Origin and characteristics of the Cerretalta soil

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SUMMARY

1 - INTRODUCTION

The hilly landscape of Montalcino area has a total surface of 24.000 Ha, on which about 3.600 hectares of vineyards produce "Brunello di Montalcino DOCG" and "Rosso di Montalcino DOC". It is known that the different nuances and peculiarities of the wines derive not only from the wine-making technological processes, the cultivars, and from agricultural techniques but also from the physical environment that plays a fundamental role in grapevine growth and grape peculiarities.

The word "Terroir" defines the interactions between the different environmental factors, like climate, geology, morphology, and soil, and the viticultural-oenological practices, which give distinctive features to the wine.

From a geological and geomorphological point of view, the Montalcino territory can be divided into several macro-sectors: from the marine clayey environment of "Crete Senesi " typical of the North and North East area of Montalcino, to the calcareous and stony hills of the north-western area, to the ancient fluvial terraces of the Orcia river, in the southern area. South-Eastward from Montalcino village, near Asso creek valley, there is an area between Cerretalta and Renieri localities, characterized by geological and pedological peculiarities, unique in the Montalcino territory. In this place, there are some natural sections characterized of reddish paleosols, strongly weathered and rich iron oxides, intercalated with gravel lenses, scarcely pedogenized, actually used for vineyard cultivation of "Casanova di Neri" farm. With this study, the Company wanted to deepen the knowledge on the geological history and the peculiarity of the site, to comprehend the geo-pedological evolution of the soil that characterized their vineyards in this area.

Fig. 1 – Panoramic picture of the paleosols object of this study

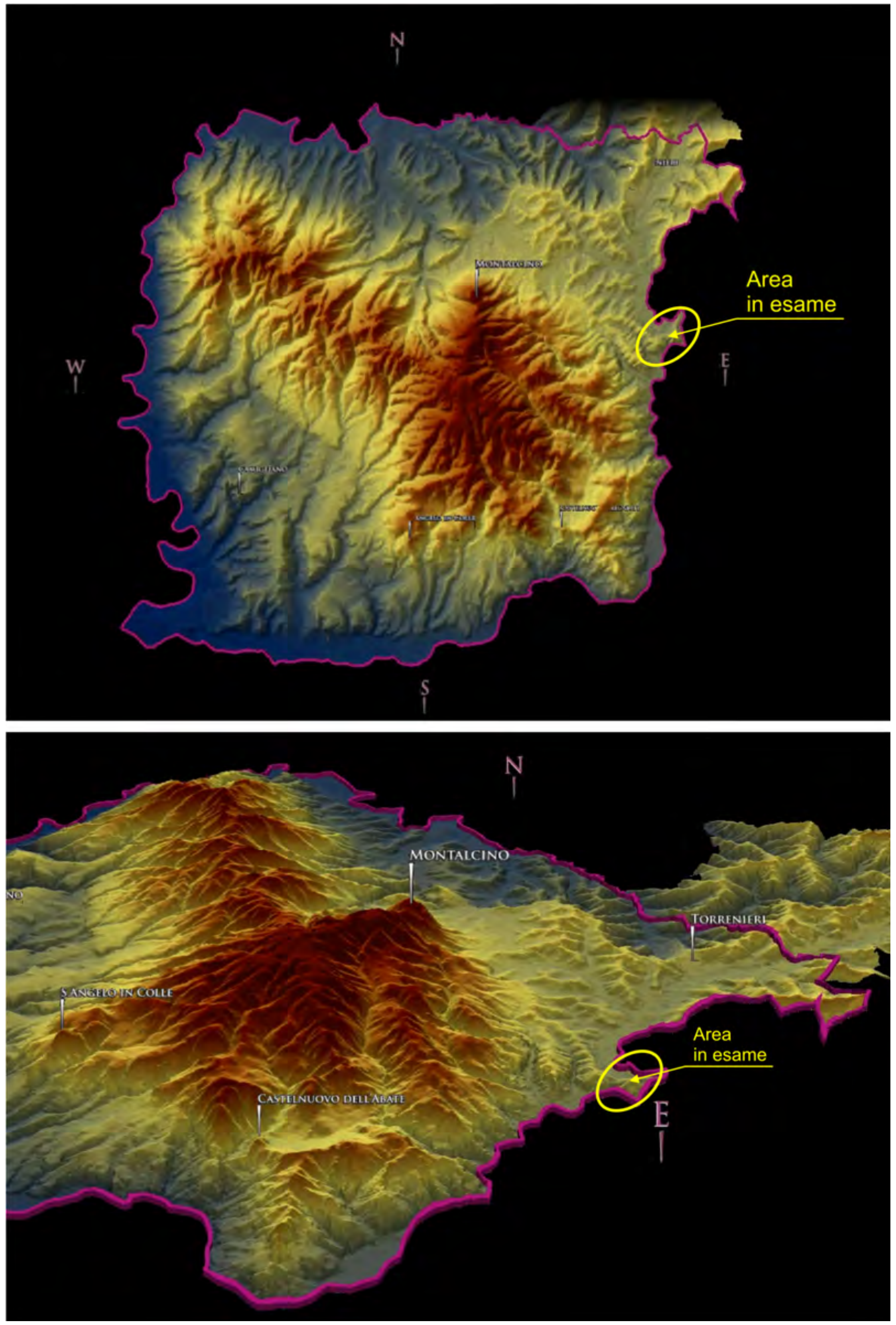


Fig. 2 – Localization of the study area (yellow circle)

2 – INVESTIGATIONS PERFORMED

In order to reach the objectives of this study, the following investigations were carried out, the results of which are indicated in the following paragraphs:

- Geomorphological survey and photo-interpretation analysis;
- Geological survey;
- Soil survey, performed by the description of soil profiles, and the sampling and laboratory analysis of the soil.

Moreover, the data and the results of a scientific paper have been taken as reference: "Pedogenesis of plinthite during early Pliocene in the Mediterranean environment. Case study of a buried paleosol at Podere Renieri, central Italy. Catena 71, 3, 425- 443 (Costantini E.A.C., Priori S., 2007)".

2.1 – GEOMORPHOLOGICAL SETTING

The vineyards of the study were located in the south-eastern slope to Cerretalta locality, at an average elevation of about 255 m a.s.l.

Fig. 3 – Studied vineyards

The main morphological elements are tectonic scarps along faults, in one of which is located the Asso creek, the most important hydrographic elements in the area. Here, the creek bed produces a large meander characterized by linear segments intercalated to abrupt changes of direction. This testifies the presence of a tectonic system, which drives the creek path and forms the isolated relief of Cerretalta locality. In geology, such tectonic relief, bordered by faults, is called "horst".

