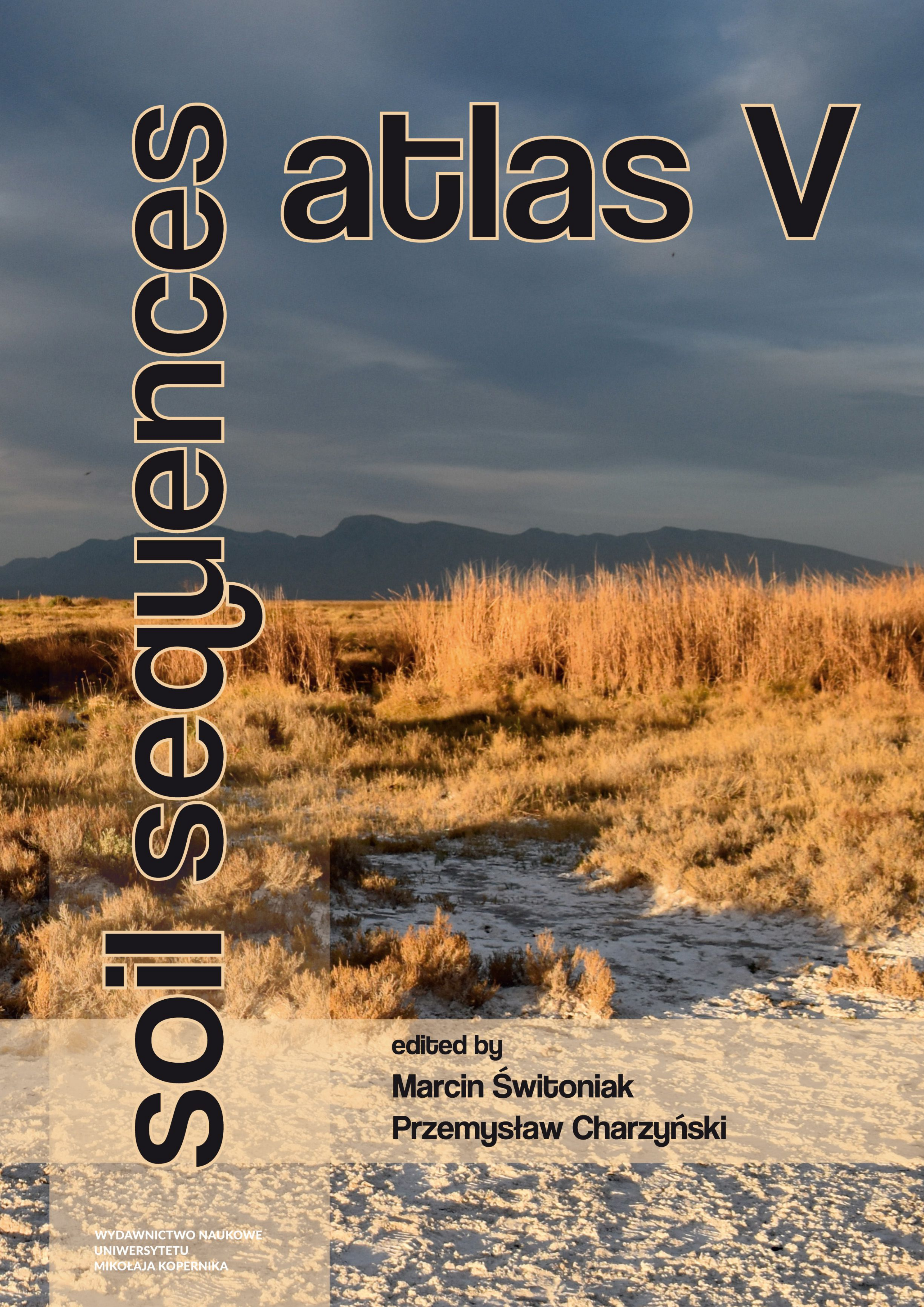

soil sequences atlas V

edited by
Marcin Świtoniak
Przemysław Charzyński

WYDAWNICTWO NAUKOWE
UNIWERSYTETU
MIKOŁAJA KOPERNIKA

Soil Sequences Atlas V

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EDITED BY
MARCIN ŚWITONIAK
PRZEMYSŁAW CHARZYŃSKI

TORUŃ 2022

Editors
Marcin Świtoniak, Nicolaus Copernicus University, Toruń, Poland
Przemysław Charzyński, Nicolaus Copernicus University, Toruń, Poland

