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SOIL CATENA PROPERTIES OF DAHER AL- JABAL IN SOUTH SYRIA

Hussam H. M. Husein[1*] Tareq Nammora[2] Ibrahim Zaghtiti[3] Anwar Al-Khateeb[4] and Ehsan Zenyah[5]

[1,3]General Commission for Scientific Agricultural Research, Damascus 12573, Syria.
[2]Damascus University, Faculty of Literatures and Human Sciences, Department of Geography; Damascus, Syria
[4,5]General Commission for Scientific Agricultural Research, Sweida, Syria
[*]Corresponding author: hussamhmhusien@gmail.com

Abstract

Soil catena concept is a sequence of soils extends across relief positions and is developed from similar parent material. This study highlighted on the important aspects and properties of soil catena of Daher El-Jabal in Jabal Al-Arab mountainous area South eastern of Syria, by implementing pedologic study in 2010-2012. Six soil profiles have been studied along pedo-genetic transect in order to highlight the soil catena prevailing properties. The results reveal that the soil has formed from igneous basaltic parent casts, related to Neogen era, where reliefs had the key role in the developing of soil solum. Consequently, Entisols were dominated on eroded summits, Inceptisols on back slops and mountain flanks, Mollisols on depressions. Both water erosion of soil surface and leaching inside soil solum processes were responsible for variation of soil texture, as such soils showed evident of changing in particles size distribution as well as in clay content. Cation exchange capacity (CEC) was less than moderate with domination of Magnesium cation. Soil trace elements were poor to somewhat poor. Soil pH values in general were low; which reflect the pedo-genic character of igneous parent material in which soil drifted from. In some cases, where soil body subjected to continuous leaching of soil bases, in particular calcium cation; soil profiles became totally freed from calcium carbonates. Accordingly soil problems related to downing of soil reaction (pH) are more expected to be increasing by time. This is main reason for some physical diseases, which beginning arise on pomes fruits, particularly bitter pit.

Keywords: Soil catena; Secondary calcium carbonate; Neogen basalt; Bitter pit

Introduction

Soil preserves a record of landscape evolution and climate that can be interpreted by quantifying numerous chemical and physical properties accumulated in soil profiles (Khomo, 2008), the knowledge about soil properties is vital for making decisions about uses and management of land, soil conservation, environmental protection, and precision agriculture, on the other side soil is complex because it forms at the boundary of the lithosphere, atmosphere, hydrosphere and biosphere (Buckman and Brady, 1984), nature of soil requires multidisciplinary research for a full comprehension of its complexity, and there has been recent advocacy for such approaches (Brantley *et al*., 2007). There are several landscapes like mountain, plain, valley, deltas and so on. All these landscapes may be dominated by different climatic zones and therefore comprising of different soils. All these are characterized by topography, hydrology and vegetation. As a result there are many soil forming factors that leads to different soil forming processes which results in different soils formation, despite of the fact that they are formed on the same parent material (Blume, 1980), soil complexity can hence best be understood in the context of geological material open to spatially. Milne (1935) in his attempts to simplify soil complexity, approached soil catena as a sequence of soil types, repeated in similar sites or topographic situation, within a region which is arguably the best heuristic tool to underpin pedological researches for understanding soil landscape evolution (Khomo, 2008), this can be seen by the use of "chaine du sol" in French soil literature as it was used for vegetation/ soil slope relationship. A representative work is that of Duchaufour; (1961). Soils within identical parent material, exists within uniform climatic region and affected by parallel soil forming factors still may have varied features due to local relief and or internal drainage characteristics. This group of soils forms a catena (Steila, 1976). Brown and Thorp (1942) investigated Gray-Brown Podzolics soil in Miami catena. Greene (1947) saw the catena's resemblance to a soil profile rotated to its side in how soils down a profile or catena are hydrologically connected. Similar concepts can be found in more recent soil science literature (Opp, 1983; 1985). In fact, a number of different approaches to the classification of soil geochemical catenas and soil catenas on slopes have been developed by now (Dalrymple *et al*., 1968). The specific variability of landscape structure and functioning within a catena depends on eluvial, illuvial and coluvial processes; their intensity is in turn determined by drainage conditions (Komisarek, 2000; Marcinek *et al*., 1998), In case of mountainous region, soils with relatively higher altitudes, soils develops in relatively cool and often humid climate which contain more organic matter than similar soils a bit further downhill (Buringh,1979), and Landscape position may be used to describe the habit of the soil series (Hole,1953).

The main processes of catenary differentiation are surface wash, soil creep, solution and rapid mass movements, Johason, (1982). These processes vary in their relative importance and effectiveness, with climate and slope. It should be noted that catenal processes are not limited to soil transformation along a slope, but concern all aspects of ecosystem functioning and a number of interlinks between landscape units (Ostaszewska, 2002). Arnold and Wilding (1991), explain the understanding of processes involved in catena in relation to anisotropic characteristics of soils. He argues that, it is necessary to understand that all soils are anisotropic. Anisotropy is a major factor in determining the process acting in the soil, lateral movement is significant cause of variability in some soils (Luxmoore et al., 1991). For these process to have greater effect the ground surface must slope downward continuously from the crest to the base of the slope, Leaching and re deposition of chemical constituents constitutes a physical link between catena members. The practical significance of this process in the tropics was recognized by (e.g. Greene, 1945; 1947; Milne, 1947). Silica iron, exchangeable bases all changes along catena as a result of different soil processes that have acted on soil development, According to Johnson, (1982), the differences between the soils of a catena are generally related to their position and their drainage characteristics so that emphasis is placed on the difference between the freely drained upper parts of the slope and imperfectly to poorly drained lower positions.