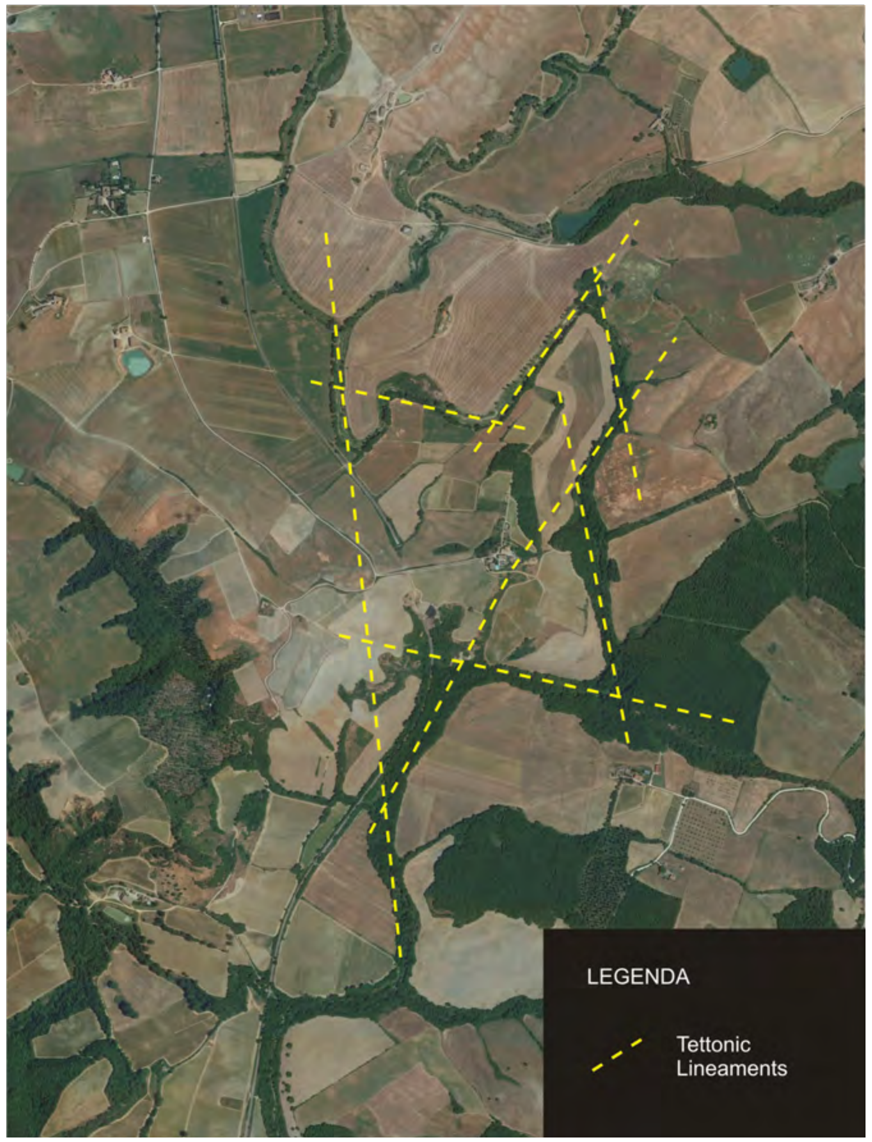


Fig. 4 – Tectonic lineaments of the study area

From the analysis of the aerial photographs of the past century, available on the WebGIS of the Tuscany Region, it is clear that the area has been subject to limited land movements from the '50s, which did not intensively alter the orography of the site. The vineyards of the area currently owned by Az. Agr. Casanova di Neri, were planted during the '70s, and then re-planted until 2007, without relevant modification of the slope (see Fig.7 in the following page).

Fig. 5 – Aerial photograph of Cerretalta (1954)

Fig. 6 – Aerial photograph of Cerretalta (1978)

Fig. 7 – Aerial photograph of Cerretalta (2007)

2.2 – GEOLOGICAL SETTING

In Tuscany, after the Alpine orogenesis, in Late Miocene (around 8 Million of years B.P.), started to develop distension tectonics, characterized by high-angle direct faults with North-West / South-East direction. Such faults system originated tectonic depression, called “graben” or “basins”, laterally delimitated by reliefs, in the study area called “Pliocene Siena basin” and “Murlo-Montalcino ridge”, respectively (Fig.8).