Publication was peer reviewed

Cover design
Marcin Świtoniak

Photographs on the cover
Marcin Świtoniak

ISBN 978-83-231-4960-6
eISBN 978-83-231-4961-3
https://doi.org/10.12775/978-83-231-4961-3

Co-funded by

Erasmus+

WYDAWNICTWO NAUKOWE UNIWERSYTETU MIKOŁAJA KOPERNIKA
Redakcja: ul. Gagarina 5, 87–100 Toruń
tel. (56) 611 42 95, fax (56) 611 47 05
e-mail: wydawnictwo@umk.pl
Dystrybucja: ul. Mickiewicza 2/4, 87–100 Toruń tel./fax (56) 611 42 38
e-mail: books@umk.pl
www.wydawnictwo.umk.pl
Druk i oprawa: Wydawnictwo Naukowe UMK ul. Gagarina 5, 87–100 Toruń

CONTENTS

FOREWORD

The significant spatial variability of soil cover results from the diverse impacts of different soil-forming factors. This book presents pedovariability in the form of a collection of soil sequences typical of particular landscape types. The fifth part of the Soil Sequences Atlas contains description of 73 pedons (with soil profile photo, description of morphology and laboratory data) grouped into 15 chapters each representing a different environmental setting specific to very diverse regions from five continents – North and South America, Africa, Europe and Asia. The Atlas begins by presenting a pedo-landscapes from Americas – from Mexico to Peru. Next comes a group of chapters devoted to The Mediterranean Region – Spain, Italy, Slovenia and Tunisia. The next two chapters concern the soils of Central Europe – Hungary and Poland. At the end there are examples of steppe (Russian chernozems), semi-arid (Iran) and subtropical soils of Southeast Asia (Thailand). Out of 32 reference groups, as many as 17 are represented in the fifth part of atlas Soil Sequences Atlas. The most common soils are Calcisols (semi-arid areas) and the soils with clay illuviation (Luvisols) developed in very diverse environments.

The collected data is intended as a useful educational tool in teaching soil science, and in supporting an understanding of the reasons behind the variability of soil cover, and also as a WRB classification guideline. It is intended to be useful not only to students but also to practitioners in agriculture, forestry, environmental protection and landscape planning.

The Atlas was developed as part of the EU Erasmus+ SYStem project (Share Your Soils – Project No 2019-1-PL01-KA203-065101 Strategic Partnerships for higher education (KA203) of Erasmus+ programme of the European Union).

Marcin Świtoniak

Przemysław Charzyński

LIST OF ACRONYMS

Al_o – aluminium extracted by an acid ammonium oxalate solution
BD – bulk density
BS – base saturation
CEC – cation exchange capacity
COLE – The coefficient of linear extensibility
ECe – electrical conductivity of the saturated paste extract
EC – electrical conductivity
FAO – Food and Agriculture Organization of the United Nations
Fe_d – iron extracted by a dithionite-citrate-bicarbonate solution
Fe_o – iron extracted by an acid ammonium oxalate solution
IUSS – International Union of Soil Science
N_t – total nitrogen
OC – organic carbon
OM – organic matter