The mountainous basaltic area of Jabal Al-Arab (1800 m) is extended on three Agricultural Satiability Zones (ASZ 1, 2, 3) with a rainfall 500, 250, 200 mm respectively, Hill slopes are a convenient scale to view locally interacting factors and processes that impinge on soil formation because they are delimited by a hillcrest and a basal stream. Beyond the boundaries demarcated by crests and streams, hydrological connectivity ceases. The contour line of (900 m and up) which known as Daher Al-jabal receives more than 500 mm rainfall annually, makes it a promising agriculture area, (Habib, 2006) moreover, prevailing soil is drifted from recent basaltic igneous rocks, which is rich in nutrient elements (Van Lier, 1965) high soil water retention, higher content of organic matter (Yuan *et al*., 2000), good permeability and stable structure (Hoyos and Comerford, 2005). Agriculture sector in the area has developed to a great extent as a result of agricultural investments in soil ameliorative and land reclamation; In order to bring new land under investing, and to improve current invested land productivity, through a series of processes such as land de-rocking, leveling and terraces forming. The agriculture intensification improved the incomes of local famers but the usage of this land without knowledge on their properties, capabilities and suitability, has caused many problems such as physiological diseases (pitter bit) related to micro-nutrient elements deficit. This current agricultural obstacles central question is how weathering and soil properties change along catenas in different relief classes across an arid to semi-arid climate gradient. Answering this question by studding unique soil catena across basalt rock and along complex relief will enhance understanding of pedogenesis and landscape evolution pathways in arid and semi-arid climates underlain by granite and inform efforts to conserve and manage them, Results can be generalized on all soils existing on Jabal Al-Arab area which have similar landscape and the same parent materials.

Materials and Methods

The study area is located on Jabal Al-Arab mountain south Syria far 8km east of Sweida agricultural research center; with elevation ranges from 1600 to 1700m. a. s. l., (Figure 1).

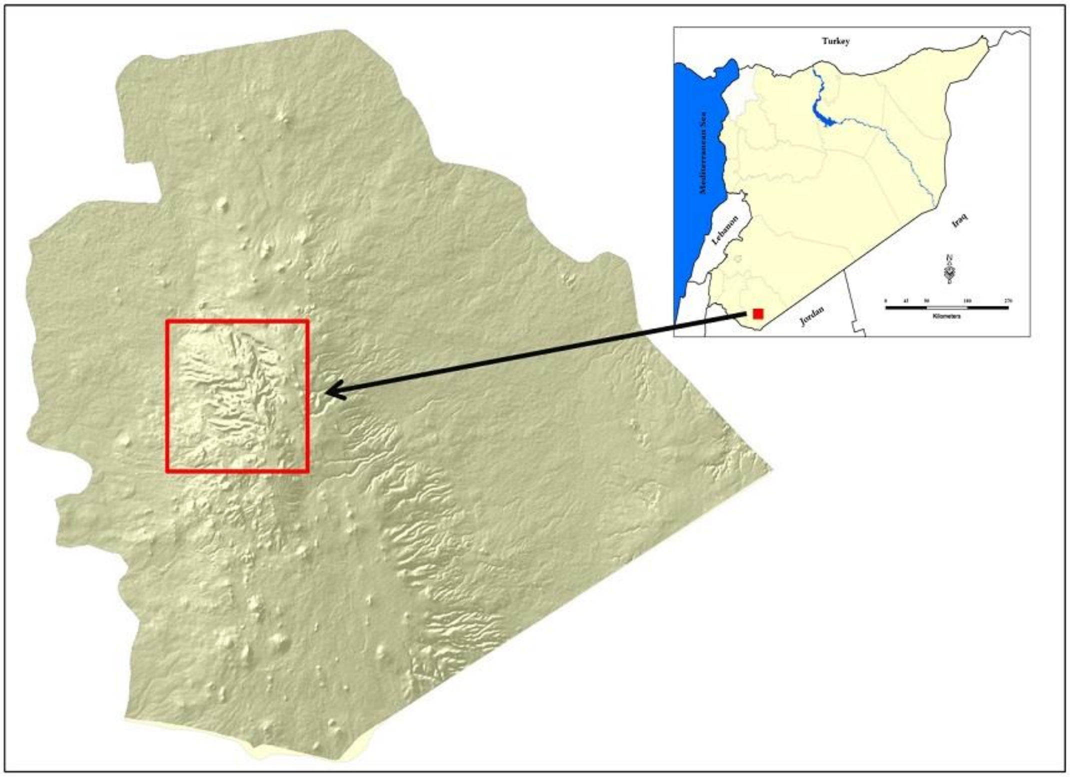

Figure 1. The location of Daher Jabal Al-Arab south eastern of Syria

The terrain characterized by very complicated reliefs, rocky and sloppy landscape, according to the study was implemented by "TECHNOEXPORT" 1962-1966. The parent material of the area is originated from volcanic neogene rocks of Quaternary recent basalt.

