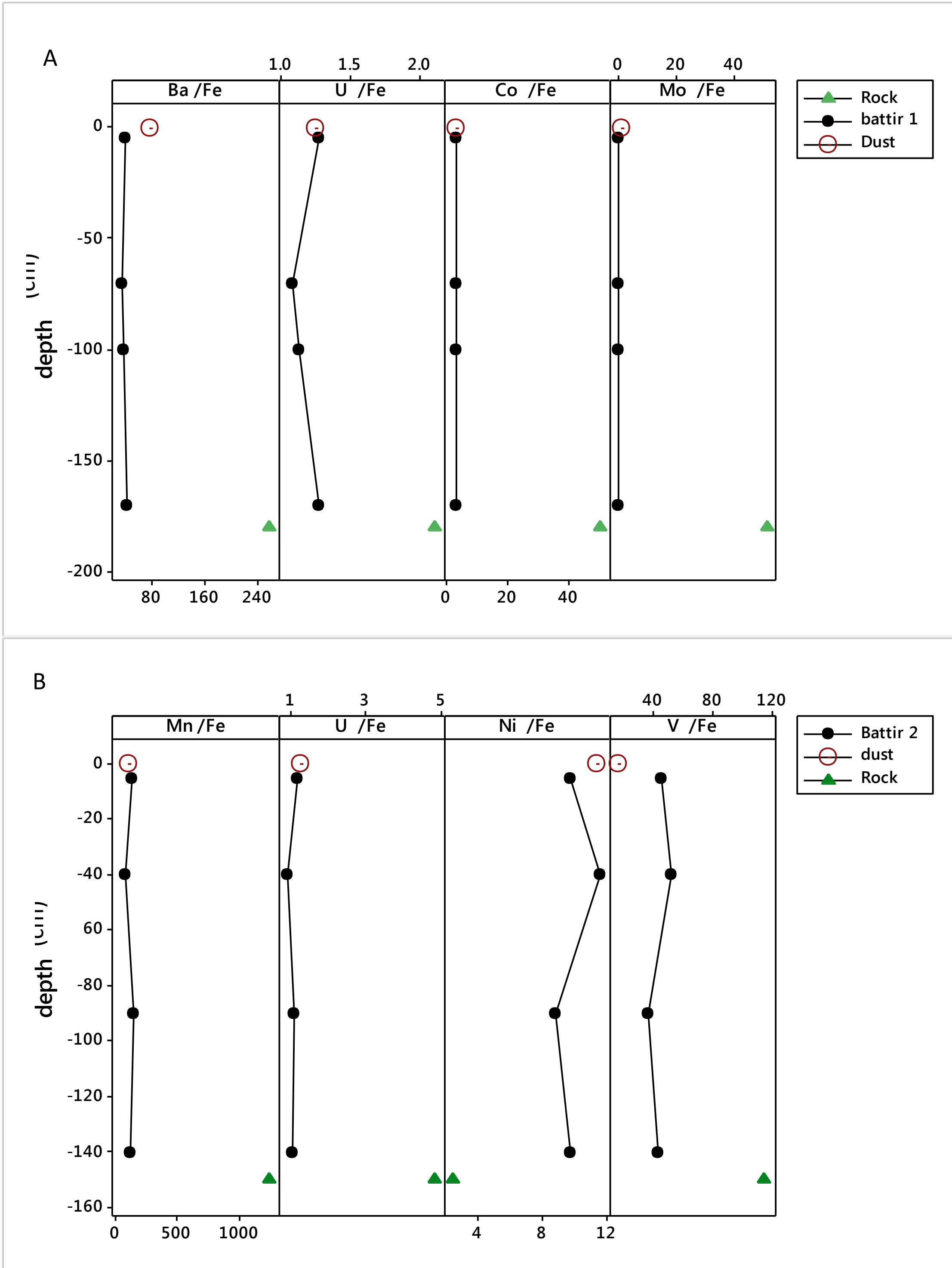


Figure 0.13 Trace elements concentration in Typical Terra Rossa profiles: A. Battir 1 pedon in west south. B. Battir 2 pedon in in west south.

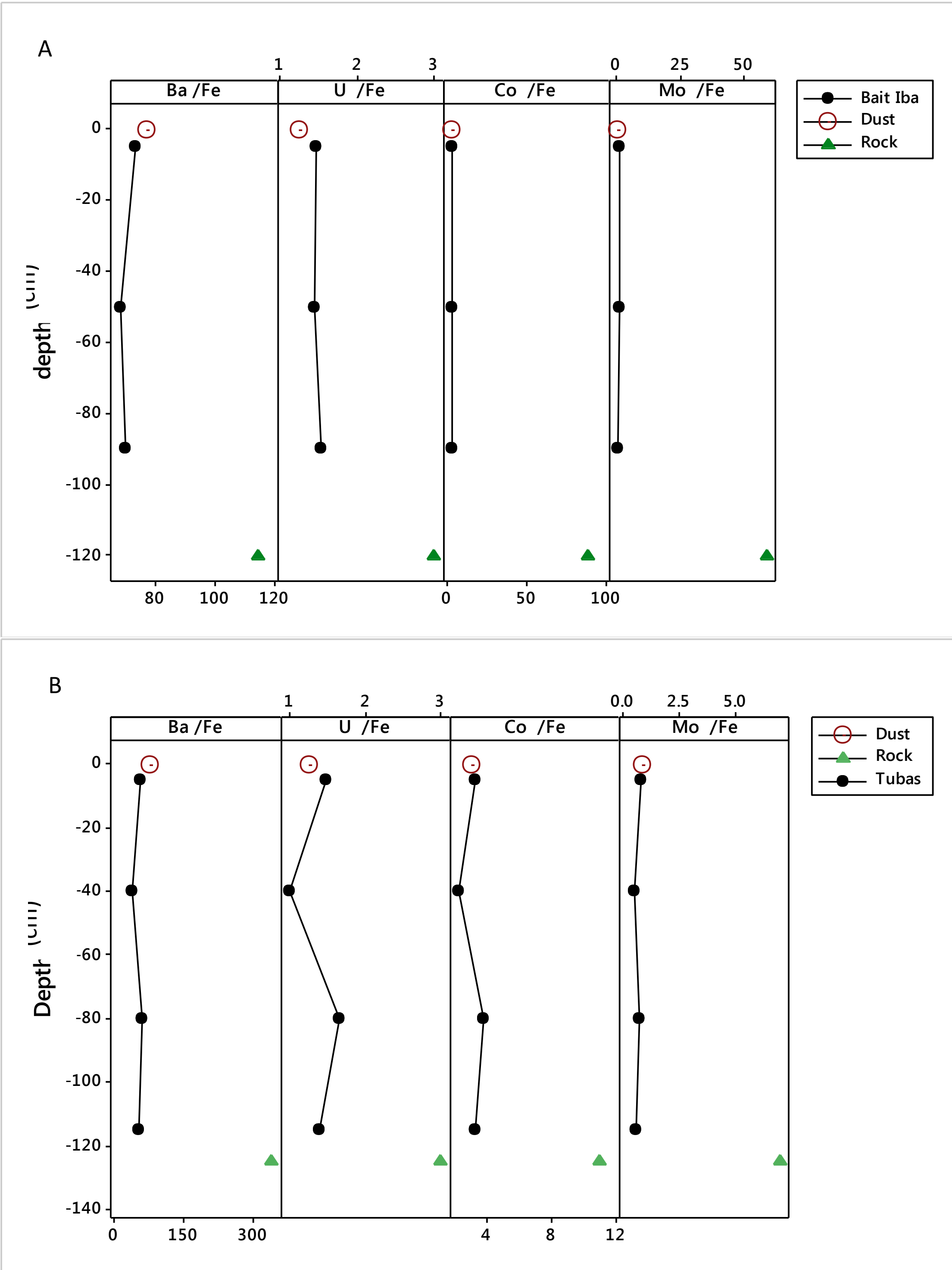


Figure 0.14 Trace elements concentrations in Pale Rendzina profile: A. Bait Iba pedon in west north. B. Tubas pedon in east north.

Vandium is a uniqe trace element. The knowledge on natural behaviour of vanadium in soils is rather poor. Vanduim was deffernt between two soil types and between east and west (Table 5.7; Fig 5.13.A). Its concentration was high in Typical Terra Rossa and less in Pale Rendzina (Fig 5.15). Zr is generally considered as an immobile element in soils and weathering profiles (Kurtz et al., 2000); from Zr/V ratio V is immobile evidenced by the relative depletion if Ca was the most leaching elements. Typical Terra Rossa in eastern site was high V concentration; while Pale Rendzina was poor V concentration. Vanadium separate the soil types and each site of soil pedon (Fig.5.16).