METHODS

The soils were classified according to WRB 2015[1]. The soil morphology descriptions, textural classes and symbols of soil horizons are given after Guidelines for Soil Description[2]. The samples were taken from selected soil horizons and after preparation (drying, separation of root and sand fraction >2 mm by sieving) they were analyzed in the laboratory. In most cases texture was determined by (i) combining the Bouyoucos[3] hydrometer and sieve method or (ii) by pipette and sieve method. Organic carbon (OC) content was determined by the wet dichromate oxidation method, and total nitrogen (Nt) content by the Kjeldahl method. The reaction was measured in H_2O and 1 M KCl in 1:2.5 suspension for mineral samples, and 1:10 suspension for organic samples. Calcium carbonate ($CaCO_3$) content was determined by Scheibler volumetric method. Potential (hydrolythic) acidity (HA) was determined by Kappen method and exchangeable cation (bases) content was estimated by leaching with 1 M ammonium acetate with a buffer solution pH 8.2. Pedogenic forms of iron and aluminum were extracted: Fe_t and Fe_d by $HClO_4$–HF, Fe_d by sodium dithionite–citrate–bicarbonate[4] and Fe_o and Al_o by ammonium oxalate buffer solution[5]. Other soil analyses were performed according to the standard methods[6]. Color has been described according to Munsell[7]. It was recorded (i) in the moisture condition (single value) or (ii) in the dry and moisture condition (double values).

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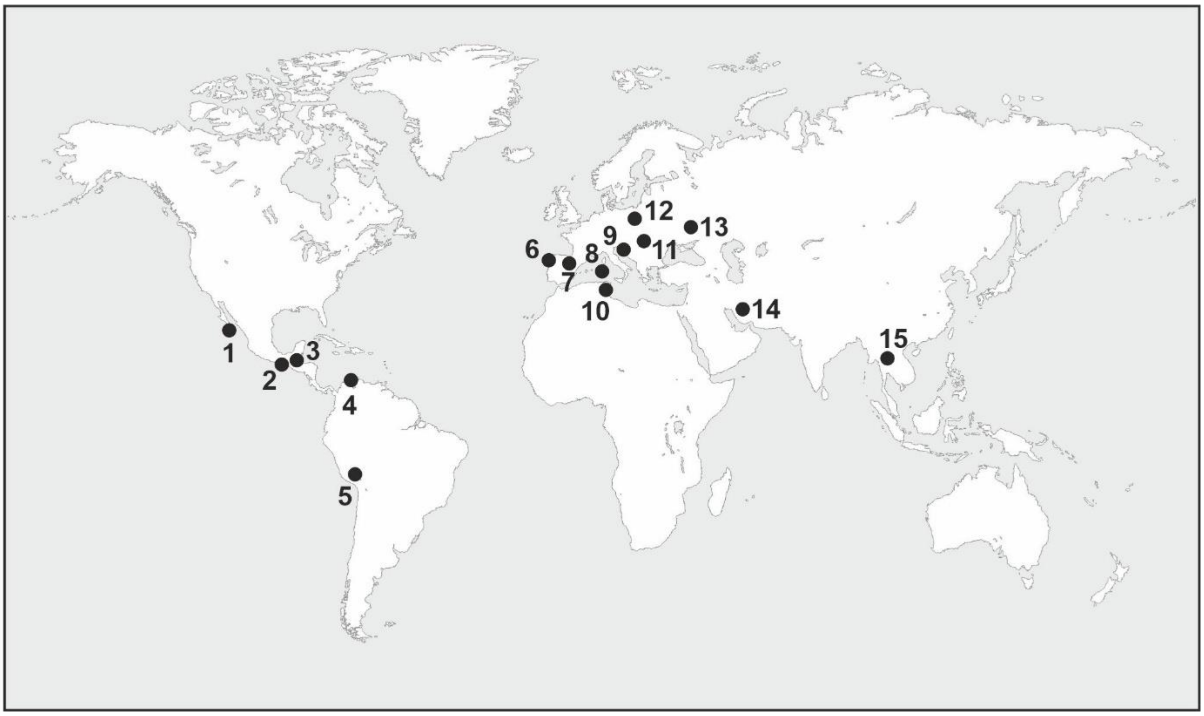
Soil Reference Groups Index