From geomorphologic concept, the area considered as residual extinguished volcanoes, rising from beyond areas and forming mountainous area with non-symmetrical flank slopes (Abou Nukta, 1982) (Figure 2).

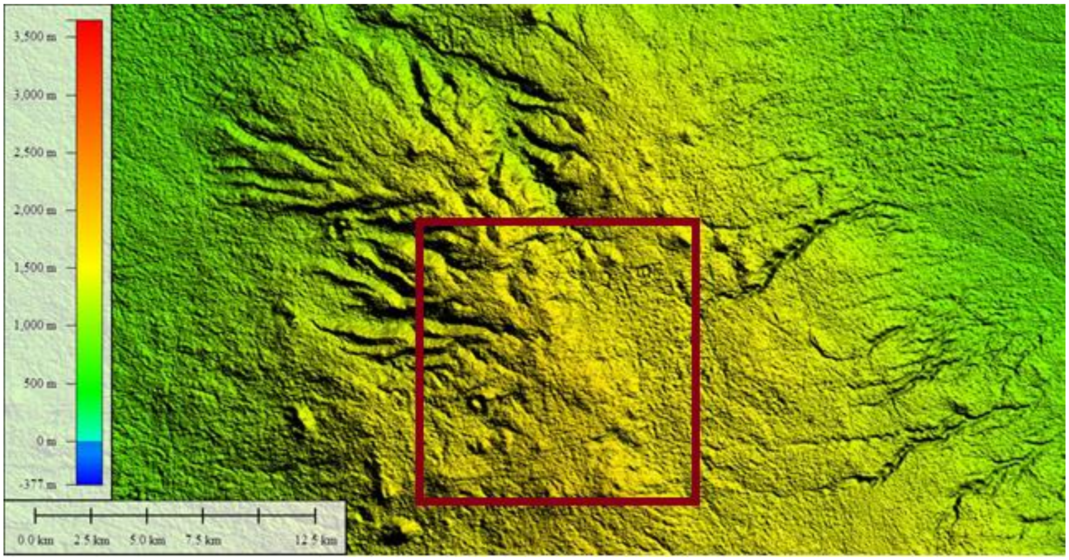

Figure 2. The Digital elevation model (DEM) of the study area

Generally, the area submitted to Mediterranean climate with cold rainy winter and dry somewhat hot summer, precipitation exceed 500 mm annually, mostly snow, mean annual temperature 11.9 C^o. The soil moisture regime is Xeric and the temperature soil regime is Thermic (Arab Center for Study Arid region and Dry lands ACSAD, 1980) the diagram below gives an over simplified picture of study area soil moisture and temperature regimes, (Figure 3).

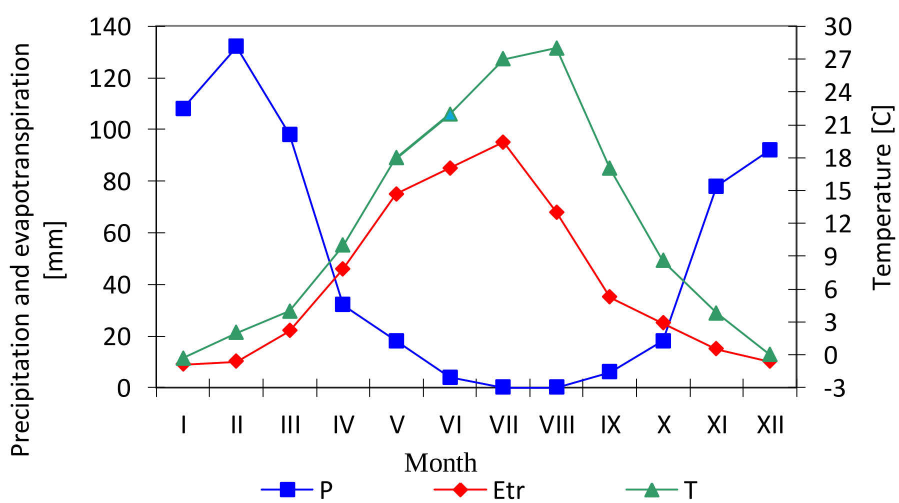

Figure 3. Illustrates Xeric soil moisture, Thermic temperature soil regimes

According to their position on landscape, the soil may receive water from some sources other than the rainfalls, such as some temporary bicarbonates streams (HCO_3 :150-500 mg kg^{-1}) (Ilaiwi, 1983). Basaltic cracks (if any) are assisting water percolation to aquifers, in some tiny depressions, the impermeable rocks hamper the infiltration of water which caused waterlogging and appearance of redoximorphic features, (Figure 4).

Figure 4. Waterlogging in some tiny depressions on the study area

According to pluviothermic quotient (Emberger, 1955); the area located in semi wet bio-climate with cold variant, Oak (*Quercus calliprinos*; L) shrubs are dominated in some isolated spots, (Nahal, 1986) accompanying with Red Hawthorn (*Crataegus sinacia*; Boiss), Blackberry (*Rubus sanctus schreb*; L) and Thyme (*Thymus sinacia*; Boiss), (Figure 5).