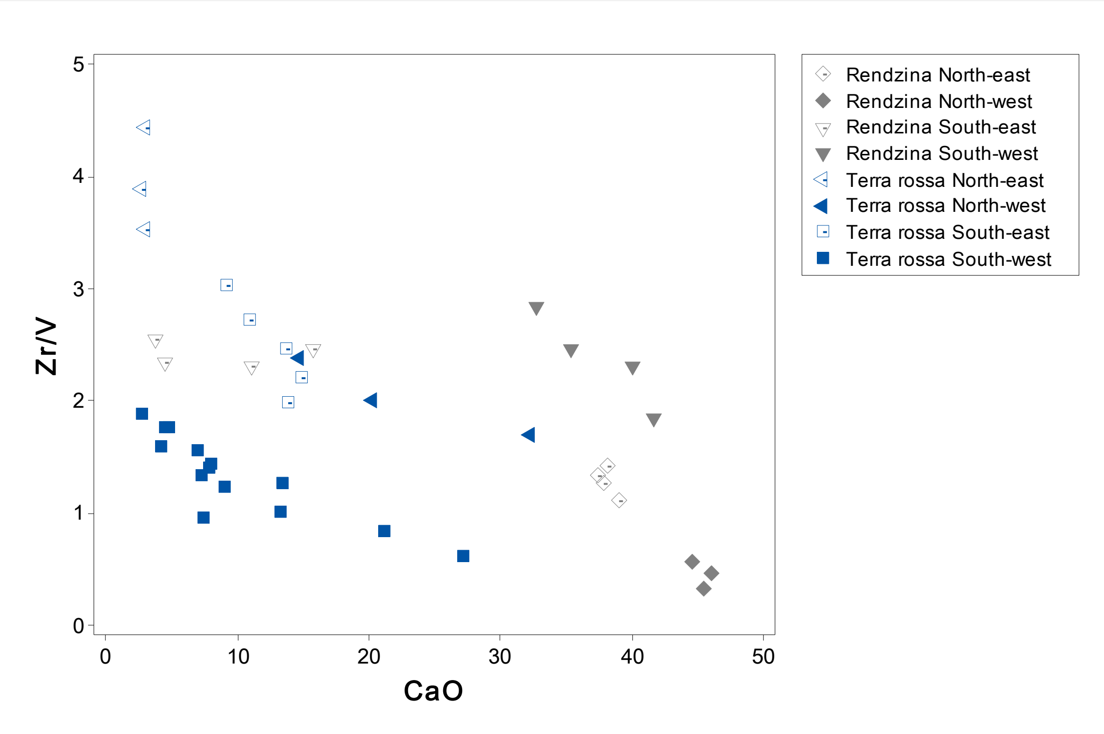


Figure 0.15 Plots of Zr/V ratio and CaO

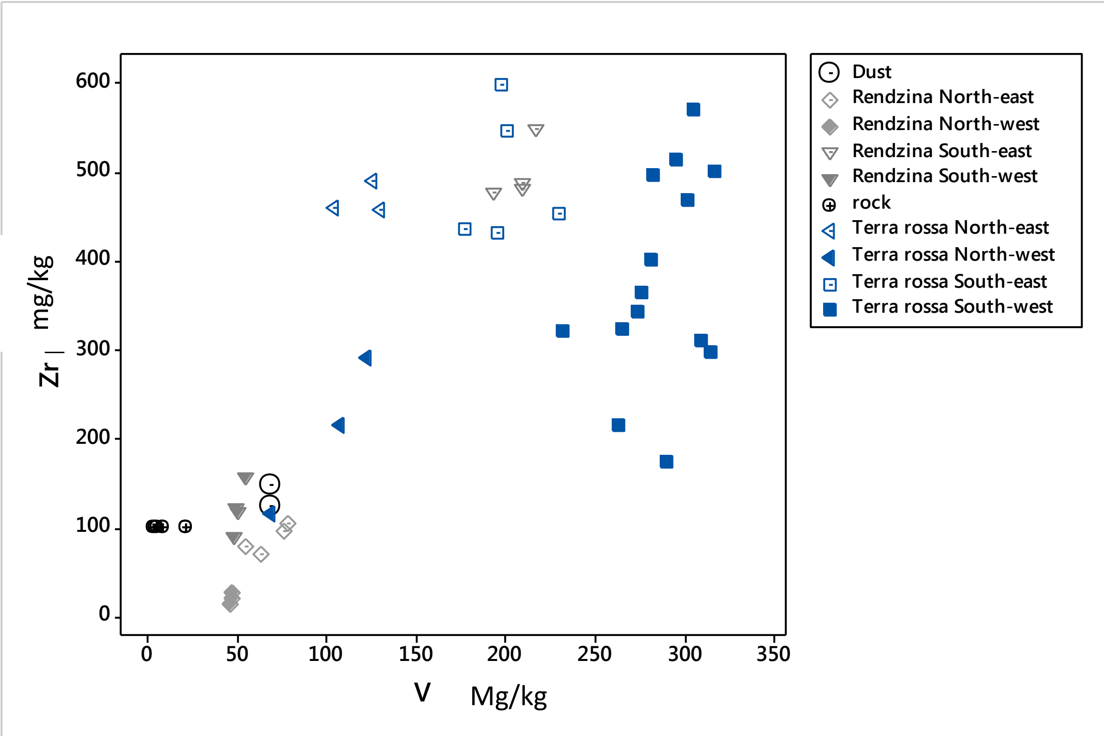


Figure 0.16 Plots of Zr and V

Some trace elements have a positive correlation with V: Zr, Ba, Mn, Co, Th and Cu and some trace elements have a negative correlation as Sr (Fig.5.17). Some trace elements plots show a clear separation for each type and site as Ba-V, Th-V, Mn-V and Co-V. However, the poor knowledge about Vanadium behaviour in soils prevents a meaningful discussion. Chapter 6.3 was discussed Vanadium in more details.

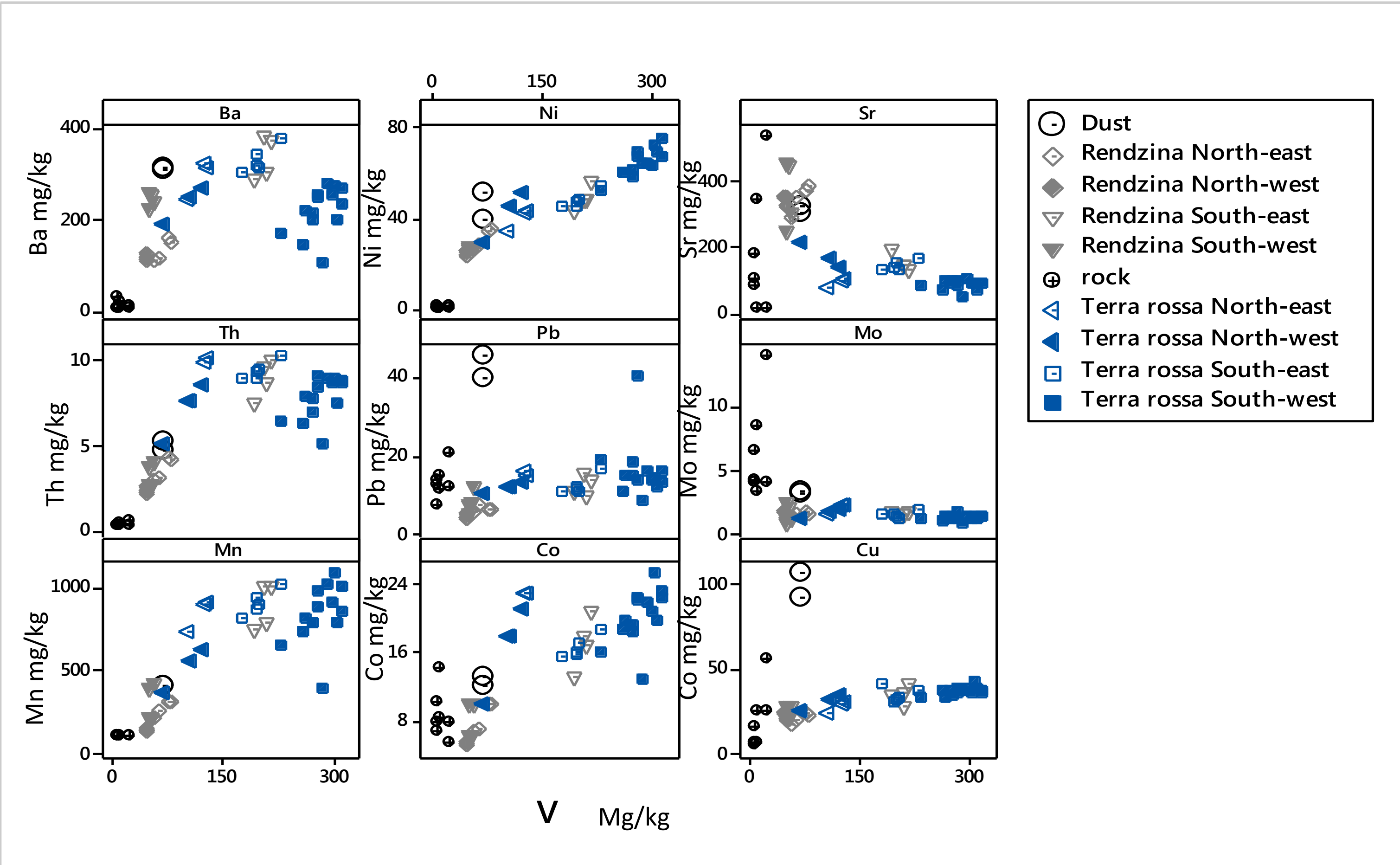


Figure 0.17 Plots of (Ba, Ni, Sr, Th, Pb, Mo, Mn, Co and Cu) Vs. Vanadium (mg/kg)

1.23.3 Rare earth elements

Rare earth elements results are presented in soil samples in (Tables 5.9) (Appendix G), dust and rock samples in (Table 5.10) (Appendix I). Total Rare earth elements results were heterogeneous and different between Terra Rossa and Rendzina, with some difference between east west, due to the precipitation , REE are mainly associated with clays so if there is more calcite there is less REE and vice versa.

Spider diagram lognormal patterns of the REE abundance normalized to chondritic values displayed differences between dust sample and rock samples (Fig. 5.18). In addition REE in soil is close to the dust more than rock (Fig 5.19).

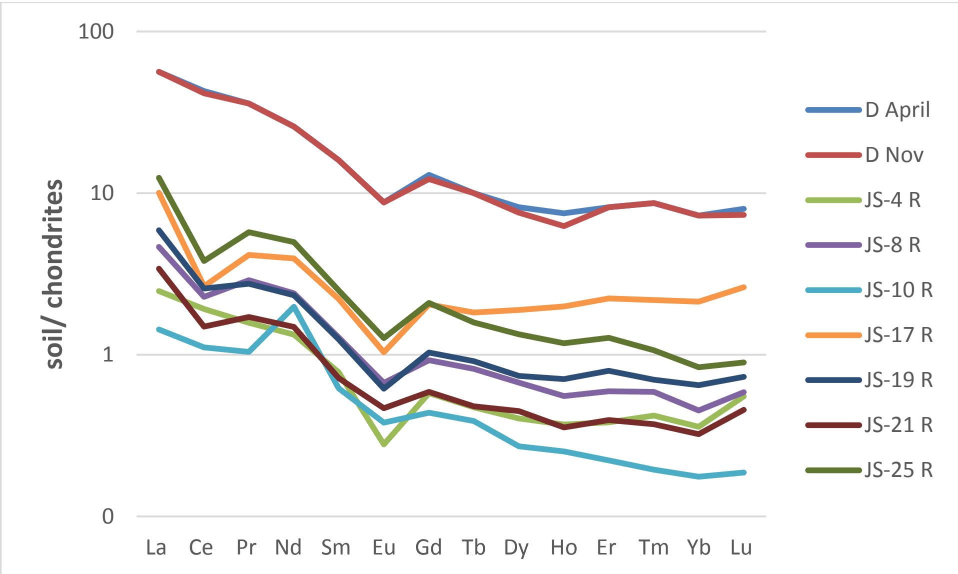


Figure 0.18 Spider diagram lognormal patterns of the REE abundance normalized to chondritic in rock and dust samples; D: dust.

Table 0.9 REEs concentration in 40 soil samples

Sample No.	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
mg/kg														
JS 1	37	72.5	9.2	36.	7.1	1.54	6.58	1.02	5.73	1.15	3.53	0.50	3.24	0.49
JS 2	38	73.0	9.4	36.	7.2	1.55	6.69	1.03	5.84	1.12	3.56	0.49	3.30	0.50
JS 3	39	75.1	9.7	38.	7.5	1.59	6.63	1.07	6.18	1.23	3.67	0.51	3.44	0.52
JS 4	38	75.5	9.6	37.	7.3	1.50	6.67	1.08	6.16	1.22	3.76	0.51	3.42	0.52
JS 5	38	73.2	9.5	36.	7.2	1.54	6.32	1.00	5.61	1.08	3.28	0.45	3.02	0.45
JS 6	32	61.6	7.8	30.	6.1	1.29	5.37	0.86	4.75	0.94	2.84	0.39	2.64	0.42
JS 7	41	82.1	10.0	39.	7.8	1.65	7.03	1.17	6.40	1.27	3.90	0.53	3.52	0.53
JS 8	22	36.9	5.4	20.	4.1	0.90	3.52	0.59	3.22	0.62	1.88	0.25	1.71	0.26
JS 9	30	57.8	7.5	29.	5.9	1.25	5.11	0.84	4.71	0.92	2.82	0.39	2.66	0.39
JS 10	34	66.3	8.5	33.	6.6	1.40	5.86	0.92	5.10	1.03	3.11	0.43	2.87	0.41
JS 11	29	56.7	7.2	28.	5.6	1.18	5.02	0.79	4.42	0.88	2.60	0.35	2.38	0.36
JS 12	38	73.2	9.6	37.	7.3	1.54	6.52	1.04	5.80	1.15	3.55	0.50	3.24	0.49
JS 13	34	67.3	8.6	33.	6.7	1.44	5.95	0.99	5.52	1.09	3.24	0.46	3.04	0.45
JS 14	22	55.7	5.6	20.	4.2	0.80	3.64	0.58	3.25	0.64	2.03	0.29	1.96	0.31
JS15	38	80	9.9	38.	7.1	1.6	6.8	1.10	6.4	1.25	3.78	0.62	3.82	0.53
JS16	36	76	9.7	37.	6.7	1.5	6.3	1.09	6.1	1.21	3.68	0.60	3.72	0.51
JS19	33	70	8.7	33.	6.1	1.4	5.6	0.96	5.3	1.04	3.19	0.52	3.28	0.47
JS20	29	60	7.6	28.	5.3	1.2	4.9	0.82	4.6	0.87	2.72	0.46	2.70	0.39
JS21	34	74	9.0	34.	6.4	1.3	6.0	0.98	5.6	1.09	3.35	0.55	3.38	0.48
JS22	33	71	8.8	33.	6.0	1.3	5.7	0.96	5.5	1.06	3.28	0.52	3.50	0.48
JS23	38	81	10.1	38.	6.9	1.5	6.5	1.03	5.9	1.15	3.61	0.59	3.65	0.50
JS24	33	72	8.7	33.	5.9	1.3	5.6	0.91	5.2	1.00	3.09	0.49	3.19	0.44
JS25	33	71	8.8	33.	6.0	1.3	5.7	0.95	5.3	1.01	3.01	0.50	3.05	0.43
JS26	15	30	3.7	15	3	0.7	3.3	0.46	2.7	0.5	1.7	0.27	1.5	0.22
JS27	14	28	3.5	14	2.7	0.6	3	0.43	2.5	0.5	1.6	0.25	1.4	0.21
JS30	13	21	2.9	11	2.3	0.5	2.7	0.39	2.3	0.5	1.5	0.24	1.4	0.21
JS31	12	20	2.7	11	2.1	0.5	2.6	0.35	2.1	0.5	1.4	0.23	1.3	0.21
JS32	10	17	2.4	9	1.8	0.4	2.1	0.29	1.6	0.3	1	0.17	0.9	0.14
JS33	11	19	2.5	10	1.9	0.5	2.2	0.32	1.8	0.4	1.1	0.18	0.9	0.14
JS34	12	21	2.7	11	2.2	0.5	2.4	0.33	1.9	0.4	1.2	0.18	1	0.15
JS36	18	35	4.4	17	3.5	0.8	3.9	0.52	2.9	0.6	1.7	0.28	1.6	0.23
JS37	31	63	7.7	30	5.9	1.4	6.3	0.89	4.9	1	3	0.47	2.7	0.39
JS38	33	67	8.2	32	6.4	1.5	7	0.96	5.3	1.1	3.3	0.52	2.9	0.44
JS40	38	81	9.5	37	7.4	1.7	8	1.12	6.2	1.2	3.7	0.6	3.4	0.5
JS42	40	85	9.9	39	7.8	1.8	8.5	1.19	6.5	1.3	3.9	0.62	3.5	0.53
JS43	29	61	7.1	27	5.4	1.2	5.9	0.81	4.6	0.9	2.7	0.44	2.5	0.37
JS44	12	23	2.9	11	2.3	0.5	2.5	0.34	2	0.4	1.2	0.2	1.1	0.16
JS45	13	24	2.9	11	2.2	0.5	2.4	0.33	1.8	0.4	1.1	0.18	1	0.14
JS46	17	33	4.1	16	3.2	0.8	3.5	0.48	2.7	0.6	1.7	0.27	1.4	0.22
JS47	17	33	4	16	3.1	0.7	3.5	0.48	2.7	0.6	1.6	0.26	1.4	0.22