STUDY AREAS



NUMBER OF CHAPTER – REGION AND COUNTRY:

1 – BAJA CALIFORNIA PENINSULA, MEXICO
2 – OAXACA, MEXICO
3 – CHIAPAS, MEXICO
4 – GUAJIRA, COLOMBIA
5 – PUNO AND MADRE DE DIOS, PERU
6 – SANTIAGO DE COMPOSTELA, SPAIN
7 – EBRO RIVER BASIN, SPAIN
8 – SARDINIA, ITALY
9 – COAST REGION, SLOVENIA
10 – MENZEL CHAKER, TUNISIA
11 – NYÍREGYHÁZA, HUNGARY
12 – BRODNICA LAKE DISTRICT AND ŚWIECIE PLATEAU, POLAND
13 – CENTRAL RUSSIAN UPLAND, RUSSIA
14 – ZAGROS MOUNTAINS, IRAN
15 – PHRAE PROVINCE, THAILAND

Soils with andic properties on alkaline basalt in Mediterranean climate. A toposequence study in the Marghine district (Sardinia, Italy)

Antonio Ganga, Ludmila Ribeiro Roder, Gian Franco Capra,

The study area is located on Mt. Sant'Antonio (808 m a.s.l.) This is a basaltic (basanite) formation, part of the volcanic complex of Montiferru in the Marghine sub-region, in the central-west part of Sardinia, Italy (Capra et al., 2009)(Fig. 1).

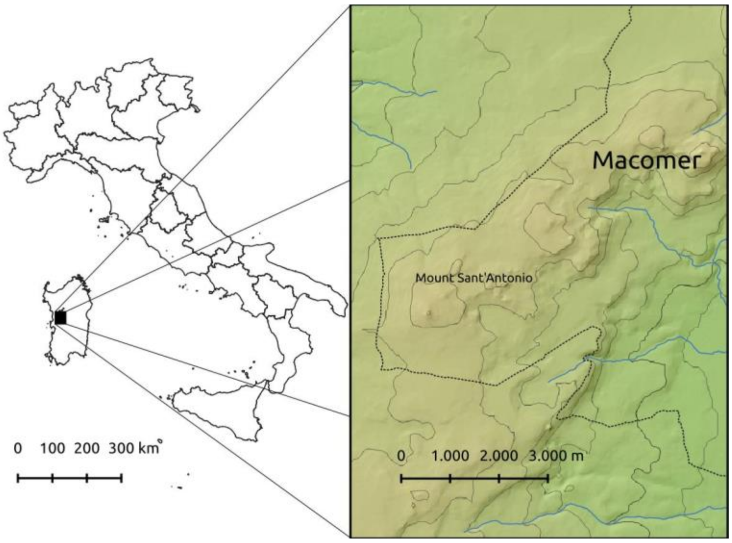


Fig. 1. Location

Lithology and topography

The formation was formed in the late Pliocene–Early Quaternary by intense magmatic activity leading to the accumulation of alkaline basaltic lava, such as basanite, from different emission centers (Vernia et al., 1977). Mt. St. Antonio represents an emission center of an old shield volcano. It is characterized by the presence of a series of trachybasaltic taps that extended to the west and north-west. The general structures are represented by: "*two dikes formed by trachybasaltic lava characterized by a grain size rougher than that of gaining rocks, with large plagioclasic elements that detach in the phenocrystalline association*" (Vacca et al., 2009; Carmignani et al., 2001).

Land use

The landscape is characterized by the intense activity of reforestation during the last part of the 19th century. Currently, the vegetation is composed of autochthonous species such as oaks (*Quercus Pubescens Q. Ilex* and *Suber*), and exotic species such as pine (*Pinus* spp.), eucalyptus (*Eucalyptus camaldulensis*), locust tree (*Acacia saligna*). Several perennial herbaceous species are present (*Luzula forsteri, Viola alba subsp. dehnhardtii, Brachypodium sylvaticum, Cyclamen repandum and Ornithogalum pyrenaicum*). Historically, this area has been affected by wildfires and intense agricultural activities. Currently, parts of the areas are occupied by forests and plantations. The agricultural activities are limited to semi-extensive farming.