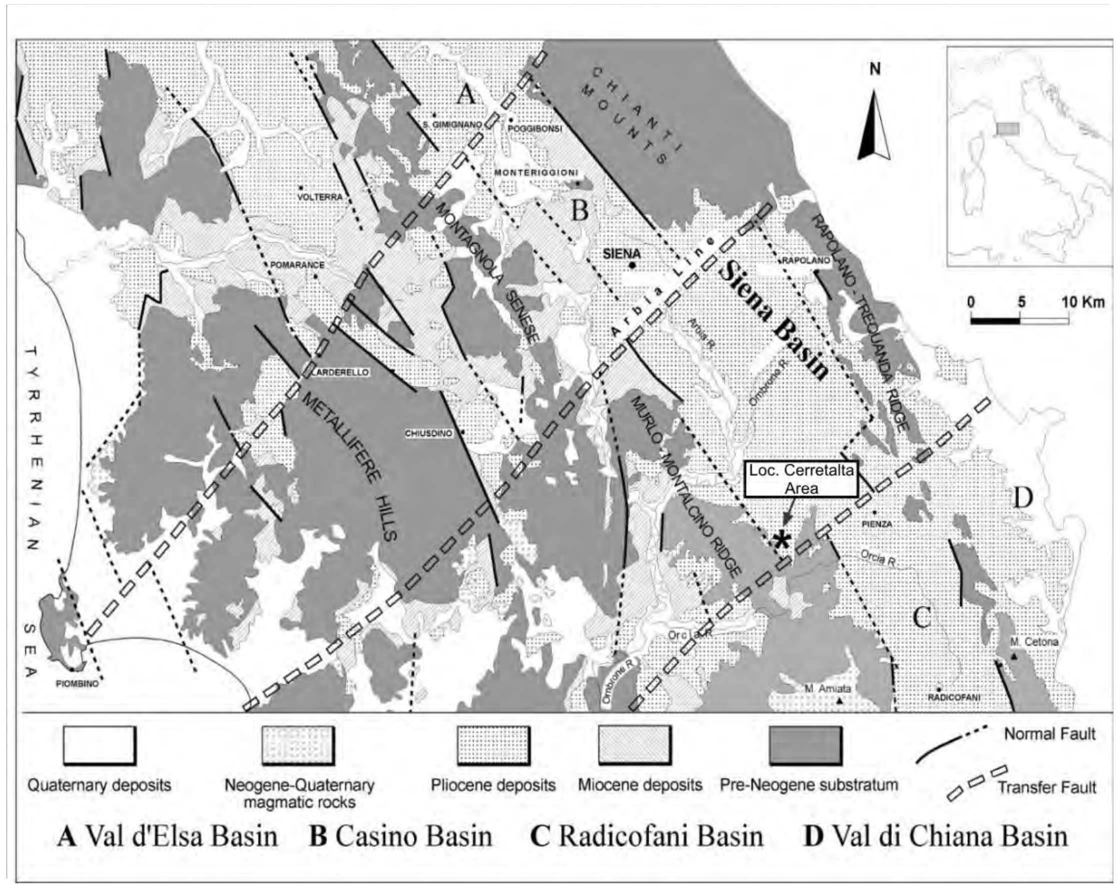


Fig. 8 – Tectonical sketch of southern Tuscany

The paleogeographic evolution of the Neogene Tuscan basins can be summarized in six phases (according to AMBROSETTI et al.1978):

1. Upper Tortonian - Lower Messinian: formation of lacustrine basins in the whole southern Tuscany (south of the Arno river).

2. Middle-upper Messinian: first marine transgression in western Tuscany.

3. End of the Messinian: marine regression caused by the western Tuscany uplift.

4. Lower-middle Pliocene: second marine transgression, much wider than the previous one. The eastern limit, this time, is the Chianti ridge. This is the maximum marine extension of the Pliocene. The western basins (Volterra, …) have very irregular boundaries and poor longitudinal development. The eastern basins (basin of the Val d'Elsa, of Siena, of Radicofani etc.) had larger longitudinal development, but had transversal discontinuities between them due to raised transverse structures (thresholds).

5. Middle-upper Pliocene: marine regression by general uplift of most of the Tuscany territory. In the upper Pliocene, all the marine basins southward of the Arno river and eastward to mid-Tuscan ridge emerged.

6. Pleistocene: short cycles of marine deposition were only along the Tyrrhenian coast. Eastward to mid-Tuscan ridge the basins were only characterized by fluvial and lacustrine deposition in small areas. Most of the area was strongly eroded by river and creeks.

The Siena basin, where the study area is located, consists of an elongated tectonic depression that extends from the northern Serchio river valley, South-South-Eastward through the Elsa, Arbia, and Orcia river valleys, until the Valdichiana basin and Bolsena lake.

This basin is limited to the North by the Chianti hills, to the West by the Montagnola Senese and the Murlo-Montalcino ridge, to the South by the Pienza threshold and finally to the East by the Rapolano – Trequanda. It appears cut in two parts by a transversal line, considered a "transfer fault", called "Arbia line" (BOSSIO et al., 1992, Fig.8).

This basin has been interpreted as a half-graben with the master fault located in the eastern margin and characterized by a maximum dislocation reaching 2000 m in the area of Rapolano Terme. Smaller faults are located in the western margin, but their average dislocation is less than 100 m. The main fault is clearly identified on the surface in the area of Rapolano Terme.

During Miocene, Siena basin was filled with lacustrine sediments, while in the Pliocene the sedimentation was exclusively marine until the regression of the middle-upper Pliocene, with the emergence of the whole basin. If the Miocene sediments outcrop only in the western margin of the Siena basin, the Pliocene marine sediments outcrop throughout the basin, covering the Miocene deposits and the pre-Neogenic sequences.

The Pliocene marine transgression was reported at the beginning of the early Pliocene (*Sphaeroidinellopsis seminulina* zone) in the western margin of the basin, while in the eastern margin it was referred to the early-middle Pliocene (*Globorotalia puncticulata* area). Two different depositional periods characterized the Pliocene marine sedimentation in this basin. The first in the early Pliocene is represented by coarse sediments at the edges of the basin and by neritic clays in the internal part. The second started during the final phase of the early Pliocene – beginning of middle Pliocene and consists of coastal marine sands, conglomerates that turn to neritic clays containing turbidite sands, and then shallow sea sands, in the inner part of the basin (GANDIN and SANDRELLI, 1982). The highest part of this stage records the marine regression occurred in Tuscany during the middle Pliocene and culminated with the emergence of the basin at the beginning of the Upper Pliocene.

This cycle of marine transgressions - regressions was likely due to an association between sea level eustatic variations and sin-sedimentary tectonics. The lifting of the middle Pliocene has been interpreted as the isostatic response to the post-collisional tectonics (BOSSIO et al., 1992).

The stratigraphic succession of Cerretalta locality

The surface geological survey, carried out during this study, confirmed that in this area, located in the south-western part of Siena basin, traces of both Pliocene depositional stages are observable. These two marine depositional stages are intercalated by a third depositional stage, described from the bottom to the top, as follow:

1. STAGE A – MARINE: It starts with gravelly sand that covers, with discordant limit, the pre-neogenic substrate, here characterized by Ligurian Unit, indeed from the Cretaceous formation of Santa Fiora flysch. These sands turn to sandy clays. At the top of this stage, the sandy clays gradually pass to coarse sands with conglomerate lenses. These final deposits testify a marine regressive trend due to the gradual raising of the basin margins.

2. STAGE B – CONTINENTAL: the first level, about 10 m thick, is characterized by sandy clays with traces of roots, ostracods, and characean green algae, which testify a shallow lacustrine environment. Above, the deposits are characterized by silt and silty-clay deposits, intercalated to gravel lenses. Such lenses can be some meters thick, with slight inverse gradation and basal erosive boundary. The clasts have very variable size, from few mm to 40-50 cm, with rounded or sub-rounded shape, and origin from limestones and sandstones of Ligurian Unit. The silty level have reddish in colour, due to iron oxides release, and are characterized by strong pedogenesis (plinthites – laterization process) clearly evident in upper part of Cerretalta vineyards. Traces of iron oxides release and reddish colour of the soil are also observable in pocket of fine material inside the gravel lenses. This stage B testify a continental deposition that started with a shallow lake, later filled by fluxes of sediments and evolved in an alluvial fan. The sedimentological features of the gravel lenses indicate a high energy deposition, namely "Debris flow" or "hyper-concentrated fluxes", whereas the finer sediments, weathered, testify a less violent sedimentation and prolonged period of stability.

3. STAGE C – MARINE: a second marine transgression submerged the environment of stage B (alluvial fan). This stage started with silty-clays dark grey, intercalated by small gravel lenses. In these deposits, abundant gypsum crystals and natrojarosite concretions are observable. Natrojarosite is a hydrous sulphate of potassium, sodium and iron, formed by the weathering of pyrite (Iron Sulphur) typically deposited in a scarce oxygenated environment, like river delta or lagoon. The sediments succession gradually become conglomerates with inverse gradation. In this layer, fragments of shallow sea mollusks (e.g. *Ostrea*). Above, the sediments are rich in planktonic foraminifers characteristic of deeper sea. Examining the stratigraphic and sedimentological characteristic, it is possible to determine the depositional evolution from lagoon or transitional environment (e.g. delta) to open sea.