Table 0.10 REEs concentrations in two dust samples and seven rock samples

Sample No.	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Mg/kg														
Dust Nov	18	35	4.3	16	3.2	0.7	3.5	0.5	2.7	0.6	1.8	0.26	1.6	0.24
Dust March	18	34	4.3	16	3.2	0.7	3.3	0.5	2.5	0.5	1.8	0.26	1.6	0.22
JS4 Rock	0.8	1.57	0.19	0.83	0.16	0.02	0.16	0.02	0.13	0.03	0.08	0.013	0.08	0.02
JS8 Rock	1.5	1.87	0.35	1.49	0.26	0.05	0.25	0.04	0.22	0.04	0.13	0.018	0.10	0.02
JS10 Rock	0.5	0.91	0.12	1.22	0.12	0.03	0.12	0.02	0.09	0.02	0.05	0.006	0.04	0.01
JS17 Rock	3.2	2.17	0.50	2.44	0.44	0.08	0.55	0.09	0.62	0.16	0.49	0.065	0.47	0.08
JS19 Rock	1.9	2.11	0.33	1.44	0.25	0.05	0.28	0.05	0.24	0.06	0.18	0.021	0.14	0.02
JS21Rock	1.1	1.22	0.20	0.92	0.14	0.04	0.16	0.02	0.15	0.03	0.09	0.011	0.07	0.01
JS25Rock	4.0	3.12	0.69	3.09	0.50	0.10	0.57	0.08	0.44	0.09	0.28	0.032	0.18	0.03

Typical Terra Rossa (Fig.5.20.A), which was in west south, had higher concentration of REEs than non-Typical Terra Rossa as Terra Rossa West-North (Fig. 5.20.B), which was similar to Pale Rendzina soil. In other hand, the REEs concentration in Terra Rossa East-South, which was less rain, was less concentration than the Terra Rossa in western site (Fig.5.20.C). This means that the precipitation and leaching affect REEs concentration.

Pale Rendzina (Fig.5.21.A), as west north, had less concentration of REEs, while Brown Rendzina, as Rendzina east south (Fig. 5.21.B), hads high concentration, similar to Typical terra rossa. Moreover, the REEs concentration in Rendzina in northern east site, which had less rain, was close to the Rendzina western site (Fig.5.21.C).

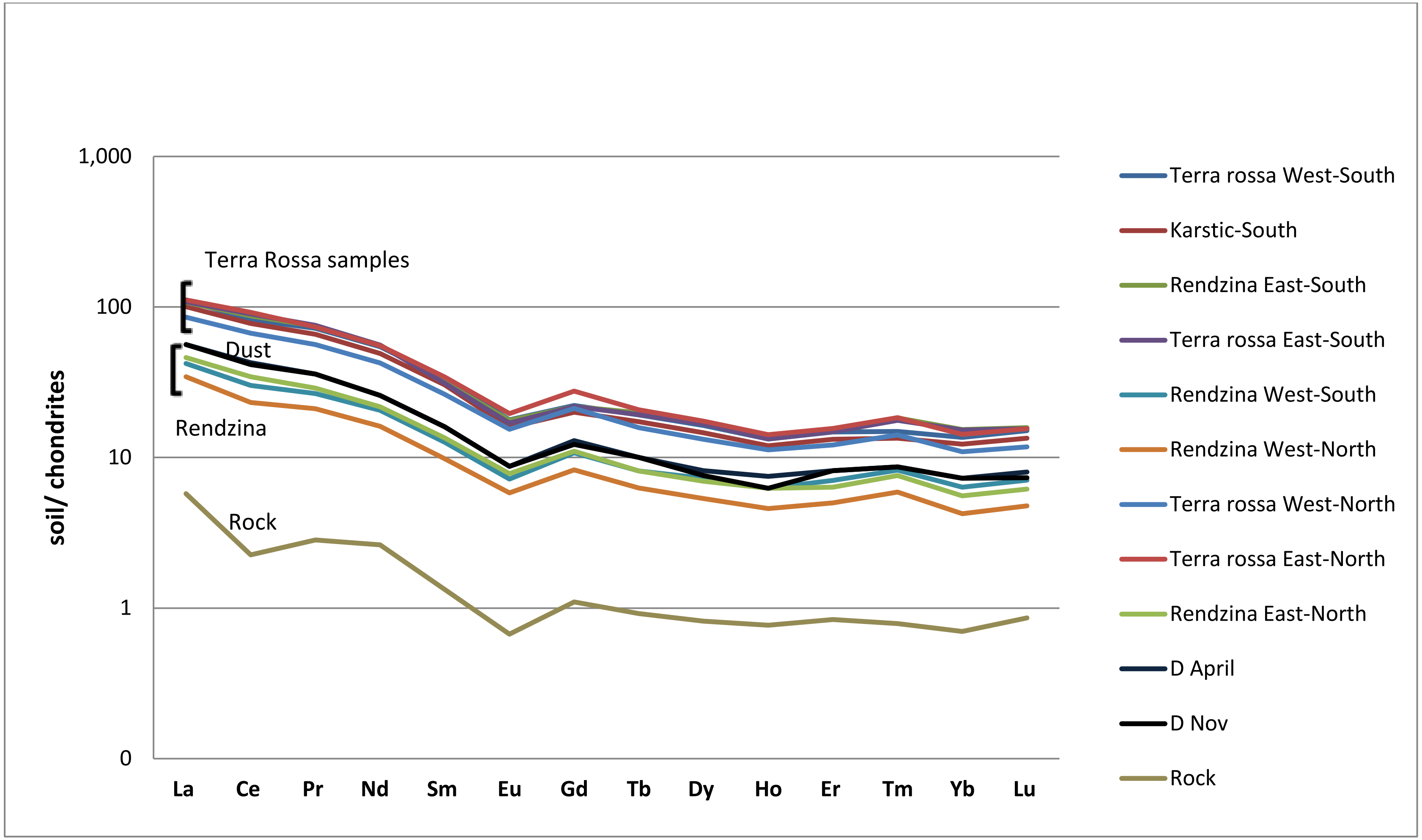


Figure 0.19 Spider diagram lognormal patterns of the REE abundance normalized to chondritic in average soil site pedon and rock and two dust samples

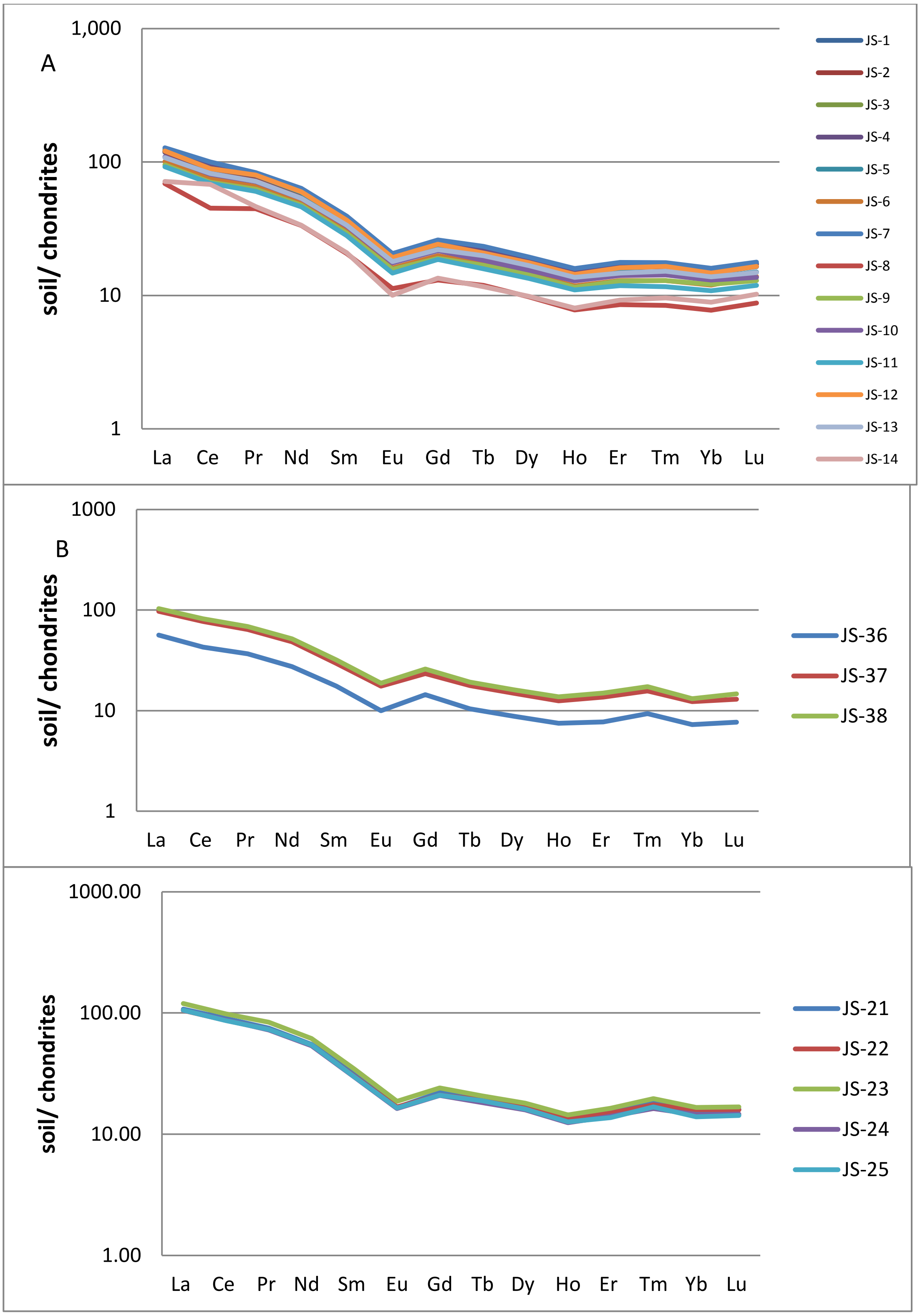


Figure 0.20 Spider diagram lognormal patterns of the REE abundance normalized to chondritic in Terra Rossa soil. A. Typical Terra Rossa western site B. non Typical Terra Rossa. C. Terra Rossa eastern site.