Climate

The climate is typical for the inland area of Sardinia: continental, warm and sub-humid. The average annual rainfall is 905 mm and temperature of 14.6°C (Ente Autonomo Flumendosa, 1998). The Köppen Climate Classification subtype for this climate is 'Csb' (Warm-summer Mediterranean climate). The average annual potential evapotranspiration (Thornthwaite and Mather, 1957) is 806.9 mm. Soil temperature and soil moisture regimes are estimated as thermic and xeric.

Profile 1 – Mollic Katoleptic **Andosol** (Protoandic, Thixotropic)

Location: Alkali basalts, Vulcanic flow in hillslope, lower slope (2,6%), east aspect (125°N), Eucaliptus plantation (burnt in 1996) undergrowth, 640 m a.s.l., **N** 40°14'15.9'' **E** 8°32'53.7''

Morphology:

Oi – 0,5–0 cm, slightly decomposed organic material, leaves;

Ah1 – 0–5 cm, *mollic* horizon, dark gray color (5YR 2.5/2), wet, silt loam, gravel 10/15%, moderate lumpy and polyhedral subangular structure with fine-sized top-down trend, brittle from wetness, abundant small (<1mm) to very small (1–2 mm) pores, normal drainage, abundant oblique and vertical roots of small dimensions; intense biological activity;

Ah2 – 5–25 cm, *mollic* horizon, dark gray (2.5YR 3/2), wet, loam, gravel 10%, common pores ranging in size from small (1–2mm) to medium (2–5mm); moderate subangular polyhedral type aggregation of fine to medium; crumbly when wet; normal drainage; common roots running from horizontal to vertical and oblique, mostly small but also medium in size; medium biological activity;

Bw – 25–45 cm, reddish brown (7.5R 3.5/6), wet, loamy sand, skeleton 10%, small (1–2mm) to medium (2–5mm) common pores, moderate fine to medium sized subangular polyhedral aggregation; crumbly when wet; normal drainage; common roots running from horizontal to vertical and oblique, mostly small but also medium in size; medium biological activity;

R – 45–(60) cm, weak altered Pliocenic Basalts.

Table 1. Texture

Horizon	Depth [cm]	Percentage share of fractions, size of fractions in mm							Textural class
		> 2.0	2.0-1.0	1.0-0.5	0.5-0.2	0.2-0.05	0.05-0.002	<0.002	
Ah_1	0–5	7.2	12.0	2.0	2.0	29.1	46.2	8.7	SiL
Ah_2	5–25	15.3	7.0	1.5	1.8	37.6	44.3	7.8	L
Bw	25–45	36.0	6.0	1.0	1.0	55.4	32.0	4.6	LS
R	45–(60)	-	-	-	-	-	-	-	-

Table 2. Chemical and physicochemical properties

Horizon	Depth [cm]	OC [$g\cdot kg^{-1}$]	Nt [$g\cdot kg^{-1}$]	C/N	pH		$CaCO_3$ [$g\cdot kg^{-1}$]
					H_2O	KCl	
Ah_1	0–5	63	7,1	9	7.4	6.8	
Ah_2	5–25	55	5,9	9	6.2	5.2	
Bw	25–45	31	3,0	10	6.1	6.1	
R	45–(60)	-	-	-	-	-	-

Profile 2 – Endoskeletic **Umbrisol** (Protoandic, Amphiarenic, Colluvic, Pachic)
Location: not altered Alkali – Basalts covered by colluvial materials in hillslope, 2–6% slope, aspect SE (105° N) deciduous coppice (Nuts and Chestnut), 655 m a.s.l., **N** 40°13'23.22'' **E** 8°42'22.18'