Figure 5. Some natural vegetation of the study area

Soil survey and laboratory analyses

Six soil pedons along south east transect have been manually dug in order to describe and record all layers and horizons occurred in the pits along pedo-genetic transect. Field work has been done in summer and fall 2008-2009. Soil describing and sampling were based on procedures of Soil Survey Division Staff (1993). The morphological study and soil profile description were based on field book for describing soils U.S.D.A-NRCS (1998). Color of dry soil samples were recorded using the Munsell Soil Color Charts. Soil samples were submitted to following chemical and physical analyses:

- Organic carbon was determined by Walkley-Black method (1934), modified by Nelson and Sommers (1982).
- Particle-size analysis was performed by hydrometer method with application of sodium-hexametaphosphate ($Na_6P_6O_{18}$) as a chemical dispersion agent. Sands fraction were separated on hole sieves 1–0.5– 0.2–0.1mm, respectively Soil Survey Staff (1975).
- Soil reaction (pH) was measured in suspension of H_2O (1:1), (0.01M) $CaCl_2$ (1:2) and (1M) KCl (1:2), Soil Conservation Service (1992).
- Exchangeable cations (Ca^{++}, Mg^{++}, K^+, N^+) were estimated by Mehlich method ($BaCl_2$-TEA, pH=8.2). All samples treated in the field by diluted HCl, none of them reacted.
- Total Nitrogen was estimated by (Kjeldahl, 1883) and McRae (1988). Electrical Conductivity (EC) was measured in suspension of H_2O (1:2), Soil Conservation Service (1992).
- Available phosphorus was estimated by (Olsen et al, 1954).Total potassium was estimated by (Jackson, 1956).
- Available Boron extracted by hot water, estimated using flam-photometer.
- Traces elements (Cu, Zn, Mn, Fe) estimated by extracting using DTPA solution.

Soil profiles were classified and accomplished using (Soil Survey Staff-Soil Taxonomy, 1999) and (F.A.O-ISRIC, WRB, 1998).

Results and discussion

Distinguish soil catena has been observed along pedo-genetic transect of the study area, in which the complicated reliefs in the area had a major role in evaluating and developing soil from slightly eroded igneous parent material.

Several soil forming processes can be detected, which acting both on topsoil and subsoil These processes including; accumulation of organic matter; leaching of calcium carbonates and other bases; reduction and transformation of iron and the migration of clay particles either from up to down within the horizon, or from one horizon to another. In most sites these processes are overshadowed by erosion processes, which is a result of accelerated water runoff as well as anthropogenic denudation. All these processes, in addition to some soil properties, such as epo-or endo-saturation were taken in consideration while classifying soils at higher categories (Soil Orders). Hence, three soil orders according to (Soil Survey Staff-Soil taxonomy, 1999) are existing adjacently: Mollisols, Entisols and Enceptisols; according to (WRB, 1998), the higher categories were: Rogosols and Cambisols.

Soil moisture regime (Xeric); diagnostic features and horizons were used to classify soil at lower categories. Soil families classified and distributed according to soil texture in control section, soil temperature regimes (thermic) and clay minerals (mixed) which consists mainly of Smectite (60%) and Kaolinite, Illite (less than 40%) (Habib, 1983). All previous concepts permeated to classify soil pedons as following:

<u>PEDON T5 1</u>

Classification

USDA(2003): Fine, mixed, thermic, Typic Xerochrepts

WRB (1998): Haplic Rogosols

Location: Sweida Governorate, Jabal Al-Arab, Daher Al-Jabal

Coordinates: E 32^{0}40`20.6 N 36$^0$42`26.7

Altitude: 1680 m a. s. l

Physiography: Shoulder

Topography: Concave slope, 10% slope gradient, southeastern

Drainage class: Well drained

Parent material: Neogene basalt

Vegetation: Cherry orchard 6 years old

Date of Sampling: July 16-2010

Horizon	Depth(cm)	Description
Ap	0-25	Dull brown (7.5YR5/4M); clay loam; weak fine to moderate granular structure; few fine roots; fine vertical pores; friable; few stones 1-2 cm, clear wavy boundary
A/C	25-35	Dull reddish brown (5YR4/4M); clay loam; fine to moderate angular blocky structure; hard dry, friable wet; very few roots, clear wavy boundary.
C1	35-55	Grayish brown (5YR5/2M); sandy clay; moderate angular blocky structure; hard dry, friable wet; very few roots, few stones 1-2 cm, clear broken boundary.
C2	55+	Grayish brown (5YR5/2M); sandy clay; moderate angular blocky structure; hard dry, vesicles of clay (5YR4/6M).

Basic physical and chemical analysis

Horizon	Depth (cm)	Particles size disruption (%). Ø mm			Texture	OM %	pH H_2O 5.2.1	pH KCl 5.2.1	Total $CaCO_3$ %	CEC_{ef} cmol/kg	EC $mS.m^{-1}$
		Clay	Silt	Sand							
Ap	0-25	38	26	36	clay loam	1.11	6.91	6.1	nil	32.8	0.14
A/C	25-35	42	22	36	clay	0.83	6.95	6.2	nil	36.3	0.19
C1	35-55	48	14	38	clay	0.73	6.48	5.6	nil	32.8	0.14
C2	55+	32	18	50	sandy clay loam	0.2	6.93	6.1	nil	38.1	0.23