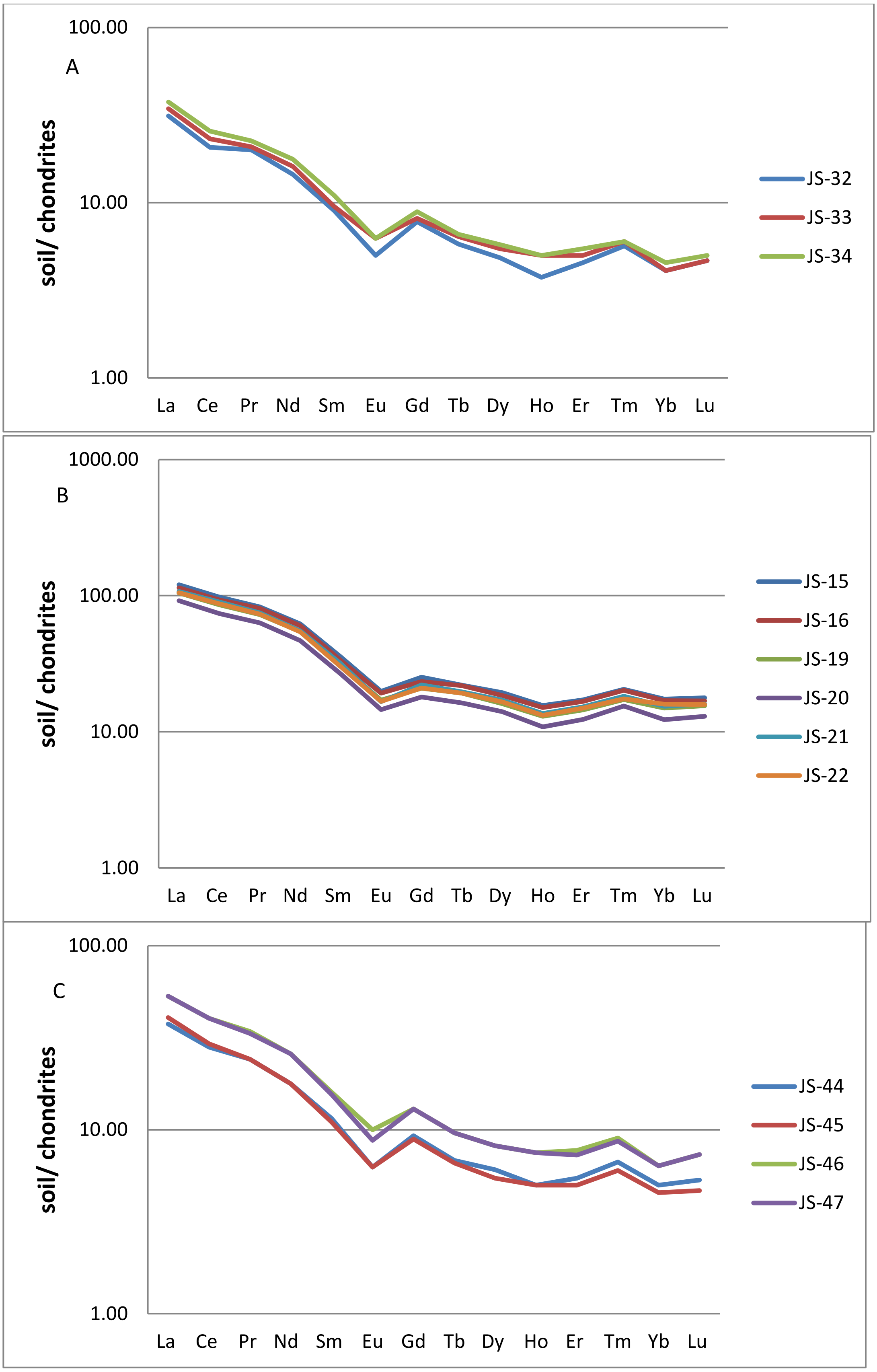


Figure 0.21 Spider diagram lognormal patterns of the REE abundance normalized to chondritic in Rendzina soil. A. Pale Rendzina western site B. Brown Rendzina. C. Brown Rendzina eastern site.

The REE composition of the soil, rock and dust samples, including the paparmeters light rare earth (LREE La-EU), heavy rare earth, (HREE, Gd–Lu), and the total REE are displayed in Tables 5.11 and 5.12. Total REE was highest in Terra Rossa soil samples, more than Rendzina, dust and rock (Fig 5.22). South Terra Rossa soil samples TREE were more than north terra rossa, whereas Rendzina samples, dust and rock were close to each other. In addition, LREE was richer than HREE in different way (Table 5.10 and 11), in Rendzina and dust it was more enrichment of the LREE, depletion of the HREE comparing with Terra Rossa and rock samples (Fig. 5.23)

The REE patterns show remarkable negative Ce-anomalies (Ce/Ce* =0.41-1.18), moderate to weak Eu-anomalies (Eu/Eu* = 0.42–0.73), and unusual enrichments REE (LaN/SmN = 3.13– 4.98, GdN/YbN = 5.67–11.62).

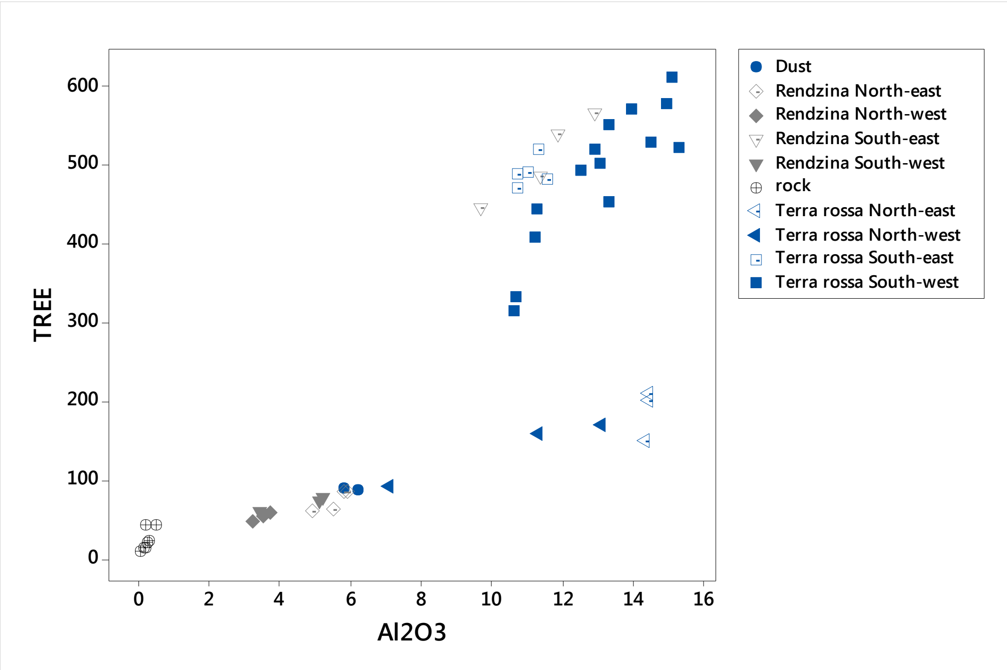


Figure 0.22 Plots of total rare earth elements (TREEs) and Aluminum (wt %)

Table 0.11 REEs correlations and anomalies in 40 soil samples

Sample No.	TREE	LREE	HREE	LaN/YbN	GdN/YbN	LaN/SmN	Ce anomalies	Eu anomalies
JS 1	501.29	372.62	128.67	8.01	1.65	3.31	0.93	0.65
JS 2	576.77	427.19	149.58	7.95	1.65	3.30	0.92	0.65
JS 3	527.99	389.74	138.26	7.93	1.57	3.29	0.91	0.65
JS 4	549.28	405.97	143.31	7.75	1.59	3.31	0.94	0.62
JS 5	521.82	391.68	130.14	8.81	1.70	3.37	0.91	0.67
JS 6	451.51	335.61	115.9	8.38	1.66	3.27	0.93	0.65
JS 7	609.8	452.24	157.56	8.00	1.63	3.27	0.97	0.65
JS 8	312.79	235.46	77.33	8.88	1.68	3.35	0.81	0.69
JS 9	406.95	301.1	105.85	7.86	1.56	3.25	0.92	0.67
JS 10	492.4	368.23	124.17	8.38	1.66	3.30	0.92	0.65
JS 11	443.2	333.3	109.9	8.52	1.72	3.28	0.93	0.64
JS 12	570.36	426.94	143.42	8.23	1.64	3.30	0.91	0.65
JS 13	519.22	385.94	133.29	7.81	1.60	3.22	0.93	0.66
JS 14	331.07	250.14	80.92	8.05	1.52	3.42	1.18	0.60
JS15	564.68	416.79	147.89	6.92	1.45	3.39	0.98	0.66
JS16	539.59	396.15	143.44	6.74	1.38	3.41	0.97	0.69
JS19	485.56	360.84	124.73	7.03	1.40	3.41	0.98	0.67
JS20	445.04	329.63	115.41	7.46	1.47	3.44	0.97	0.66
JS21	518	381.92	136.08	7.00	1.44	3.38	1.00	0.63
JS22	488.49	356.21	132.28	6.58	1.31	3.48	0.99	0.67
JS23	470.82	341.47	129.34	7.21	1.45	3.47	0.98	0.65
JS24	488.86	361.47	127.39	7.26	1.44	3.55	1.00	0.65
JS25	482	355.9	126.1	7.57	1.51	3.52	0.99	0.66
JS26	78.05	67.4	10.65	6.87	1.79	3.13	0.96	0.65
JS27	72.69	62.8	9.89	6.88	1.75	3.24	0.96	0.61
JS30	59.94	50.7	9.24	6.38	1.57	3.53	0.82	0.58
JS31	56.99	48.3	8.69	6.35	1.63	3.57	0.84	0.62
JS32	47.1	40.6	6.5	7.64	1.90	3.47	0.83	0.60
JS33	51.94	44.9	7.04	8.40	1.99	3.62	0.87	0.71
JS34	56.96	49.4	7.56	8.25	1.96	3.41	0.88	0.63
JS36	90.43	78.7	11.73	7.73	1.99	3.21	0.94	0.63
JS37	158.65	139	19.65	7.89	1.90	3.28	0.97	0.67
JS38	169.62	148.1	21.52	7.82	1.97	3.22	0.97	0.65
JS40	199.32	174.6	24.72	7.68	1.92	3.21	1.02	0.64
JS42	209.54	183.5	26.04	7.86	1.98	3.21	1.02	0.64
JS43	148.92	130.7	18.22	7.97	1.92	3.36	1.02	0.62
JS44	59.6	51.7	7.9	7.50	1.85	3.26	0.93	0.61
JS45	60.95	53.6	7.35	8.94	1.96	3.69	0.93	0.63
JS46	84.97	74.1	10.87	8.35	2.04	3.32	0.94	0.69
JS47	84.56	73.8	10.76	8.35	2.04	3.43	0.96	0.62

Table 0.12 REEs correlations and anomalies in tow dust samples and seven soil samples

Sample No.	TREE	LREE	HREE	La/Yb	GdN/YbN	La/Sm	Ce anomalies	Eu anomalies
Dust Nov	88.4	77.2	11.2	7.73	1.78	3.52	0.95	0.61
Dust March	86.88	76.2	10.68	7.73	1.68	3.52	0.92	0.63
JS4 Rock	11.89	8.35	3.53	6.92	1.61	3.18	0.97	0.42
JS8 Rock	19.35	14.17	5.19	10.31	2.04	3.64	0.62	0.62
JS10 Rock	8.68	6.56	2.12	8.14	2.48	2.32	0.91	0.73
JS17 Rock	40.91	24.02	16.88	4.72	0.96	4.55	0.41	0.49
JS19 Rock	21.65	15.39	6.26	9.10	1.60	4.72	0.64	0.54
JS21Rock	12.68	9.27	3.41	10.55	1.83	4.75	0.62	0.72
JS25Rock	40.91	30.66	10.25	14.84	2.50	4.98	0.45	0.55