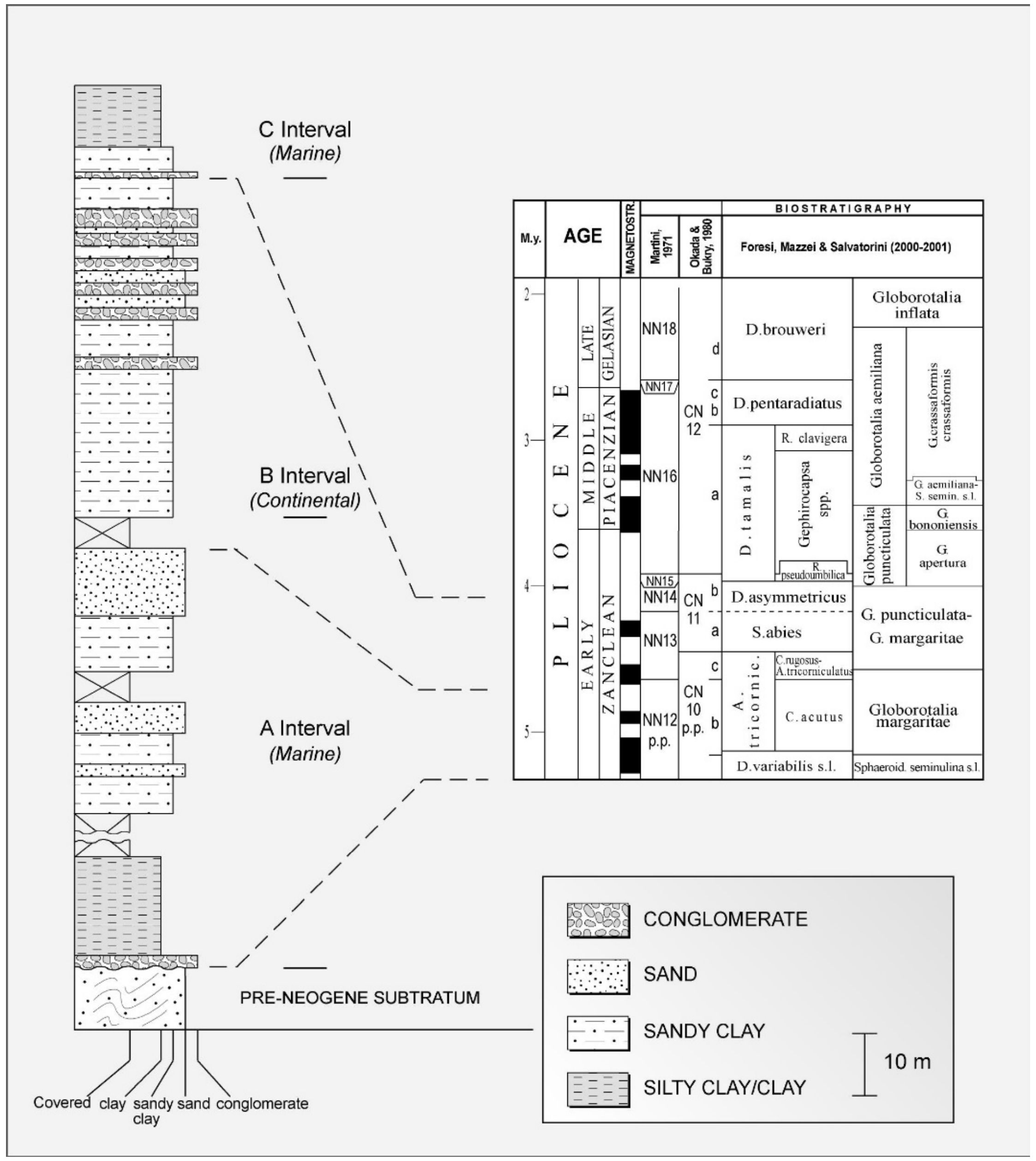


Fig. 9 – Sketch of stratigraphic succession of the Cerretalta area (from Bossio et al., 1992)

In the general geological context described above, it is necessary to describe in detail the typical aspect of the soils, here characterized by the presence of "Plinthites", formed during stage B.

The plinthite (from the Greek *plinthos* = brick) is a type of soil rich in clay and iron oxides, and poor in organic matter, which, following wetting-drying cycles, undergoes an irreversible hardening, becoming "laterite" or "petroplinthite". This soil type develops in a tropical or sub-tropical climate, generally in a sub-surface horizon, periodically saturated with water. Climatic, morphological, vegetational or anthropic changes (such as deforestation, for example) can dry the plinthite and irreversibly harden it. The largest areas where plinthites currently form are the intertropical regions, namely Brazil, central Africa, Indonesia, the southern part of the United States (Lousiana, Georgia, Florida), the southern Australian coasts and the south-eastern China (Fig.10).

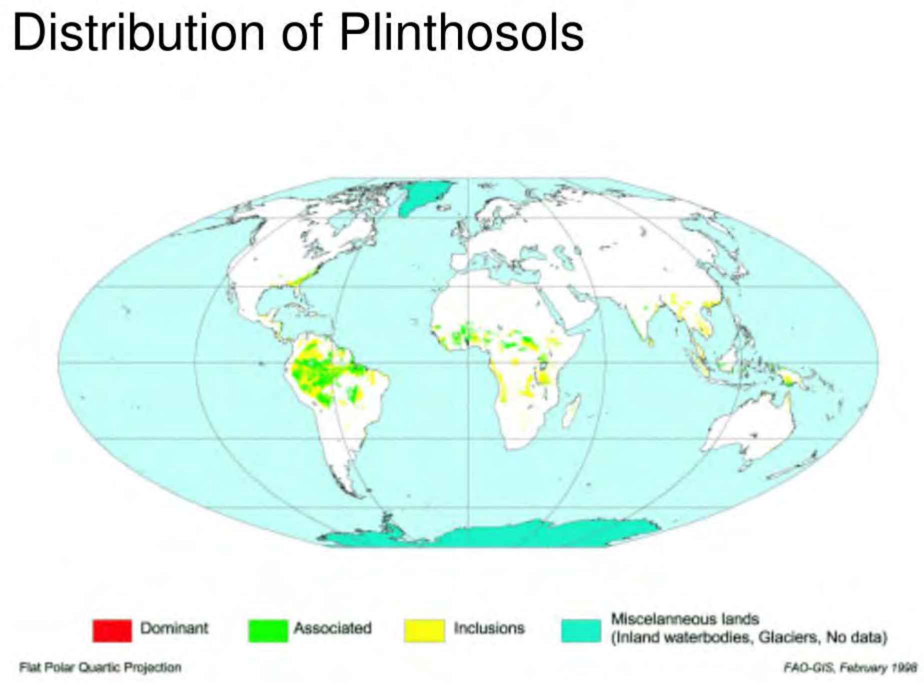


Fig. 10 – World distribution of plinthite soils

2.3 – SOIL PROFILES

In order to show analytically the results of the surface geological survey, 5 soil profiles were dug until a depth of about 1 m, through an excavator machine.