Horizon	Depth(cm)	Macro nutrients			Micro nutrients				
		Tot. N	K	P	Fe	Cu	Mn	Zn	B
		cmol/kg	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}	mg kg^{-1}
Ap	0-25	0.04	298.85	16.15	22.1	0.933	29.65	1.24	0.98
A/C	25-35	0.04	298.89	9.03	20.17	0.477	40.35	1.073	1.7
C1	35-55	0.03	228.3	5.49	29.37	0.42	126.3	1.051	1.26
C2	55+	0.04	211.7	2.65	44.66	0.553	63.32	0.86	0.9

PEDON T5 2

Classification

USDA(2003): Fine, mixed, thermic, Typic Xerochrepts

WRB (1998): Leptic Cambisols

Location: Sweida Governorate, Jabal Al-Arab, Daher Al-Jabal

Coordinates: E 36^{0}42`00 N 32$^0$40`19.9

Altitude: 1672 m. a. s. l

Physiography: Terrace

Topography: Flat plain

Drainage class: Well drained

Parent material: Neogen basalt

Vegetation: Hazel nut 6 years old

Date of Sampling: July 16-2010

Horizon	Depth(cm)	Description
Ap	0-25	Dull reddish brown (5YR4/3M); clay; angular blocky broken to moderate to fine granular structure; few fine to moderate roots; hard dry; few stones 1-2 cm, clear wavy boundary
Bw	25-60	Dark reddish brown (5YR3/4M); clay; moderate angular blocky structure; very sticky, very plastic, hard dry, friable wet; very few roots, clear wavy boundary.
B2	60-70	Dark reddish brown (5YR3/3M); clay loam; moderate angular blocky structure; moderately sticky, moderately plastic, hard dry, friable wet; very few roots, few stones 1-2 cm, redoximorphic features of iron and magnesium (N2/0, 10YR8/8), clear broken boundary.
B3	70+	Dark brown (7.5YR3/4M); sandy clay; few roots, voids filled with clay (5YR4/6W).

Basic physical and chemical analysis

Horizon	Depth (cm)	Particles size disruption (%). Ø mm			Texture	OM %	pH H_2O 5.2.1	pH KCl 5.2.1	Total $CaCO_3$ %	CECef cmol/kg	EC $mS.m^{-1}$
		Clay	Silt	Sand							
Ap	0-25	42	24	34	clay	0.92	6.5	5.55	nil	31	0.14
Bw	60-25	56	24	20	clay	0.83	6.73	5.53	nil	40.03	0.15
B2	70-60	38	26	36	clay loam	0.18	7.04	5.36	nil	31.13	0.17
B3	+70	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	38.1	n.d.

Horizon	Depth(cm)	Macro nutrients			Micro nutrients				
		Tot. N cmol/kg	K $mg\ kg^{-1}$	P $mg\ kg^{-1}$	Fe $mg\ kg^{-1}$	Cu $mg\ kg^{-1}$	Mn $mg\ kg^{-1}$	Zn $mg\ kg^{-1}$	B $mg\ kg^{-1}$
Ap	0-25	0.08	417.6	21.04	32.27	0.953	70.17	1.616	1.68
Bw	60-25	0.07	482.7	12.53	38.66	0.828	53	1.442	0.9
B2	70-60	0.05	471.6	14.42	27.92	0.194	34.41	1.057	1.44
B3	+70	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

PEDON T5 3

Classification
USDA(2003): Fine, mixed, thermic, Typic Xerochrepts
WRB (1998): Leptic Cambisols
Location: Sweida Governorate, Jabal Al-Arab, Daher Al-Jabal
Coordinates: E 36^{0}42`32.8 N 32$^0$40`19.6
Altitude: 1669 m. a. s. l
Physiography: Shoulder
Topography: Concave slope, 10% slope gradient, southeastern
Drainage class: Well drained
Parent material: Neogen basalt
Vegetation: Cherry orchard 6 years old
Date of Sampling: July 16-2010

Horizon	Depth(cm)	Description
Ap	0-25	Brown (7.5YR4/3M); clay loam; weak fine to moderate granular structure; moderately sticky, moderately plastic, hard dry, friable wet, many fine to moderate roots; few stones 1-2 cm, clear wavy boundary
Bw	25-35	Dark reddish brown (5YR3/3M); clay; fine to moderate angular blocky structure; moderately sticky; moderate plastic; hard dry, friable wet; few roots, clear wavy boundary
B2	35-55	Dark reddish brown (5YR3/3M) and brownish gray (7.5YR4/1M); clay loam; moderate angular blocky structure; moderately sticky, moderately plastic; hard dry, friable wet; very few roots, stones 1-2 cm (20 % volume), redoximorhic feature (7.5YR8/8).

Basic physical and chemical analysis

Horizon	Depth (cm)	Particles size disruption (%). Ø mm			Texture	OM %	pH H_2O 5.2.1	pH KCl 5.2.1	Total $CaCO_3$ %	CEC_{ef} cmol/kg	EC $mS.m^{-1}$
		Clay	Silt	Sand							
Ap	0-30	40	28	32	clay	1.3	6.4	5.57	nil	38.13	0.18
Bw	30-60	44	28	28	clay	0.4	6.8	5.49	nil	36.3	0.16
B2	60+	44	22	34	clay	0.1	7.2	6.38	nil	38.13	0.22