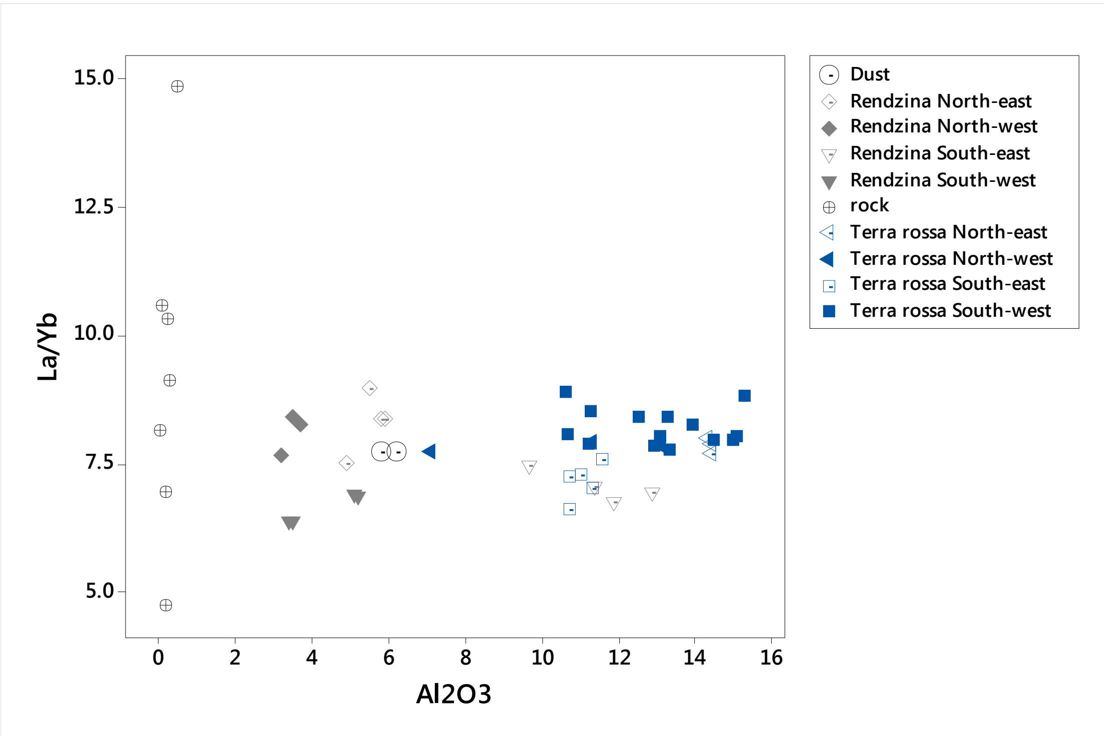


Figure 0.23 Plots between Lanthanum (LREE) and Ytterbium (HREE)

In battir 1 pedon, LREE/ HREE (La/Yb) and Eu anomalies increased at first 70 cm then it almost become staple (Fig.5.24.A). TREE and Ce anomalies decreased at first 70 cm then it increased but TREE decreased again after 100 cm. All REE parameters, including Ce and Eu anomalies were very close to the dust more than rock and enforce observations presented above.

In battir 2 pedon, LREE/ HREE and Eu anomalies increased at first 40 cm then it decreased after 90 cm, after that increased again (Fig.5.24.B). While TREE and Ce anomalies decreased at first 40 cm then it increased, after that it decreased again after 90 cm.

Rendzina was similar to Terra Rossa in changing along the soil profile. Bait Iba pedon (Fig. 5.25.A), all REE items increased but TREE and Ce anomalies decreased at 50 cm. Tubas pedon; LREE/ HREE increased at first 40 cm then decreased while Eu anomalies increased too but after 80 cm it decreased (Fig.5.25.A). In other hand, TREE and Ce anomalies increased, Ce anomalies increased in small amount.

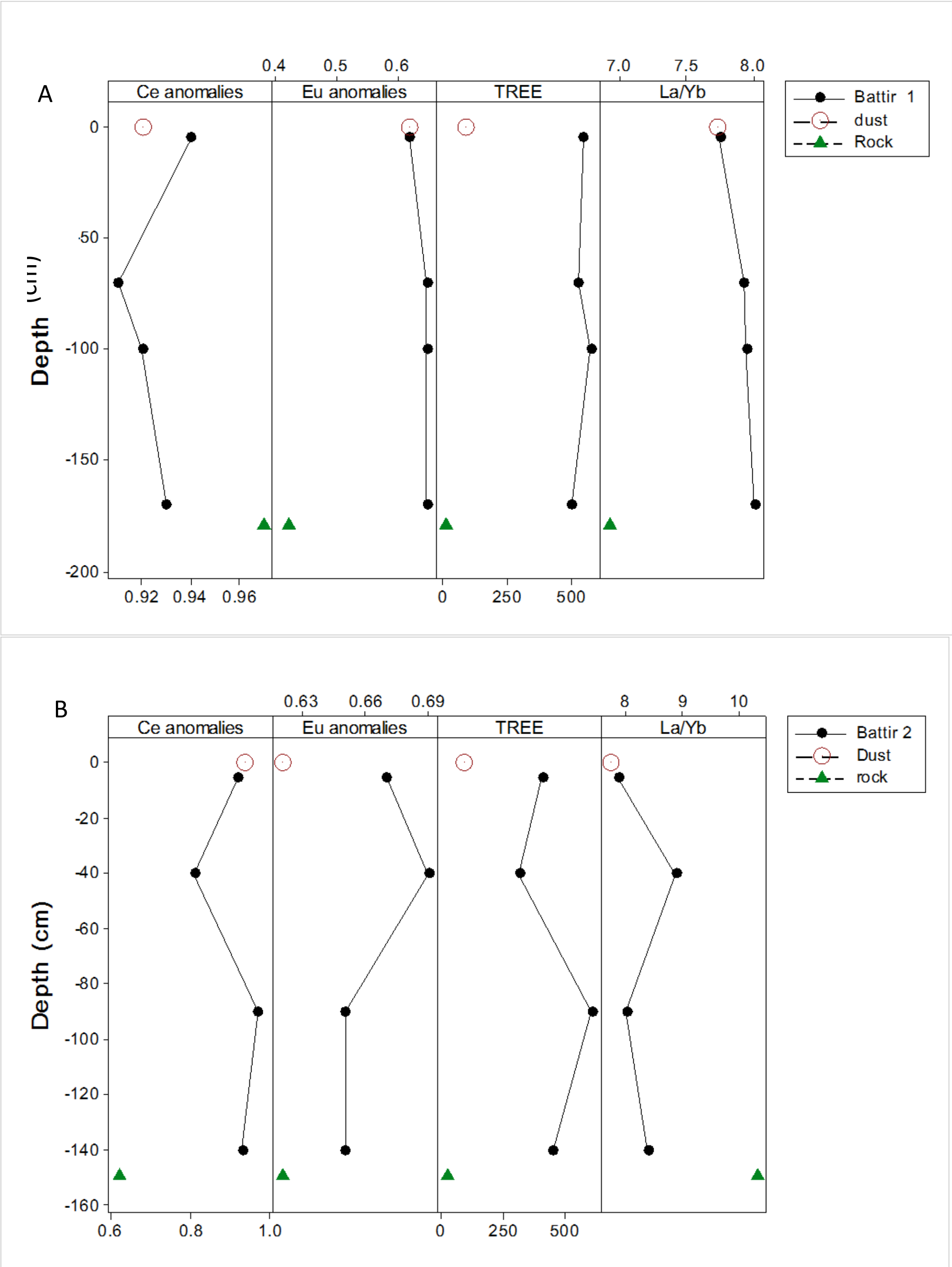
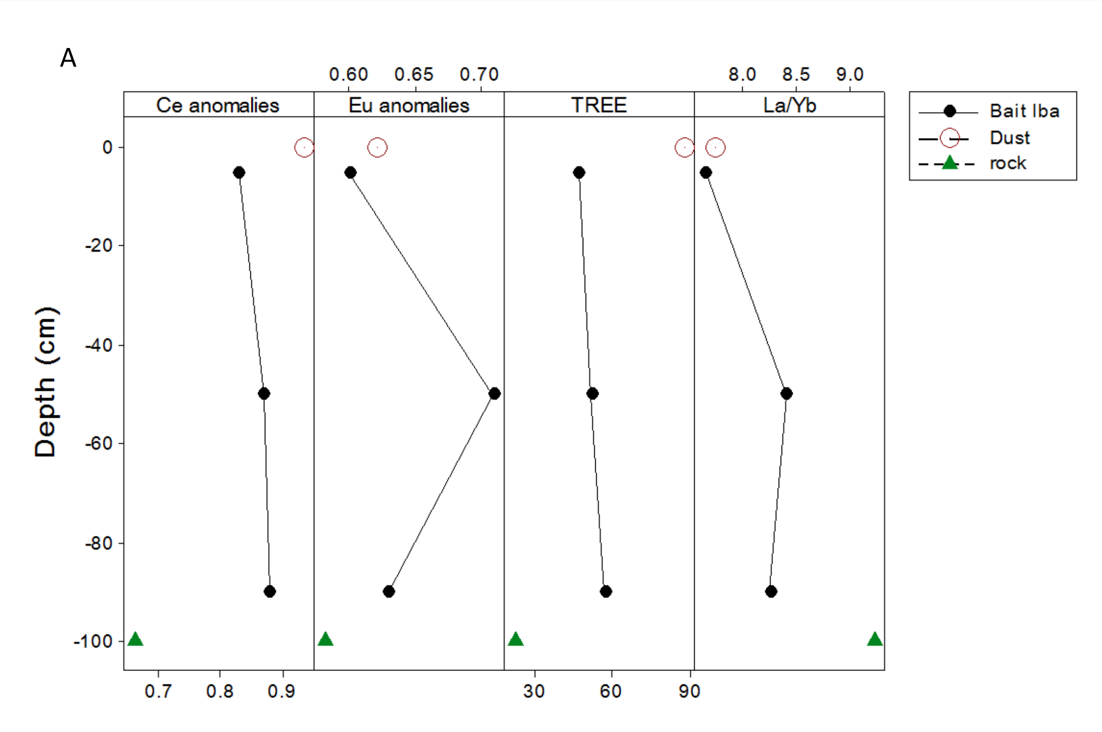


Figure 0.24 REEs correlations and anomalies in Typical Terra Rossa profiles: A. Battir 1 pedon in west south. B. Battir 2 pedon in in west south.



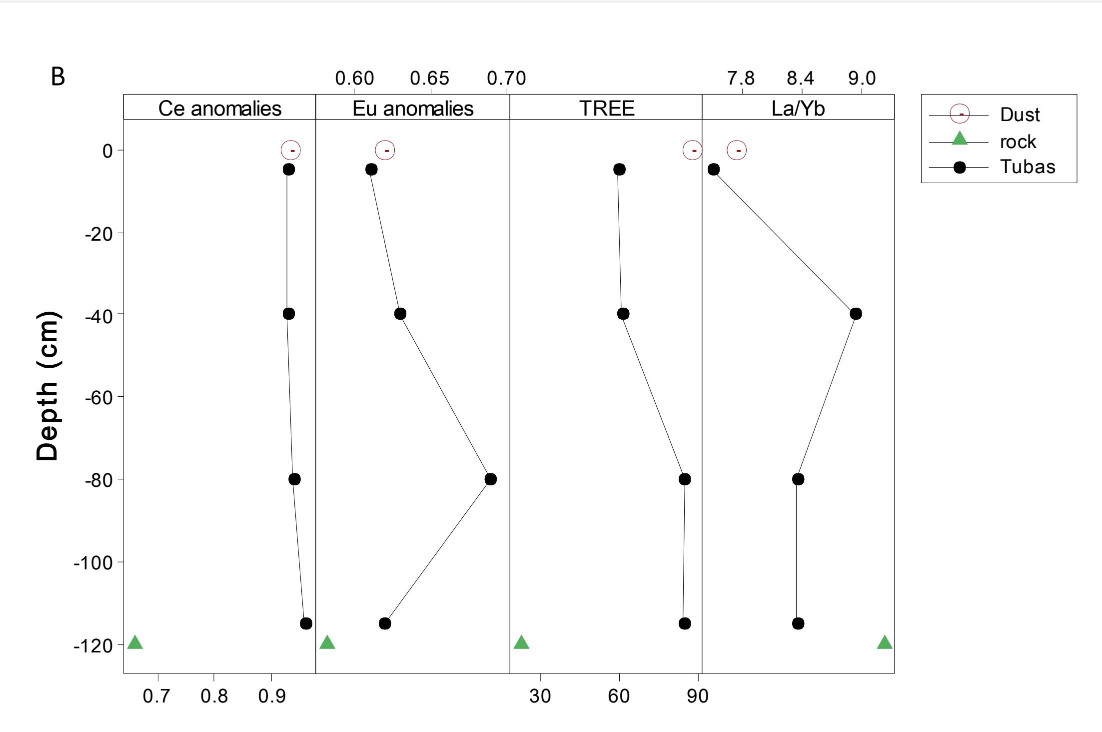


Figure 0.25 REEs correlations and anomalies in Pale Rendzina profile: A. Bait Iba pedon in west north. B. Tubas pedon in east north.

Chapter Six:

Discussion

1.24 Differences between soil types

The soil types ranged between Typical Terra Rossa and Pale Rendzina. Some Terra Rossa soils in Palestine look like Typical Terra Rossa but have relatively high calcite content and mineralogical and chemical characteristics which are close to Rendzina. On other hand, Brown Rendzina resembles Typical Terra Rossa.