Morphology:

Ah1 – 0–8 cm, *umbric* horizon, *colluvial* material, dark gray (5YR 2.5/2), wet, loam, gravel <5%, moderate polyhedral and subangular to angular fine structure; crumbly when wet; abundant pores of very small (<1mm) and small (1–2 mm) sizes; normal drainage; common roots with oblique and vertical course of small dimensions; intense biological activity;

Ah2 – 8–30 cm, *umbric* horizon, *colluvial* material, dark gray (5YR 2.5/2) wet, loamy sand, gravel <5%, moderate angular and polyhedral medium structure, crumbly when wet, abundant pores of very small (<1mm) and small (1–2 mm) sizes, normal drainage, common small roots with oblique and vertical course and in smaller quantities of medium size, intense biological activity;

Ah3 – 30–50 cm, *umbric* horizon, *colluvial* material, dark gray (5YR 2.5/2), loamy sand, gravel <5%, angular polyhedral type aggregation of medium to coarse size with a strong degree of aggregation; crumbly when wet, common pores of small size (1–2 mm), normal drainage, roots from common to sparse with oblique and vertical course of small size and in smaller quantities of medium size, average biological activity;

Ah4 – 50–70/75 cm, *umbric* horizon, *colluvial* material, dark gray (5YR 2.5/2), loamy sand, gravel 5–10%, strong angular polyhedral medium to coarse structure, crumbly when wet, common small pores, normal drainage, scanty medium and small roots with oblique and vertical course, average biological activity;

2C – 70/75–(90) cm, gravels 60/70% of rounded type of coarse size (10–25 cm).

Table 3. Texture

Horizon	Depth [cm]	Percentage share of fractions, size of fractions in mm							Textural class
		> 2.0	2.0-1.0	1.0-0.5	0.5-0.2	0.2-0.05	0.05-0.002	<0.002	
Ah_1	0–8	4.1	1	5	1.2	44.3	33.1	15.4	L
Ah_2	8–30	12.1	2	7	1.6	47.0	33.2	9.2	LS
Ah_3	30–50	6.6	1	6	2.1	50.3	31.7	8.9	LS
Ah_4	50–70/75	3.3	2	1	4	55.6	29.7	7.7	LS
2C	70/75–(90)	70.0	-	-	-	-	-	-	-

Table 4. Chemical and physicochemical properties

Horizon	Depth [cm]	OC [$g \cdot kg^{-1}$]	Nt [$g \cdot kg^{-1}$]	C/N	pH		$CaCO_3$ [$g \cdot kg^{-1}$]
					H_2O	KCl	
Ah_1	0–8	114	8,4	14	6.1	5.1	-
Ah_2	8–30	42	3,5	12	5.6	4.4	-
Ah_3	30–50	31	2,1	15	5.9	4.6	-
Ah_4	50–70/75	30	2,0	15	6.1	4.6	-
2C	70/75–(90)	-	-	-	-	-	-

Profile 3 – Haplic **Umbrisol** (Protoandic, Chromic, Colluvic, Anoloamic)
Location: Hillslope/ basaltic plateau, slope 2–6% , mixed forest with *Quercus Pubescens* and *Quercus Suber*, aspect SE (160° N), 725 m a.s.l., **N** 40°13'25.5" **E** 8°42'06.6"

Morphology:

Ah1 – 0–10 cm, *umbric* horizon, dark gray (7.5YR 3/2), wet, sandy loam, gravel 5–10%, moderate subangular polyhedral fine structure, crumbly when wet; common pores of small (1–2 mm) and medium size (2–5 mm); normal drainage, common roots with vertical and oblique course of small dimensions, intense biological activity;