Horizon	Depth (cm)	Macro nutrients			Micro nutrients				
		Tot. N cmol/kg	K mg kg^{-1}	P mg kg^{-1}	Fe mg kg^{-1}	Cu mg kg^{-1}	Mn mg kg^{-1}	Zn mg kg^{-1}	B mg kg^{-1}
Ap	0-30	0.12	396.75	54.48	65.73	2.789	59.94	2.15	0.7
Bw	30-60	0.13	551.7	39.96	91.13	2.36	75.89	1.68	1.72
B2	60+	0.06	551.7	14.14	110.9	1.082	46.49	0.729	0.6

PEDON T5 6

Classification

USDA(2003): Fine, mixed, thermic, Typic Xerorthents

WRB (1998): Leptic Rogosols

Location: Sweida Governorate, Jabal Al-Arab,

Daher Al-Jabal

Coordinates: E 36^{0}42`38.2 N 32$^0$40`18.6

Altitude: 1680 m. a. s. l

Physiography: Foot slope

Topography: Concave slope, 10% slope gradient, southeastern

Drainage class: Well drained

Parent material: Neogen basalt

Vegetation: Fallow

Date of Sampling: July-16-2010

Horizon	Depth(cm)	Description
A	0-30	Brown (7.5YR4/3M); clay loam; weak fine to moderate granular structure; moderately sticky; moderately plastic; hard dray; feasible wet; many fine to moderate roots; Few fine stones 1-2 cm, clear smooth boundary
BC	30-60	Dull yellowish brown (10YR4/3M); clay; fine to moderate angular blocky structure; very sticky; very plastic; hard dry, friable wet; few fine to moderate roots, clear wavy boundary.
C	60+	Grayish brown (5YR5/2M); sandy clay; few roots, voids filled with clay (10YR4/3 M)

Basic physical and chemical analysis

Horizon	Depth (cm)	Particles size disruption (%). Ø mm			Texture	OM %	pH H_2O 5.2.1	pH KCl 5.2.1	Total $CaCO_3$ %	CEC_{ef} cmol/kg	EC $mS.m^{-1}$
		Clay	Silt	Sand							
A	0-30	36	30	34	clay loam	0.9	7.2	6.47	nil	24.95	0.21
BC	30-60	34	34	32	clay loam	0.6	6.8	5.72	nil	36.3	0.13
C	60+	n.d.	n.d	n.d.	n.d.	n.d	n.d.	n.d.	n.d.	n.d.	n.d.

Horizon	Depth(cm)	Macro nutrients			Micro nutrients				
		Tot. N cmol/kg	K mg kg^{-1}	P mg kg^{-1}	Fe mg kg^{-1}	Cu mg kg^{-1}	Mn mg kg^{-1}	Zn mg kg^{-1}	B mg kg^{-1}
A	0-30	0.15	317.6	25.96	29.82	1.213	54.59	1.94	1.14
BC	30-60	0.08	219.95	7.91	140.5	0.807	50.70	1.19	1.04
C	60+	n.d.	n.d.	n.d	n.d.	n.d.	n.d.	n.d.	n.d.

PEDON T5 7

Classification

USDA(2003): Fine, mixed, thermic, Typic Xerochrepts

WRB (1998): Haplic Cambisols

Location: Sweida Governorate, Jabal Al-Arab, Daher Al-Jabal

Coordinates: E $36^0$42`32.9 N $32^0$40`18.2

Altitude: 1678 m. a. s. l

Physiography: Backslope

Topography: Concave liner slope, 5% slope gradient, eastern

Drainage class: Well drained

Parent material: Neogen basalt

Vegetation: Fallow

Date of Sampling: July-16-2010

Horizon	Depth(cm)	Description
A	0-28	Dull yellowish brown (7.5YR5/4M); clay; weak fine to moderate granular structure; very sticky; very plastic; hard dray; friable wet; many fine to moderate roots; few stones 1-2 cm, clear wavy boundary
Bt	28-50	Dull yellowish brown (7.5YR4/3M); clay; fine to moderate

		angular blocky structure; very sticky; very plastic; hard dry, friable wet; few fine to moderate roots; clear wavy boundary.
C	50+	Grayish brown (5YR5/2M); sandy clay; few roots; pockets of clay (7.5YR4/3M).

Basic physical and chemical analysis

Horizon	Depth (cm)	Particles size disruption (%). Ø mm			Texture	OM %	pH H_2O 5.2.1	pH KCl 5.2.1	Total $CaCO_3$ %	CECef cmol/kg	EC $mS.m^{-1}$
		Clay	Silt	Sand							
A	0-28	42	26	36	clay	1.3	6.41	5.94	nil	36.3	0.18
Bt	28-50	52	22	36	clay	1.02	6.42	5.7	nil	36.3	0.13
C	50+	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

Horizon	Depth(cm)	Macro nutrients			Micro nutrients				
		Tot. N cmol/kg	K $mg\ kg^{-1}$	P $mg\ kg^{-1}$	Fe $mg\ kg^{-1}$	Cu $mg\ kg^{-1}$	Mn $mg\ kg^{-1}$	Zn $mg\ kg^{-1}$	B $mg\ kg^{-1}$
A	0-28	0.12	114.4	7.97	1.513	1.44	94.55	2.213	1.14
Bt	28-50	0.06	101	5.23	136.8	1.09	111.3	1.08	0.72
C	50+	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.