Each soil profile was described following the conventional FAO guidelines for soil description. Each soil horizon individuated in the profile was described and sampled for laboratory physical-chemical analysis.

The location and the analytical description of the profiles, conventionally called CER1, CER2, etc., are shown below. The laboratory test certificates made on each sample are shown in Annex 1 in the appendix to this report.

Fig. 11 – Location of the five soil profiles CER.

PROFILE CER 1

Survey date: 18/06/2019
Coordinates: 43.045398° N - 11.561855° E
Locality: Cerretalta **Municipality:** Montalcino
Elevation: 260 m s.l.m.
Slope: 8%
Aspect: South-West (225°)
Stoniness: small scarce (1%)
medium absent – coarse absent
Morphological element: Backslope
Parent material: marine sediments; silty-clayey
Qualities: Common sheet erosion,
low runoff,
internal drainage: somewhat poorly dranined.
Rooting limit: no limit.
International soil classification (WRB):
Stagnic Cambic Calcisols (Clayic)

HORIZONS

Ap 15 cm brown colour (10YR 4/6); scarce coarse fragments (<5%) of medium gravel (5-20 mm), sub-rounded, poorly weathered; texture: loamy clay; structure subangular blocky, medium, moderately developed; resistant; adhesive; weakly plastic, hydraulic conductivity moderately high (1-10 µm/s); HCl reaction violent; bulk density medium (1,2-1,4 g/cm3); boundary clear wavy.

Bkg1 80 cm pale brown colour (10YR 5/3); redox mottles of iron lost, grey (7,5YR 6/0), common (2-15%) medum (5-15 mm), scarce coarse fragments (<5%) of medium gravel (5-20 mm), sub-rounded, poorly weathered; texture: silty clay; structure subangualr blocky large, weakly developed; resistant; adhesive; plastic, hydraulic conductivity moderately low (0,1-1 µm/s); calcium carbonate nodules very small (3-5 mm) common (2-20%); HCl reaction violent; bulk density high (>1,4 g/cm3); boundary gradual wavy.

Bkg2 120 cm pale brown colour 10YR 5/3; redox mottles of iron lost, grey (7,5YR 6/0) many (15-30%), coarse (>15 mm); coarse fragments absent; texture: silty clay; structure subangolar blocky coarse, weakly developed; resistant; adhesive; plastic, hydraulic conductivity moderately low (0,1-1 µm/s); calcium carbonate nodules very small (6-20 mm) common (2-20%); roots coarse (6-10 mm) few (5-10/mq); HCl reaction violent; bulk density high (>1,4 g/cm3); unknown boundary.

PHYSICAL AND CHEMICAL ANALYSIS

Horizon	Depth (cm)		Sand	Silt	Clay	Carbonates (%)		Organic matter	Total nitrogen
	from	to		%		total	active	%	g/kg
Ap	0	15	21.3	39	39.7	10.8	3	1.4	1.2
Bkg1	15	50	10.6	44.2	44.2	19.1	6.3	0.3	0.55

Horizon	pH	EC	Exchange complex (meq/100g)					Mg/K	K exch.	P abs.
		dS/m	Calcium	Magnesium	Potassium	Sodium	CEC		mg/kg	
Ap	8.3	0.11	22.6	1.6	0.51	0.23	24.9	3.1	199	6
Bkg1	8.3	0.15	20.7	3.7	0.36	0.54	25.3	10.3	141	3

PROFILE CER 2

Survey date: 18/06/2019
Coordinates: 43.044812°N - 11.561544°E
Locality: Cerretalta **Municipality:** Montalcino
Elevation: 250 m s.l.m.
Slope: 20%
Aspect: South-West (225°)
Stoniness: small common (3%)
medium scarce (1%) – coarse absent
Morphological element: Backslope
Parent material: Alluvial fan deposits, clayey
Qualities: Common sheet erosion,
medium runoff,
internal drainage: moderately well drained.
Rooting limit: no limit.

International soil classification (WRB):
Stagnic Plinthosols (Eutric, Loamic)

HORIZONS

Ap 15 cm reddish colour (2,5YR 3/6); coarse fragments common (5-15%) medium gravel (5-20 mm), subrounded, moderately weathered; structure subangular blocky, moderately developed; resistant, hydraulic conductivity moderately high (1-10 μm/s); HCl reaction very weak; bulk density medium (1,2-1,4 g/cm3) ; density medium; boundary clear wavy.

Btg 70 cm reddish colour (2,5YR 4/4; redox mottles of iron lost, yellowish (10YR 5/6), common (2-15%) coarse (>15 mm), coarse fragments common (5-15%) medium gravel (5-20 mm), subrounded, very weathered; texture: clay loamy; structure prismatic medium, weakly developed; resistant, hydraulic conductivity moderately high (1-10 μm/s); illuviation coatings of iron and clay common (10-50%) along pores; roots medium (3-5 mm) few (5-10/mq); HCl reaction very weak, bulk density high (>1,4 g/cm3); boundary clear wavy.

Btvg 110 cm reddish colour 2,5YR 4/4; redox mottles of iron lost, yellowish (10YR 5/6), common (2-15%) coarse (>15 mm), skeleton absent; texture: clay loamy; structure wedge coarse, moderately developed; very resistant, hydraulic conductivity moderately low (0,1-1 μm/s); iron oxides concretions medium (21-76 mm) common (2-20%); illuviation coatings of iron and clay common (10-50%) on the aggregates; roots very coarse (>10 mm) few (5-8/mq); HCl reaction very weak; bulk density high (>1,4 g/cm3); unknown boundary.