Ah2 – 10–35 cm, *umbric* horizon, dark gray (7.5YR 3/2), wet, sandy loam, gravel 5–10%, moderate to strong subangular polyhedral medium structure, crumbly when wet; common pores of small (1–2 mm) and medium size (2–5 mm); normal drainage; roots from common to scarce with vertical and oblique course of small dimensions; average biological activity;

BC – 35–60 cm, transitional horizon, reddish brown (5YR 4/6), wet, sandy loam, graves 25%, moderate subangular polyhedral medium to coarse structure, crumbly when wet, few pores of small size (1–2 mm) and very small (<1 mm), normal drainage, roots from scarce to absent with vertical and oblique course of small dimensions, absent biological activity;

C – 60–(70) cm, parent material, sandy loam.

Table 5. Texture

Horizon	Depth [cm]	Percentage share of fractions, size of fractions in mm							Textural class
		> 2.0	2.0-1.0	1.0-0.5	0.5-0.2	0.2-0.05	0.05-0.002	<0.002	
Ah_1	0–10	4.2	2.8	2.2	12	41.0	28.5	13.5	SL
Ah_2	10–35	2.7	0.9	1.2	12	45.2	30.3	10.4	SL
BC	35–60	-	-	1	1	71.2	11.3	15.5	SL

Table 6. Chemical and physicochemical properties

Horizon	Depth [cm]	OC [$g \cdot kg^{-1}$]	Nt [$g \cdot kg^{-1}$]	C/N	pH		$CaCO_3$ [$g \cdot kg^{-1}$]
					H_2O	KCl	
Ah_1	0–10	57	4.4	13	6.3	4.3	-
Ah_2	10–35	30	2.8	11	6.1	4.7	-
BC	35–60	3	0.6	5	6.3	4.6	-

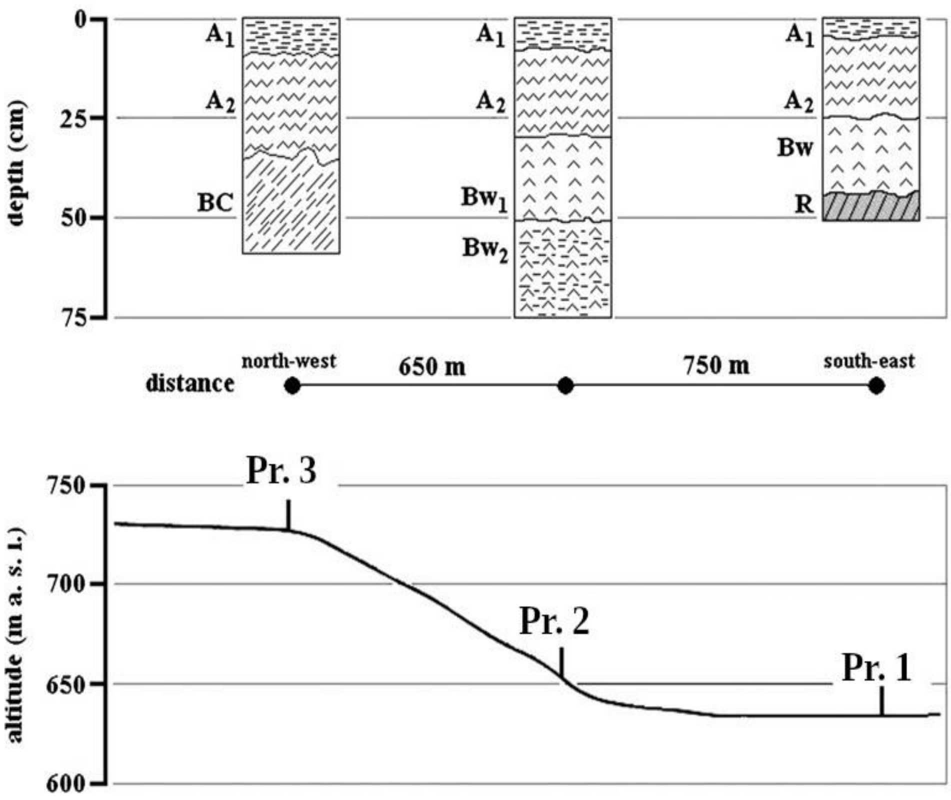


Fig. 2. Schematic representation of the soil profiles (Vacca et al., 2009)