PEDON T5 16

Classification

USDA(2003): Fine, mixed, thermic, Typic Haploxerolls

WRB (1998): Mollic Cambisols

Location: Sweida Governorate, Jabal Al-Arab, Daher Al-Jabal

Coordinates: E $36^0 42$`33.9 N $32^0 40$`14.6

Altitude: 1665 m. a. s. l

Physiography: Toeslope

Topography: Concave slope, 10% slope gradient, southeastern

Drainage class: bad drained

Parent material: Neogen basalt

Vegetation: Fallow wetland

Date of Sampling: July-16-2010

Horizon	Depth(cm)	Description
A	0-30	Brownish black (7.5YR3/2M); clay loam; weak fine to moderate granular structure; moderately sticky; moderately plastic; hard dry; friable wet; few stones 1-2 cm, clear smooth boundary
Btw	30-55	Dull reddish brown (5YR4/4M); clay; fine to moderate angular blocky structure; very sticky; very plastic; hard dry, friable wet; few fine to moderate roots; clear wavy boundary
Bt2	55-70	Dull reddish brown (5YR4/3M); clay; fine to moderate angular blocky structure; very sticky; very plastic; hard dry, friable wet; few fine root; few stone 1-2 cm; redoximorphic feature (10YR5/1) (10YR8/8); clear broken boundary
C	70-110+	Grayish yellowish brown (5YR4/2M); clay; moderate angular blocky structure; very sticky; very plastic; hard dry, vesicles of clay (5YR4/6M).

Basic physical and chemical analysis

Horizon	Depth (cm)	Particles size disruption (%). Ø mm			Texture	OM %	pH H_2O 5.2.1	pH KCl 5.2.1	Total $CaCO_3$ %	CECef cmol/kg	EC mS.m^{-1}
		clay	silt	sand							
Ap	0-30	36	20	44	clay loam	1.8	6.8	6.21	nil	29.5	0.18
Btw	30-55	50	18	32	clay	1.11	6. 5	5.8	nil	38.13	0.17
Bt2	55-70	52	18	30	clay	0.37	6.9	6.66	nil	34.94	0.21
C	110+	44	16	40	clay	0.07	6.4	5.81	nil	41.98	0.19

Horizon	Depth(cm)	Macro nutrients			Micro nutrients				
		Total N cmol/kg	K mg kg^{-1}	P mg kg^{-1}	Fe mg kg^{-1}	Cu mg kg^{-1}	Mn mg kg^{-1}	Zn mg kg^{-1}	B mg kg^{-1}
Ap	0-30	0.18	187.65	26.87	54.41	1.841	104.1	3.161	1.5
Btw	30-55	0.04	211.7	2.65	44.66	0.553	63.32	0.862	0.9
Bt2	55-70	0.1	121.25	9.76	93.31	0.89	68.28	0.784	0.66
C	110+	0.04	107.65	7.92	38.08	0.507	42.12	0.806	1.28

The evaluation and developing of soil catena existed on study area are affected to high extend with neogene basalt parent material. However, the soil drifted from this inert igneous rock characteristic of moderate to slightly acid soil reaction, clayey texture, and fine granular structure. The impact of relief was clear on solum thickness where the soils on ridges are completely eroded, primitive solua consists of on eroded part of (A) horizon intensive

weathered(C) horizon are existed on back slopes. Sola are more developed on foot and toeslopes, the consequences horizon are (A, A2, C).On terrain submitted to Anthropogenic activities, particularly leveling processes, (Bt) thin horizon appears together with strongly weathered (C) horizon. Whereas, soil located in depressions characteristic of developed sola, related to their moisture conditions and topographic location, which make them sites for accumulation and deposit of transported materials, those soil have dark epi-pedons, rich of fine roots and high contain of organic material (Mollic Horizon) over an intensive weathered parent materials (C) horizon, the consequences horizon are (A, A2, B) or (A, A2, Bw).
Soil colors are approximately the similar, originated from dark basaltic parent material. Appearance of some red and purple soil colors, are not related to high precipitation, as it common in Mediterranean region but reflect high quantities of ferric materials (Abou Nukta, 1982). One epi-pedon (T5 16) appears black with high organic material which submits the qualification of mollic horizon.
Soils showed high quantity of clay and moderate sub-angular blocky structure which is unique indicator for soils derived from basalt parent material. Variability of particles size distribution are related to many causes, mainly strong weathering of parent material, epipedons denotation on backslaps and ameliorative processes such as leveling and de-rocking, which were implemented in some sites by deep plowing, and even rupture of parent materials, all these processes increasing of fine earth translocation in endo-pedons. There was strong relation between the moisture statue and micro reliefs; on back slopes, the condition is high for water to run off. On treads, water infiltrated relatively in soil solum. Otherwise, there were some cases for waterlogging on tiny depressions (Pedon 16), where stagnant water reminds in these depressions for few months explained by existence of inert basaltic un-pierced rocks at the depth of 1-15m. Within these soils, reduction and oxidation of iron and magnesium is dominated process, as a result of consecution of draining and waterlogging, (Figure 6).