PHYSICAL AND CHEMICAL ANALYSIS

Horizon	Depth (cm)		Sand	Silt	Clay	Carbonates (%)		Organic matter	Total nitrogen
	from	to		%		total	active	%	g/kg
Ap	0	15	23.7	39.0	37.3	1.4	-	0.62	1.0
Btg	15	70	21.3	41.3	37.4	0.5	-	0.3	0.9

Horizon	pH	EC	Exchange complex (meq/100g)					Mg/K	K exch.	P abs.
		dS/m	Calcium	Magnesium	Potassium	Sodium	CEC		mg/k	
Ap	8.4	0.11	10.2	5.4	0.69	0.49	16.8	7.8	270	9
Btg	8.6	0.16	8.6	7.8	0.46	0.87	17.8	17.0	180	3

PROFILE CER 3

Survey date: 18/06/2019
Coordinates: 43.046197° N - 11.562797° E
Locality: Cerretalta **Municipality:** Montalcino
Elevation: 273 m s.l.m.
Slope: 12%
Aspect: South-east (135°)
Stoniness: small frequent (6%)
medium common (3%) – coarse absent
Morphological element: Shoulder
Parent material: Alluvial fan deposits, clayey
Qualities: Common sheet erosion,
low runoff,
internal drainage: somewhat poorly drained.
Rooting limit: no limit.

International soil classification (WRB):
Stagnic Plinthosols (Eutric, Clayic)

HORIZONS

Ap 20 cm reddish colour (2,5YR 4/6); coarse fragments scarce (<5%) medium gravel (5-20 mm), subrounded, very weathered; texture: clay loamy; structure subangolar blocky, medium, moderately developed; resistant; weakly adhesive; very plastic, hydraulic conductivity moderately high (1-10 μm/s); HCl reaction very weak; bulk density medium (1,2-1,4 g/cm3); boundary clear wavy.

Btg 80 cm dark red colour (10R 4/6); redox mottles of iron lost, gray (7,5YR 6/0), common (2-15%) coarse (>15 mm); coarse fragments scarce (<5%) gravel medium (5-20 mm), subrounded, very weathered; texture: clayey; structure angular blocky coarse, weakly developed; very resistant, hydraulic conductivity moderately low (0,1-1 μm/s); illuviation coatings of clay and iron common (10-50%) along pores; roots medium (3-5 mm) few (5-10 /mq); HCl reaction very weak; bulk density medium (1,2-1,4 g/cm3); boundary clear wavy.

Btvg 120 cm dark red colour 10R 4/6; redox mottles of iron lost, gray (7,5YR 6/0), common (2-15%) coarse (>15 mm), coarse fragments scarce (<5%) medium gravel (5-20 mm), very weathered; texture: clayey; structure massive; extremely resistant, hydraulic conductivity moderately low (0,1-1 μm/s); iron concretions medium (21-76 mm) common (2-20%); illuviation coatings of clay and iron common (10-50%) along pores; roots medium (3-5 mm) few (5-10/mq); HCl reaction absent; bulk density high (>1,4 g/cm3); boundary unknown.

PHYSICAL AND CHEMICAL ANALYSIS

Horizon	Depth (cm)		Sand	Silt	Clay	Carbonates (%)		Organic matter	Total nitrogen
	from	to		%		total	active	%	g/kg
Ap	0	20	33.8	31.1	35.1	0.9	-	1.0	1.1
Btg	20	80	26.8	28.7	44.5	0.3	-	0.3	0.8

Horizon	pH	EC	Exchange complex (meq/100g)					Mg/K	K exch.	P abs.
		dS/m	Calcium	Magnesium	Potassium	Sodium	CEC		mg/k	
Ap	8.2	0.13	13.9	2.9	0.47	0.49	19.6	6.2	184	6
Btg	8.5	0.3	9.5	5.3	0.42	2.49	18.0	12.6	164	6

PROFILE CER 4

Survey date: 18/06/2019
Coordinates: 43.046012° N - 11.563321° E
Locality: Cerretalta **Municipality:** Montalcino
Elevation: 264 m s.l.m.
Slope: 20%
Aspect: South-east (135°)
Stoniness: small frequent (15%)
medium frequent (15%) – coarse absent
Morphological element: Backslope
Parent material: Alluvial fan deposits, gravelly clayey.
Qualities: Common sheet erosion,
moderate runoff,
internal drainage: moderately well drained.
Rooting limit: no limit.

International soil classification (WRB):
Chromic Luvisols (Loamic)

HORIZONS

Ap 15 cm reddish-brown colour (5YR 4/4); coarse fragments frequent (15-25%) gravel medium (5-20 mm) and coarse (20-50 mm), subrounded, very weathered; texture: clayey; structure subangular blocky medium, moderately developed; resistant, hydraulic conductivity moderately high (1-10 μm/s); HCl reaction weak; bulk density medium (1,2-1,4 g/cm3); boundary clear wavy.

Bt 70 cm reddish-brown colour (5YR 4/6); coarse fragments frequent (15-25%) gravel medium (5-20 mm) and coarse (20-50 mm), subrounded, very weathered, texture: clay loamy; structure subangular blocky medium, moderately developed; resistant, hydraulic conductivity moderately high (1-10 μm/s); illuviation coatings of clay and iron scarce (<10%) along pores; roots medium (3-5 mm) e fine (1-2 mm) few (5-10/mq); HCl reaction weak; bulk density medium (1,2-1,4 g/cm3); boundary clear wavy.

Btg 100 cm reddish-brown colour (5YR 4/6); redox mottles of iron lost, yellowish colour (10YR 6/2), common (2-15%), medium (5-15 mm); coarse fragments frequent (15-25%) gravel medium (5-20 mm) and coarse (20-50 mm), subrounded, very weathered; texture: clay loamy; structure subangular blocky medium, weakly developed; resistant, hydraulic conductivity moderately high (1-10 μm/s); illuviation coatings of clay and iron scarce (<10%) along pores; roots coarse (6-10 mm) few (5-10/mq); HCl reaction weak; bulk density medium (1,2-1,4 g/cm3).

PHYSICAL AND CHEMICAL ANALYSIS

Horizon	Depth (cm)		Sand	Silt	Clay	Carbonates (%)		Organic matter	Total nitrogen
	from	to		%		total	active	%	g/kg
Ap	0	15	27.1	30.1	42.8	2.2	-	1.7	1.5
Bt	15	70	37.6	24.8	37.6	2.0	-	1.0	1.1

Horizon	pH	EC	Exchange complex (meq/100g)					Mg/K	K exch.	P abs.
		dS/m	Calcium	Magnesium	Potassium	Sodium	CEC		mg/k	
Ap	8.1	0.13	18.9	1.7	0.73	0.27	21.6	2.3	285	15
Bt	8.3	0.14	19.5	2.6	0.34	0.51	23.0	7.6	133	4

PROFILE CER 5

Survey date: 18/06/2019
Coordinates: 43.044852° N - 11.564405° E
Locality: Cerretalta **Municipality:** Montalcino
Elevation: 244 m s.l.m.
Slope: 10%
Aspect: South-east (135°)
Stoniness: small frequent (10%)
medium common (5%) – coarse common (2%)
Morphological element: Footslope
Parent material: Lagoon deposits, gravelly clayey
Qualities: Common sheet erosion,
moderate runoff,
internal drainage: somewhat poorly drained.
Rooting limit: no limit.