A clear difference between Terra Rossa and Rendzina was evident by grain size, mineral composition and chemical composition (major, trace and REEs). In addition, each soil type showed clear differences between western flank and eastern flank.

The bed rock of each type, as mentioned before, affected each soil type and made the differences between them. In addition, the bed rock affected the age of soils as the soft calcareous rocks were easily eroded. Therefore, Pale Rendzina is younger and less affected by dust than Typical Terra Rossa, as expressed in the Aluminum-calcium plot (Fig. 6.1) and it develop over soft rocks. Pale Rendzina is less leached and less affected by dust because and has more calcium compared with Typical Terra Rossa which is leached, older and more affected by dust. In other hand, the more calcite and less clay soil which had to be less aluminum; but some samples had stone fragments that increase calcite concentration.

The chemical and mineral composition effect on the grain size (Fig 6.2). As mentioned before Typical Terra Rossa had more alumina, silicate and iron and less calcium, while Pale Rendzina had more calcium. In addition Pale Rendzina younger this mean coarse particle need more time to become finer, while Typical Terra Rossa was the older. Moreover, the dust that more contributed in Typical Terra Rossa was very fine so it had to make the Typical Terra Rossa finer. Furthermore, the leaching was more in Pale Rendzina this had to make the Pale Rendzina more coarse comparing with Typical Terra Rossa.

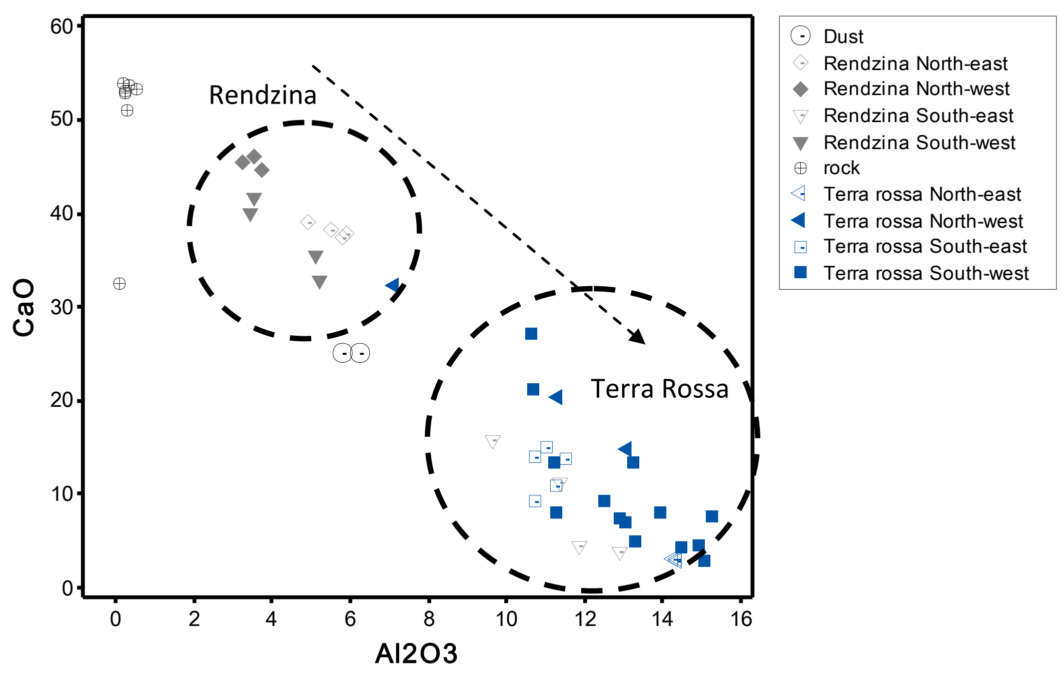


Figure 0.1 Plots of aluminum vs calcium in soil (wt %), dust and rock samples, Rendzina in gray while Terra Rossa in blue, Al and Ca has a negative strong correlation.

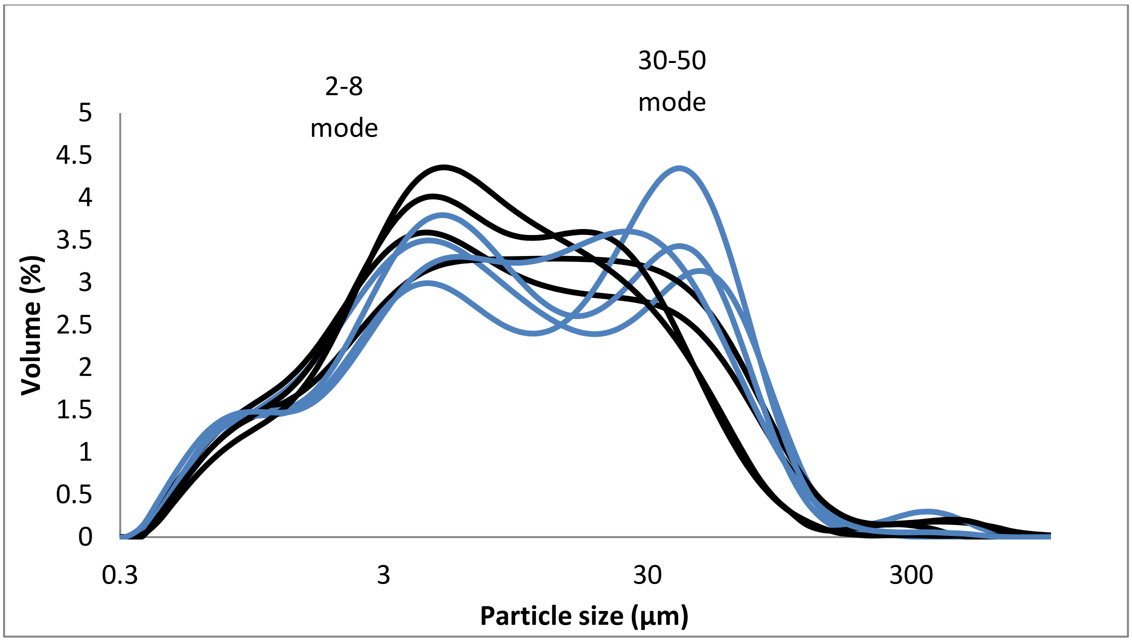


Figure 0.2 Average grain size of 40 soil samples groups. Terra Rossa soils were in black while Rendzina were in blue.

In other hand, the grain size and chemical composition results of this study was showed the important of dust, apparently its dominance, as a parent material. The published analyses of settled dust in this region showed the coarse mode of the grain size population, namely 11–40 µm; while The average grain size for this result 2-50 µm.

1.25 Leaching

Leaching, leaving quartz and clay minerals with aluminum, iron, manganese, other non-leachate elements in top soil, while the calcite and dolomite minerals with calcium, strontium and other leachate elements lost from the top layer layer.

Ca/Al ratio reflecting intensive soil leaching, for Terra Rossa profiles the leaching in top soil more than the subsoil because Ca/Al increased with the depth; as mention before Battir 2 two layer of soil. In contrast, for Rendzina profiles the leaching in top soil less than the subsoil because Ca/Al decrease (Fig.6.5).

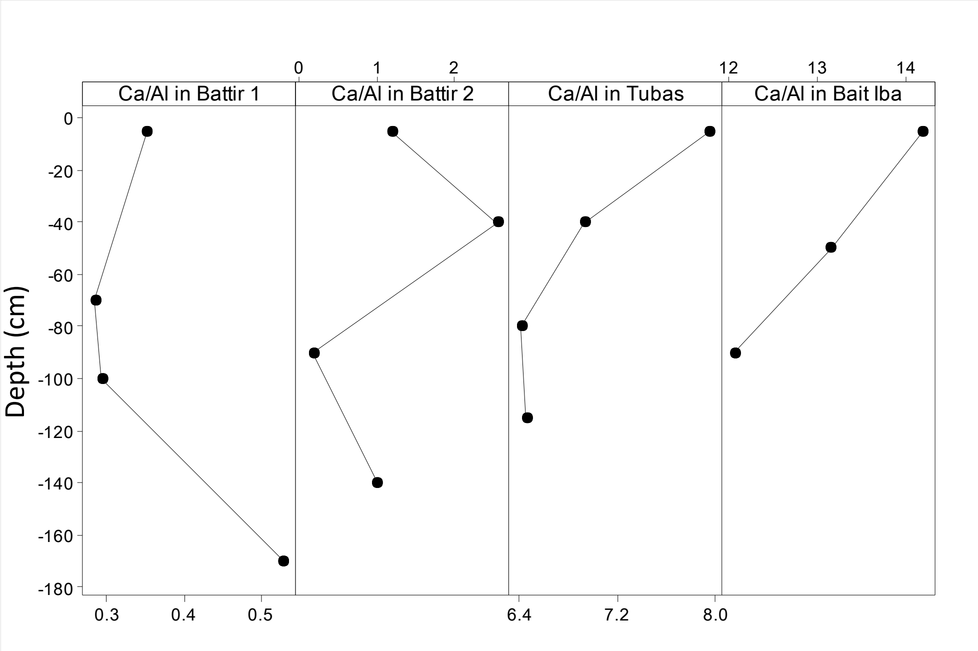


Figure 0.3 Ca/Al ratio with depth in different profiles, Ca/Al reflecting intensive soil leaching

Sr/CaO and Ba/CaO ratios, which are indicator of leaching, are positively good correlated with aluminum (Fig. 6.3) and Ba/Sr ratio, which is indicator of leaching, (Fig. 6.4), indicating that both strontium and barium are enriched in soils, relative to calcium, along with soil leaching and enrichment of aluminum (Sheldon and Tabor, 2009).

In (Fig 6.3), Battir1 was leached after 70 cm which the Ca/ Al increased. While Battir2 profile, which was tow layer of soil, soil leaching and enrichment of aluminum in upper layer. In other hand Bait Iba and Tubas profiles, which were Rendzina aluminum concentration was very comparing with Terra Rossa profiles.

From these ratios, leaching was higher in Typical Terra Rossa and lower in Pale Rendzina. In Terra Rossa North-east the calcite was very low so the Sr/CaO and Ba/CaO were high. The Ba/Sr ratio is 1.5 to 3.5 times higher in Typical Terra Rossa than in dust, and is > 3.5 time higher than in Pale Rendzina. Furthermore, Terra Rossa in western site, which is more rain, was more leaching than Terra Rossa in eastern site (Fig 6. 1,3 and 4).

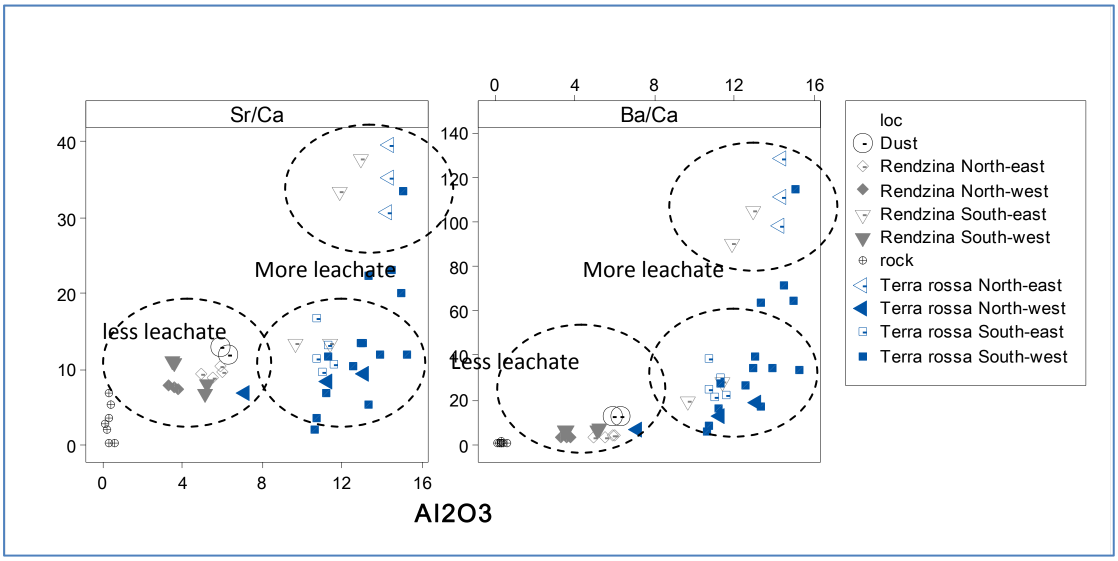


Figure 0.4 Plots between Sr/Ca and Ba/Ca with Aluminum (wt %), which is indicator of leaching. Al in (x axis) and the ratios in (y axis).