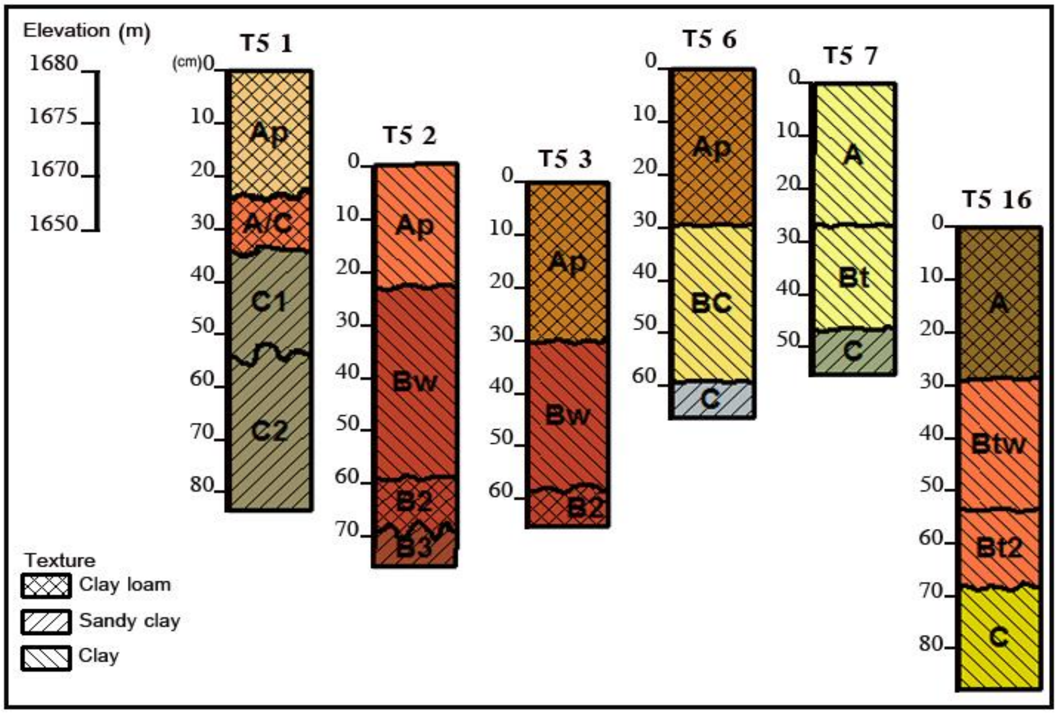

Figure 6. Soil texture within soil toposequences on the pedo-genetic transect

Mass movement process affected negatively soil thicknesses at back slopes, where the sola were shallow and the condition unsuitable for developing soil profiles but on depression the process affected positively, unless it had negative effect on aerification, as a result of fine earth accumulation, the aerobic conditions are worst.

Soil organic matter content is normal compare with mountainous soils, (Loulo, 1980).There were some exceptions especially in depressions where organic matter exceeds 2%, this related to good moisture condition which allowing herbs to grow all during the year, and to diluvial materials, come from up siding which are rich in organic materials.

Electrical conductivity values were in significant; this can be explained by none-salinity parent materials. Soils low containing of nitrogen and phosphorus, explained by igneous parent materials which is originally does not containing these elements. Iron containing was good ranging from 20.17 mg kg^{-1}in (A/C) horizon of (T5 1) to 151.3 in (A) horizon of (T5 7). Trace elements (B, Zn, Mn, Cu) contents were poor to moderate because the parent materials are poor in these elements and due to the leach-ability of those elements in low soil reaction (pH), (Habib, 1986).Soil reaction ranging from natural to slightly acid (7.3 to 6.4 in 1:2.5 water, in 1:2.5 KCl even reach to 5.2), these values are more expected to go down as a result of parent materials which are originated free of calcium carbonates, the secondary carbonates are submitted to leaching, moreover, the intensive fertilizing with some slightly acid nitrogen fertilizers, accompanying with the availability of adequate moisture within the soil assist in weathering and even dissolution of elements from this inert parent materials (calcium) and increasing of (potassium, magnesium ration) which caused obstacles of calcium absorption, this has great negative impacts on soil reaction and plants, wherein, the total leaching of calcium carbonates as a result of slightly acidic soil causes some physiological diseases such as bitter pit associated with trace elements deficit on pomes fruits, which is related to deficit of calcium. Calcium is a major component of cell wall pectin's, the deficit of calcium cause mottle on fresh fruit, during storage period, these mottles torn to bitter pits which makes fruits unpalatable, and undesirable, moreover, the fruits will not be storage for long time.

Conclusion

The study area is very promising for agricultural due to its unique climate. Rainfall is reminding the limiting factor for developing extensive and expansion agriculture sector, hence, soil reclamation, leveling and de-rocking should be concentrated in first stability zone (contour line 900 m.a.s.l. and higher) in order to establish guaranteed rainfed agriculture without depleting ground water which is originally very scarce within the region.

There are some indicators of physiological disease occurrence, caused by traces elements deficit, as such, all agriculture practices assisting to naturalizing or rising soil reaction (pH) seems to be most urgent, applying of naturalized macro nutritious and micro nutritious, is very useful agriculture practices to prevents this physiological disease to be aggravated.

Widespread of Boulders on up-soil causes obstacles for agriculture practices and inhomogeneity of soil surface, soil leveling, de-rocking on back slopes and terraces are very important, accompanying with sub-soil ripper in order to permits roots penetration, water infiltration within soil body and increasing of land capacity to water storage, even more, to increase the percolation to aquifers instead of losing water by runoff.

The area is ideal for water harvesting, hence, implementing of water harvesting techniques, surface water spreading and soil moisture conserving practices are seem to be the most important for agriculture extending.

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