International soil classification (WRB):
Stagni Calcaric Luvisols (Clayic, Sodic)

HORIZONS

Ap 20 cm pale brown colour (10YR 5/4); coarse fragments scarce (<5%) coarse gravel (20-76 mm), subrounded, weakly weathered; texture: clayey; structure subangolar blocky medium, moderately developed; resistant, hydraulic conductivity moderately low (0,1-1 μm/s); HCl reaction violent; bulk density medium (1,2-1,4 g/cm3); boundary clear wavy.

Btg1 70 cm pale brown colour (10YR 5/3); redox mottles of iron lost, gray colour (7,5YR 6/0), common (2-15%) medium (5-15 mm), coarse fragments scarce (<5%) coarse gravel (20-76 mm), subrounded, weakly weathered; texture: silty clayey; structure prismatic coarse, weakly developed; resistant, hydraulic conductivity low (0,01-0,1 μm/s); illuviation coatings of clay and iron scarce (<10%) along pores; roots coarse (6-10 mm) few (1-10) fine roots (1-2 mm) few (5-10/mq); HCl reaction violent; bulk density high (>1,4 g/cm3); boundary clear wavy.

Btg2 110 cm pale brown colour (10YR 5/3); redox mottles of iron lost, gray colour (7,5YR 6/0), common (2-15%) medium (5-15 mm), coarse fragments scarce (<5%) coarse gravel (20-76 mm), subrounded, weakly weathered; texture: silty clayey; structure prismatic, coarse, moderately developed; resistant, hydraulic conductivity moderately low (0,1-1 μm/s); illuviation coatings of clay and iron common (10-15%) along pores; roots fine (1-2 mm) few (3-5/mq); HCl reaction violent; bulk density medium (1,2-1,4 g/cm3); boundary unknown.

PHYSICAL AND CHEMICAL ANALYSIS

Horizon	Depth (cm)		Sand	Silt	Clay	Carbonates (%)		Organic matter	Total nitrogen
	from	to		%		total	active	%	g/kg
Ap	0	20	20.4	36.3	43.3	11.4	5.8	0.9	1.0
Btg1	20	70	4.3	49.4	46.3	13.8	8.3	0.4	0.7

Horizon	pH	EC	Exchange complex (meq/100g)					Mg/K	K exch.	P abs.
		dS/m	Calcium	Magnesium	Potassium	Sodium	CEC		mg/k	
Ap	8.3	0.16	19.6	3.8	0.77	0.37	24.5	4.9	301	7
Btg1	7.8	2.05	15.9	9.9	0.72	1.99	28.5	13.8	281	3