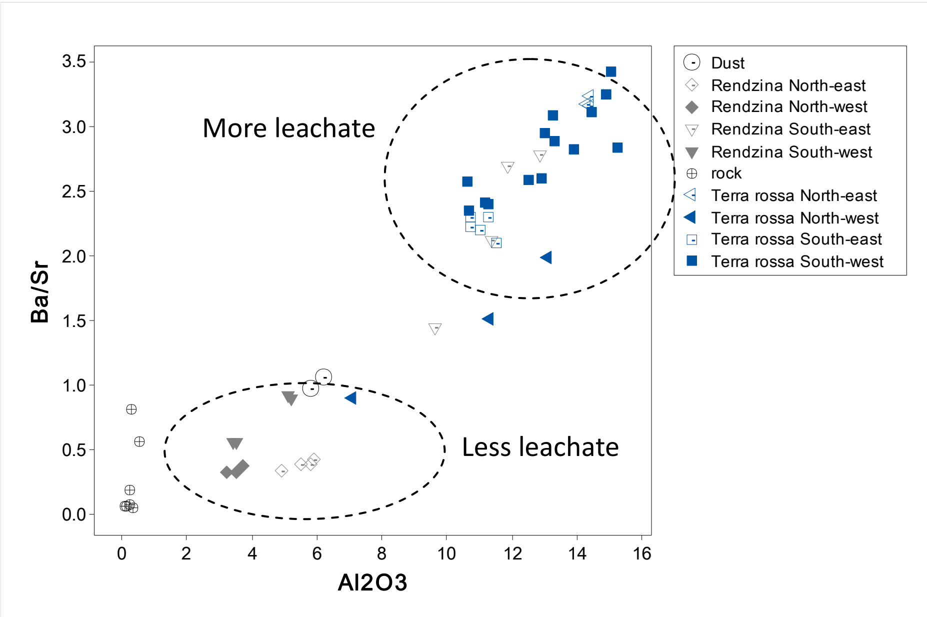


Figure 0.5 Plots between Ba/Sr with Aluminum (wt %), which is indicator of leaching. Al in (x axis) and the ratio in (y axis).

1.26 Aluminum and Vanadium:

Aluminum immobility is also evidenced by the relative depletion of Zr, which is generally considered as an immobile element in soils and weathering profiles. In certain cases mobility of zirconium in soils was observed and attributed to organic complexes, along with Al (Kurtz et al., 2000). Aluminum and zirconium have a strong positive correlation (Fig. 6.6); while Zr/Al ratio versus calcium have negative correlation. Aluminum is immobile most in eastern Typical Terra Rossa and less in western Pale Rendzina.

A limited research was conducted about vanadium in soils (Carlon, 2007). Vanadium is affected by rain (Fig. 6.7), and is similar to aluminum as it is considered to be well retained in soils (Cappuyns & Swennen, 2014).

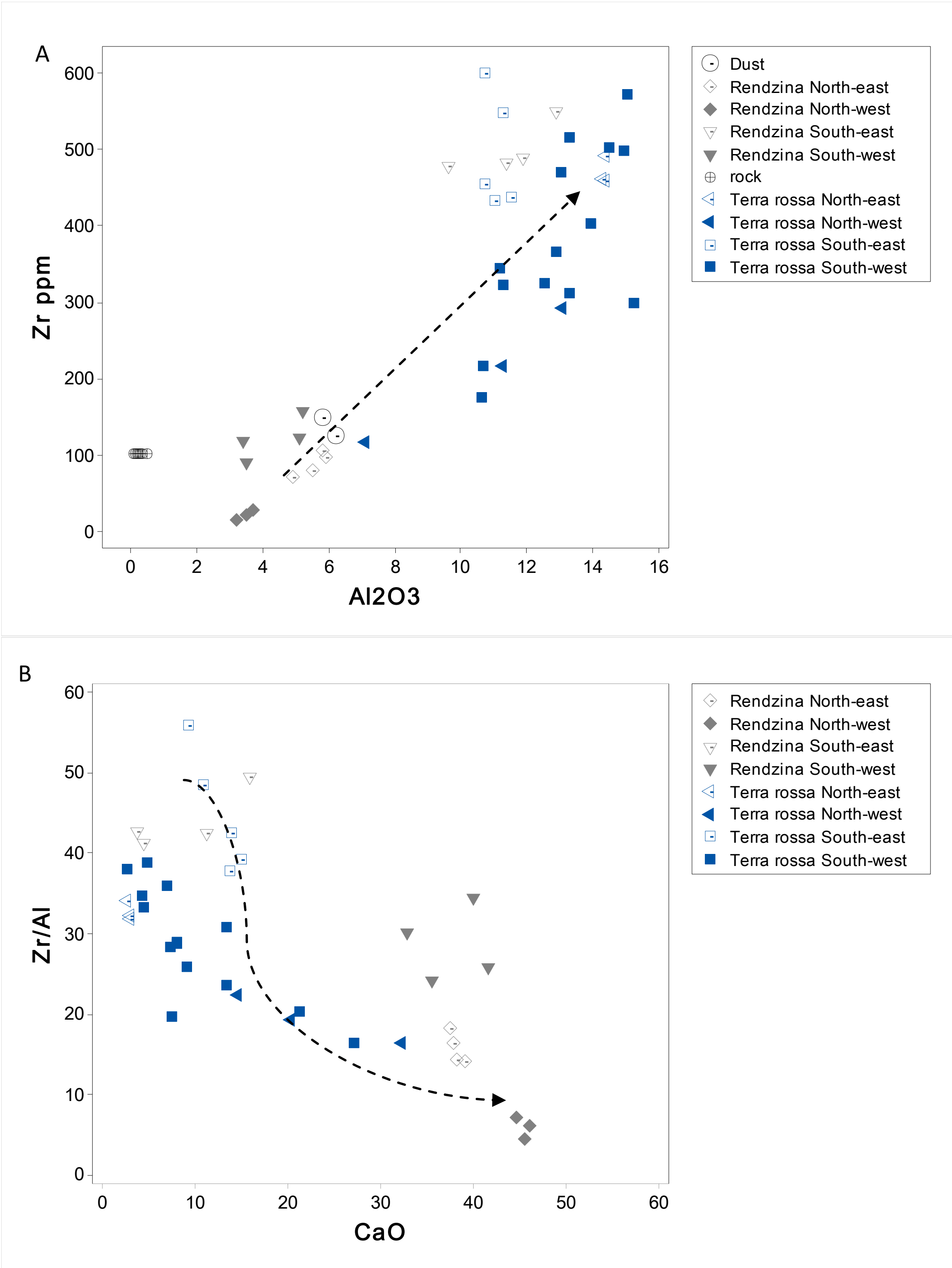


Figure 0.6 A. plots of Al (wt %) and Zr, B. plots of Zr/Al and Ca (wt %) which is indicate for rain.

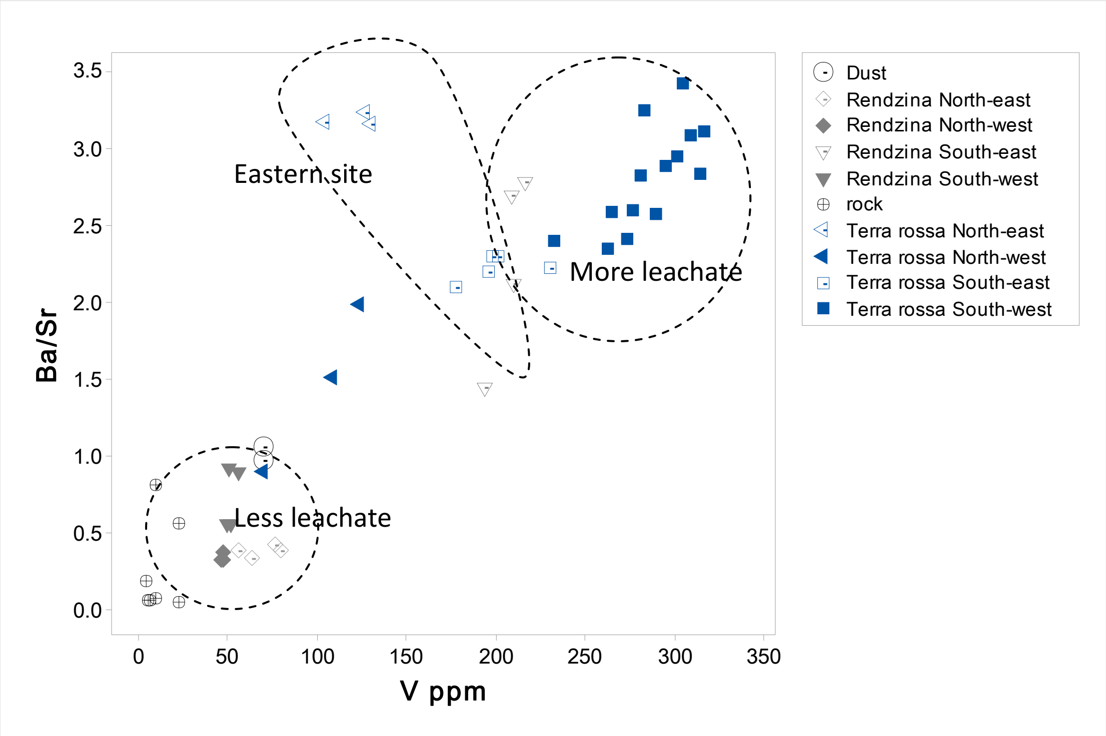


Figure 0.7 Plots between Ba/Sr with Aluminum, which is indicator of leaching. Al in (x axis) and the ratio in (y axis)

1.27 Soil Sources

Through the grain size, mineral composition and chemical composition (major, trace and REEs) results; the majority of soil come from dust as mentioned before, this is correspond with previous studies in this region. But through this study, dust is contributing the Typical Terra Rossa in eastern site, which is more rain, more than any soil type or pedon. While the Pale Rendzina was contributed by the dust in small amount comparing with Typical Terra Rossa, especially the western site.

Previous studies argued either for the insoluble residue of bedrocks, or for both dust, as the parent material of and Mediterranean soils, as mentioned before. The option is accepted today by soil scientists of this region, but the exact contribution of each source has not yet been quantified.

In general, dust is contributing more than 50% in Rendzina and more than 5/7 of the Terra Rossa soil.

Chapter Seven:

Conclusions

1. Through the grain size, mineral composition and chemical composition (major, trace and REEs) results the dust is the dominant parent material to the studied soils.
2. The aluminum , iron, vanadium and all elements that has a strong positive correlations with this three elements are indicated that elements are rather stable in the soils and mutually change their concentrations as carbonates are leached in the soil.
3. Adjacent profiles, like Battir 1 and Battir 2, Tubas and Bait Iba pedons may differ in grain size, mineral composition and chemical composition due to variability in carbonates amounts. It is suggested, by grain size, mineral composition and chemical composition (major, trace and REEs) profiles, that Battir 1 and Battir 2 these deep profiles are composed of two profiles, one on top of the other.
4. West versus East samples have finer grain size and higher concentrations of aluminum that might indicate enhanced soil clay formation under Mediterranean conditions.
   From the currents observations it comes out that the East soils are less leached, but difference in leaching is not as high.
5. A baseline of grain size, major and trace elements, REEs and minerals was added to soil science in Palestine in general and Mediterranean virgin mountain soil (Terra Rossa and Rendzina).