Soil genesis and systematic position

The main morphological features of the selected toposequence profiles are represented in Fig. 2. The soil in Profile 1 (Ah1–Ah2–Bw) is shallow and it is located on the toe slope of Mt. St. Antonio. The geomorphic surface is characterized by high stability and insignificant erosion processes. This soil presents a well-expressed horizon differentiation; the solum shows a dark reddish brown A1, a very dusky red A2 horizon (***Mollic***) and a dark red Bw horizon with a higher hue (Vacca et al., 2009). Profile 2 is located in the foot of the slope; in these morphological conditions, a deep soil can develop. In fact, the profile shows (Ah1–Ah2–Ah3–Ah4) horizonation, with scarcely differentiated horizons and with the same dark reddish brown color from top to bottom with accumulation of slope material (***Colluvial***). The last profile 3 is located between the summit and the shoulder of the slope. This area is characterized by a relatively unstable (truncation) condition. The solum with thickness of 60 cm shows a simpler horizonation (Ah1–Ah2–BC). In this profile, it can remark the absence of a Bw horizon, although it is registered the color variation from dark brown in A1 and A2, to red (***Chromic***) in BC (Vacca et al., 2009).

Overall, the A horizons in all profiles show a granular-subangular blocky type structure, with a moderate grade, fine size and high aggregate stability (Vacca et al., 2009). These characteristics may be related to the high OC content (Shoji et al., 1993). This condition is a consequence of the prevalence of forest land cover in the area. The darkness of A horizons, all showing a chroma of 2, is strictly correlated to the high level of OC. Furthermore, features characterized by a dark granular A horizons, Bw horizons with subangular blocky structure, very friable moist consistence, high permeability and high structure stability are common to volcanic soils (Lulli et al., 1988; Shoji et al., 1993; Vacca et al., 2003; Fauzi and Stoops, 2004). Soil data and geomorphological conditions justify the absence of water-logging conditions. In fact, the soils investigated present no evidence of iron pan, horizontal Fe segregation or significant content of Fe coatings (Chen et al., 1980; Vepraskas et al., 1994). Another important issue is the clay content that is not adequate to sustain shallow water tables (Malucelli et al., 1999).

Soil sequence

The allophanic **Andosol** (Profile 1) is located in the lower site of the toposequence. This topographic position shows well-defined conditions: lower surface runoff, greater water infiltration rate, absence of significant erosion and colluvial movement which may have increased the impact of weathering processes (Vacca et al., 2009). These conditions create the situation where the prolonged soil moistness avoids the transformation of short-order components. In general, the results are evidence of the role of the morphology of the slope and the importance of Al-, Fe-amorphous compounds in expressing soil andic properties and allophane content versus the volcanic origin of the parent material.

Profiles 2 and 3 are developed on a slope, and they present common significant characteristics. They are both characterized by a low content of short-order secondary minerals (allophane content 3%) and the lack of andic properties in any horizon. In fact, these non-allophanic **Umbrisols** (Profile 2 and Profile 3) are characterized by a lower weathering degree a poor expression of ***Protoandic*** properties, a larger amount of Fe-humus complexes together with a lower Alo and Sio content and a predominance of Al-humus complexes that results in an anti-allophanic effect (Vacca et al, 2009).

In general, this toposequence shows the co-existence of both allophanic, non-andic, dystric rich in humus **Umbrisols** and andic, non-allophanic **Andosols** in a small geographical frame. They are characterized by two important issues: they are developed from the same volcanic material and evolved under the same climate. In this context, the expression of andic properties is sustained by the abundance of short-range ordered Al and Fe compounds more than volcanic glass (Vacca et al., 2009).

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