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Appendixes

A. Descriptive statistics for pH, Water saturation and TOC in soil samples

	pH	Water absorption	TOC
Mean	7.977	0.61375	1.2375
Standard Error	0.023075	0.008341182	0.164383
Median	7.97	0.61	1.2
Mode	7.94	0.6	0
Standard Deviation	0.14594	0.052754268	1.039647
Sample Variance	0.021298	0.002783013	1.080865
Kurtosis	0.213917	1.769317196	10.54681
Skewness	0.360281	0.829087701	2.491406
Range	0.66	0.27	6
Minimum	7.68	0.52	0
Maximum	8.34	0.79	6
Sum	319.08	24.55	49.5
Count	40	40	40

B. Descriptive statistics for grain size in soil samples

	Clay	Silt	Sand
Mean	34.77	57.76	7.48
Standard Error	0.89	0.92	0.74
Median	34.58	57.93	6.51
Mode	#N/A	#N/A	#N/A
Standard Deviation	5.63	5.84	4.71
Sample Variance	31.72	34.16	22.19
Kurtosis	0.09	-0.15	-0.35
Skewness	-0.27	0.17	0.81
Range	23.91	26.31	17.66
Minimum	23.16	46.03	0.55
Maximum	47.08	72.34	18.22
Sum	1390.67	2310.21	299.12
Count	40.00	40.00	40.00

C. Descriptive statistics for mineralogy in dust and soil samples

	Quartz	Clay	Calcite	Dolomite	K-Feldspare	Plagioclase
Mean	29.68	27.13	27.43	4.20	5.04	4.45
Standard Error	2.10	1.43	3.94	0.71	0.37	0.40
Median	32.50	27.50	20.00	3.00	5.00	5.00
Mode	35.00	20.00	4.00	2.00	5.00	5.00
Standard Deviation	13.42	9.13	25.21	4.53	2.40	2.57
Sample Variance	180.13	83.30	635.73	20.52	5.75	6.61
Kurtosis	-0.96	-0.59	-1.01	5.75	0.11	-0.68
Skewness	-0.53	0.01	0.64	2.23	0.15	-0.04
Range	45.00	35.00	79.00	20.00	10.00	10.00
Minimum	5.00	10.00	1.00	0.00	0.00	0.00
Maximum	50.00	45.00	80.00	20.00	10.00	10.00
Sum	1217.00	1112.50	1124.50	172.00	206.50	182.50
Count	41.00	41.00	41.00	41.00	41.00	41.00

D. Descriptive statistics for Major elements in soil samples

	SiO2	Al2O3	Fe2O3	TiO2	CaO	MgO	MnO	Na2O	K2O
Mean	39.58	10.19	5.36	0.89	18.68	1.85	0.08	0.25	0.94
Standard Error	2.62	0.62	0.35	0.06	2.33	0.15	0.01	0.02	0.07
Median	44.89	11.28	5.97	1.02	13.45	1.64	0.09	0.30	1.21
Mode	#N/A	3.50	1.60	0.50	2.90	1.00	0.02	0.10	0.40
Standard Deviation	16.56	3.92	2.23	0.38	14.77	0.92	0.04	0.14	0.42
Sample Variance	274.07	15.36	4.96	0.14	218.02	0.85	0.00	0.02	0.18
Kurtosis	-1.23	-1.05	-1.08	-1.05	-1.16	0.71	-1.03	-1.35	-1.34
Skewness	-0.48	-0.61	-0.57	-0.61	0.64	1.00	-0.42	0.15	-0.59
Range	52.95	12.04	6.72	1.23	43.41	3.87	0.12	0.44	1.18
Minimum	9.70	3.20	1.50	0.20	2.59	0.60	0.02	0.10	0.20
Maximum	62.65	15.24	8.22	1.43	46.00	4.47	0.14	0.54	1.38
Sum	1583.26	407.66	214.49	35.76	747.08	74.01	3.39	10.19	37.71
Count	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00

E. Descriptive statistics for Major elements in dust and rocks samples

	SiO2	Al2O3	Fe2O3	TiO2	CaO	MgO	MnO	Na2O	K2O
Mean	6.72	1.52	0.97	0.12	44.40	3.27	0.02	0.19	0.29
Standard Error	4.32	0.85	0.57	0.07	4.33	2.20	0.01	0.06	0.13
Median	0.20	0.26	0.12	0.01	52.80	0.65	0.01	0.10	0.10
Mode	0.20	#N/A	#N/A	0.01	24.90	#N/A	0.01	0.10	0.07
Standard Deviation	12.95	2.55	1.72	0.22	12.98	6.59	0.02	0.18	0.40
Sample Variance	167.72	6.48	2.95	0.05	168.48	43.45	0.00	0.03	0.16
Kurtosis	0.77	0.76	0.76	0.73	-1.32	8.28	0.73	2.78	1.17
Skewness	1.63	1.62	1.62	1.62	-0.94	2.85	1.62	1.93	1.68
Range	30.30	6.13	4.03	0.49	29.00	20.36	0.04	0.50	1.03
Minimum	0.20	0.07	0.07	0.01	24.90	0.24	0.01	0.10	0.07
Maximum	30.50	6.20	4.10	0.50	53.90	20.60	0.05	0.60	1.10
Sum	60.50	13.66	8.74	1.08	399.60	29.44	0.17	1.70	2.65
Count	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00

F. Descriptive statistics for trace elements in soil samples

	Ba	Co	Cr	Cu	Mn	Mo	Ni	Pb	Rb	Th	U	V	Zn	Zr
Mean	245.93	15.73	351.55	30.99	667.28	1.49	47.96	12.08	40.80	6.93	1.92	177.83	85.97	317.40
Standard Error	12.29	0.96	36.65	1.10	48.27	0.06	2.49	0.97	2.80	0.42	0.08	15.46	4.00	28.90
Median	249.50	17.41	377.76	32.76	784.76	1.46	48.10	12.00	43.15	7.73	1.82	196.91	77.86	332.95
Mode	118.00	10.00	102.00	21.00	#N/A	1.70	28.00	12.00	12.00	2.70	2.30	55.00	59.00	#N/A
Standard Deviation	77.70	6.07	231.79	6.93	305.27	0.35	15.74	6.11	17.68	2.66	0.51	97.81	25.29	182.76
Sample Variance	6038.06	36.83	53727.42	48.08	93187.00	0.12	247.72	37.38	312.52	7.07	0.26	9566.56	639.68	33402.56
Kurtosis	-0.73	-1.08	-1.64	-1.05	-1.21	0.52	-1.24	11.26	-1.08	-1.17	2.77	-1.57	0.58	-1.41
Skewness	-0.29	-0.45	0.11	-0.40	-0.51	0.48	0.01	2.46	-0.33	-0.57	1.41	-0.07	0.96	-0.25
Range	284.10	20.35	648.19	25.57	960.80	1.60	51.86	36.80	56.41	8.15	2.47	270.68	108.26	584.72
Minimum	108.50	5.00	70.00	17.00	134.00	0.80	24.00	3.70	11.00	2.20	1.03	46.00	50.00	14.00
Maximum	392.60	25.35	718.19	42.57	1094.80	2.40	75.86	40.50	67.41	10.35	3.50	316.68	158.26	598.72
Sum	9837.20	629.37	14062.02	1239.59	26691.32	59.60	1918.37	483.36	1632.04	277.05	76.63	7113.39	3438.68	12696.03
Count	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00

G. Descriptive statistics for trace elements in dust and rocks samples

	Ba	Co	Cr	Cu	Mn	Mo	Ni	Pb	Rb	Sb	U	V	Zn	Zr
Mean	78.17	9.51	23.54	37.43	168.22	5.72	10.80	19.86	8.59	3.25	1.92	23.86	172.08	108.22
Standard Error	43.32	1.00	14.83	12.88	45.13	1.21	6.73	4.55	5.00	1.20	0.43	8.82	113.00	5.79
Median	11.50	8.42	0.97	24.46	100.00	4.12	0.89	14.03	1.11	2.10	1.87	9.21	12.33	100.00
Mode	5.00	#N/A	102.00	#N/A	100.00	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	69.00	#N/A	100.00
Standard Deviation	129.97	3.01	44.48	38.64	135.39	3.62	20.18	13.66	14.99	3.61	1.28	26.46	339.01	17.38
Sample Variance	16892.94	9.05	1978.85	1492.92	18330.19	13.08	407.31	186.56	224.73	13.01	1.63	699.96	114927.09	302.19
Kurtosis	0.69	-1.19	0.73	-0.28	0.74	3.41	1.37	0.58	0.76	6.19	-1.85	0.24	4.92	3.86
Skewness	1.60	0.37	1.62	1.10	1.62	1.88	1.71	1.40	1.62	2.39	0.04	1.36	2.27	2.10
Range	302.50	8.75	101.40	102.17	311.00	10.88	51.80	38.68	35.53	11.60	3.34	64.98	984.90	49.00
Minimum	5.00	5.48	0.60	4.83	100.00	3.20	0.20	7.32	0.47	0.70	0.27	4.02	10.10	100.00
Maximum	307.50	14.23	102.00	107.00	411.00	14.08	52.00	46.00	36.00	12.30	3.60	69.00	995.00	149.00
Sum	703.50	85.56	211.89	336.89	1514.00	51.45	97.24	178.77	77.29	29.27	17.25	214.75	1548.71	974.00
Count	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00

H. Descriptive statistics for REEs in soil samples

	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Mean	28.13	56.07	7.00	27.12	5.26	1.15	5.09	0.79	4.43	0.88	2.67	0.41	2.52	0.37
Standard Error	1.66	3.53	0.43	1.66	0.32	0.07	0.28	0.05	0.26	0.05	0.15	0.02	0.15	0.02
Median	32.56	64.63	8.02	31.12	5.95	1.31	5.65	0.90	5.00	1.00	3.01	0.45	2.78	0.41
Mode	12.00	21.00	2.90	11.00	2.30	0.50	2.40	0.96	2.70	0.50	1.70	0.18	1.40	0.22
Standard Deviation	10.49	22.31	2.73	10.53	2.00	0.43	1.77	0.29	1.62	0.31	0.96	0.14	0.96	0.14
Sample Variance	110.09	497.69	7.47	110.81	4.01	0.18	3.12	0.08	2.64	0.09	0.92	0.02	0.91	0.02
Kurtosis	-1.31	-1.25	-1.33	-1.33	-1.26	-1.25	-1.07	-1.31	-1.33	-1.28	-1.33	-1.32	-1.35	-1.30
Skewness	-0.55	-0.59	-0.57	-0.56	-0.53	-0.49	-0.28	-0.49	-0.48	-0.46	-0.45	-0.28	-0.44	-0.49
Range	30.96	68.00	7.67	30.25	6.04	1.40	6.40	0.90	4.90	1.00	2.90	0.45	2.92	0.39
Minimum	10.00	17.00	2.40	9.00	1.80	0.40	2.10	0.29	1.60	0.30	1.00	0.17	0.90	0.14
Maximum	40.96	85.00	10.07	39.25	7.84	1.80	8.50	1.19	6.50	1.30	3.90	0.62	3.82	0.53
Sum	1125.37	2242.92	279.88	1084.63	210.36	46.19	203.71	31.46	177.19	35.21	106.87	16.25	100.63	14.79
Count	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00	40.00

I. Descriptive statistics for REES in dust and rocks samples

	La	Ce	Pr	Nd	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu
Mean	5.43	9.11	1.22	4.83	0.92	0.20	0.99	0.15	0.79	0.17	0.54	0.08	0.48	0.07
Standard Error	2.40	4.80	0.58	2.13	0.43	0.10	0.46	0.07	0.35	0.07	0.24	0.04	0.22	0.03
Median	1.88	2.11	0.35	1.49	0.26	0.05	0.28	0.05	0.24	0.06	0.18	0.02	0.14	0.02
Mode	18.00	#N/A	4.30	16.00	3.20	0.70	#N/A	0.50	#N/A	#N/A	1.80	0.26	1.60	#N/A
Standard Deviation	7.21	14.41	1.75	6.38	1.30	0.29	1.38	0.20	1.04	0.22	0.72	0.11	0.65	0.09
Sample Variance	52.03	207.69	3.08	40.65	1.69	0.08	1.90	0.04	1.08	0.05	0.53	0.01	0.42	0.01
Kurtosis	0.55	0.73	0.66	0.64	0.66	0.68	0.67	0.62	0.60	0.79	0.46	0.51	0.42	0.39
Skewness	1.52	1.61	1.58	1.57	1.58	1.59	1.57	1.56	1.52	1.52	1.48	1.51	1.47	1.44
Range	17.54	34.09	4.18	15.17	3.08	0.68	3.38	0.48	2.61	0.58	1.75	0.25	1.56	0.23
Minimum	0.46	0.91	0.12	0.83	0.12	0.02	0.12	0.02	0.09	0.02	0.05	0.01	0.04	0.01
Maximum	18.00	35.00	4.30	16.00	3.20	0.70	3.50	0.50	2.70	0.60	1.80	0.26	1.60	0.24
Sum	48.89	81.97	10.98	43.43	8.27	1.78	8.88	1.32	7.10	1.53	4.90	0.69	4.28	0.64
Count	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00	9.00