Soil features of Loc. Cerretalta

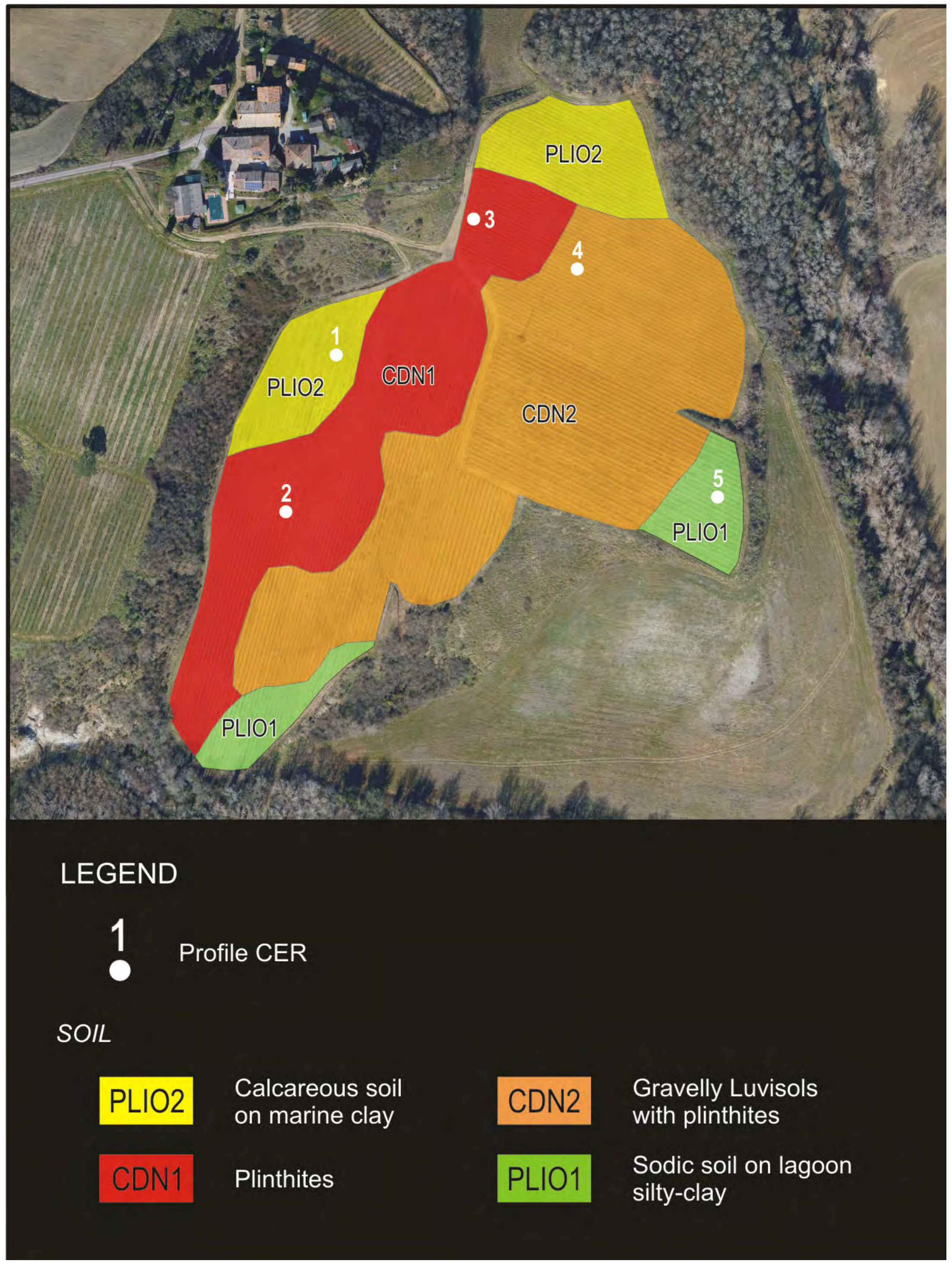


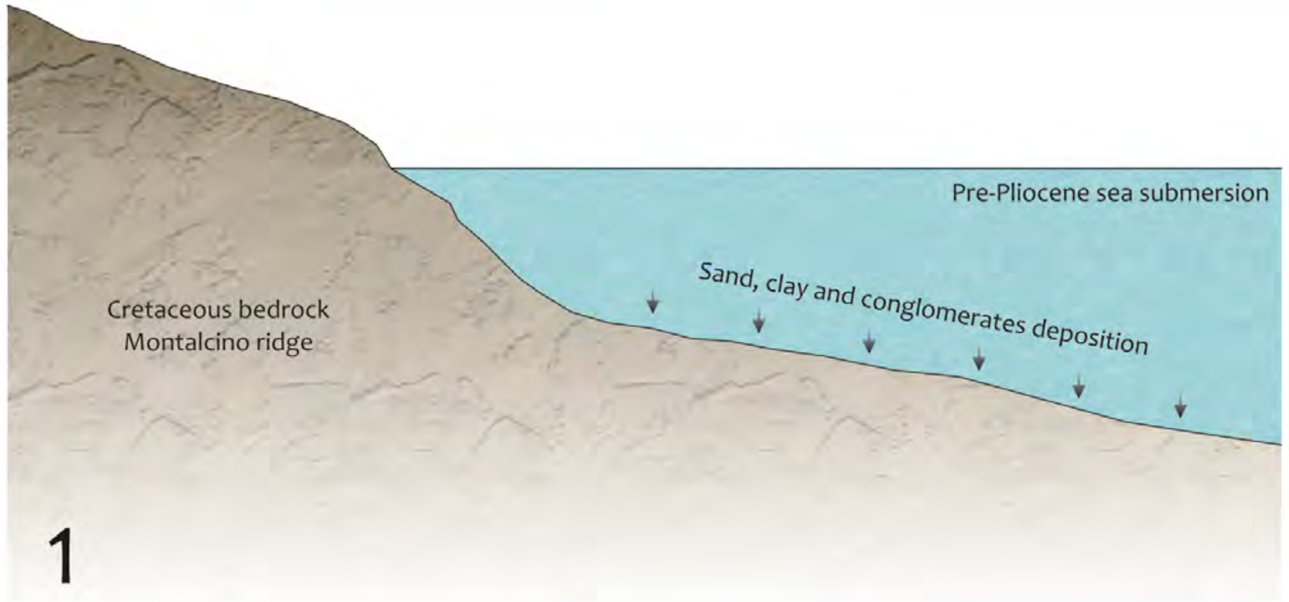
Fig. 12 – Soil map of the studied vineyards

From the geopedological survey, the studied vineyards are characterized by 4 types of sediments, which can be linked to the depositional sequence described above. In the lower part of the vineyards there are two areas with soils deriving from the lagoon-clayey silty sediments. They are loamy clay soils, rather calcareous, moderately saline-sodic in depth. In the soil map of Figure 12 they have been called PLIO1 (first depositional phase of the Pliocene). The reference profile of these soils is CER5.

The large intermediate belt of vineyards, which represents more than 80% of the total area, is characterized by alluvial fan sediments of stage B, strongly weathered. It was possible to discriminate the soil unit called "CasanovadiNeri 1" (CDN1), which represents the typical plinthite developed on finer sediments, from that called "CasanovadiNeri2" (CDN2), represented by less weathered soils formed on pebbly deposits, sometimes alternating with plinthite lenses.

The upper part of the two vineyards, is characterized by the clay-silty marine sediments of the second marine transgression, which buried the alluvial fan deposits. This type of soil is very common throughout the southern area of Montalcino, characterized by Pliocene marine deposition. In the soil map of Figure 12 this unit of soils was named PLIO2, because it is characterized by the sediments of the second marine transgression of the Pliocene period.

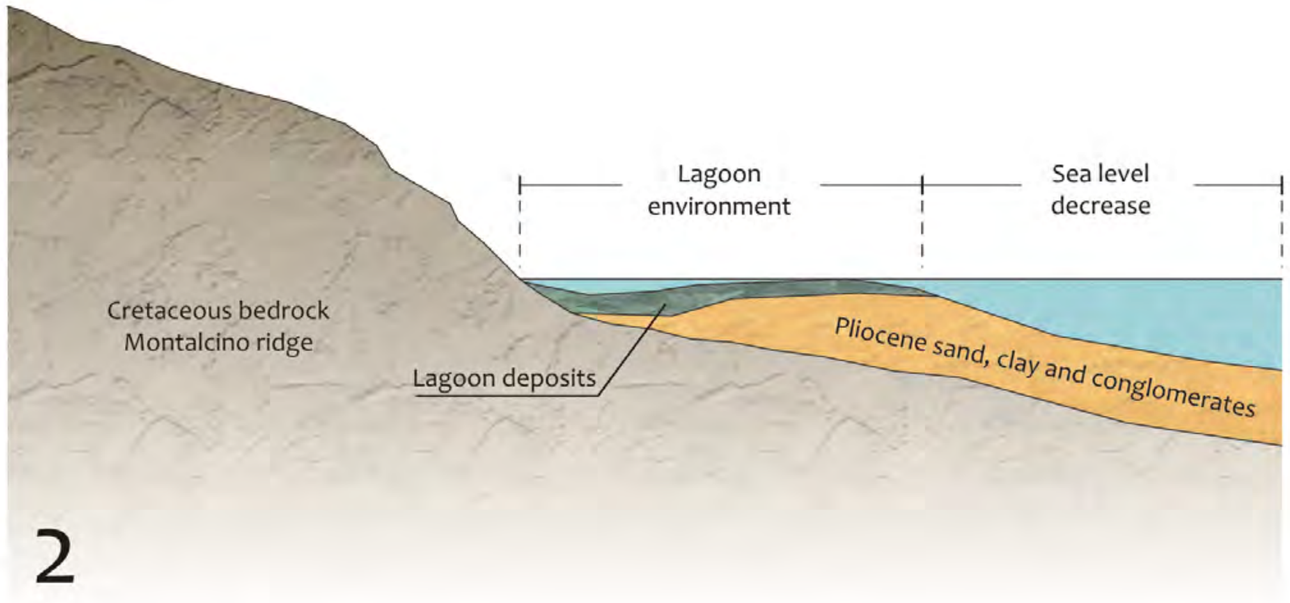
3 – SUMMARY OF THE GEOPEDOLOGICAL PROCESSES



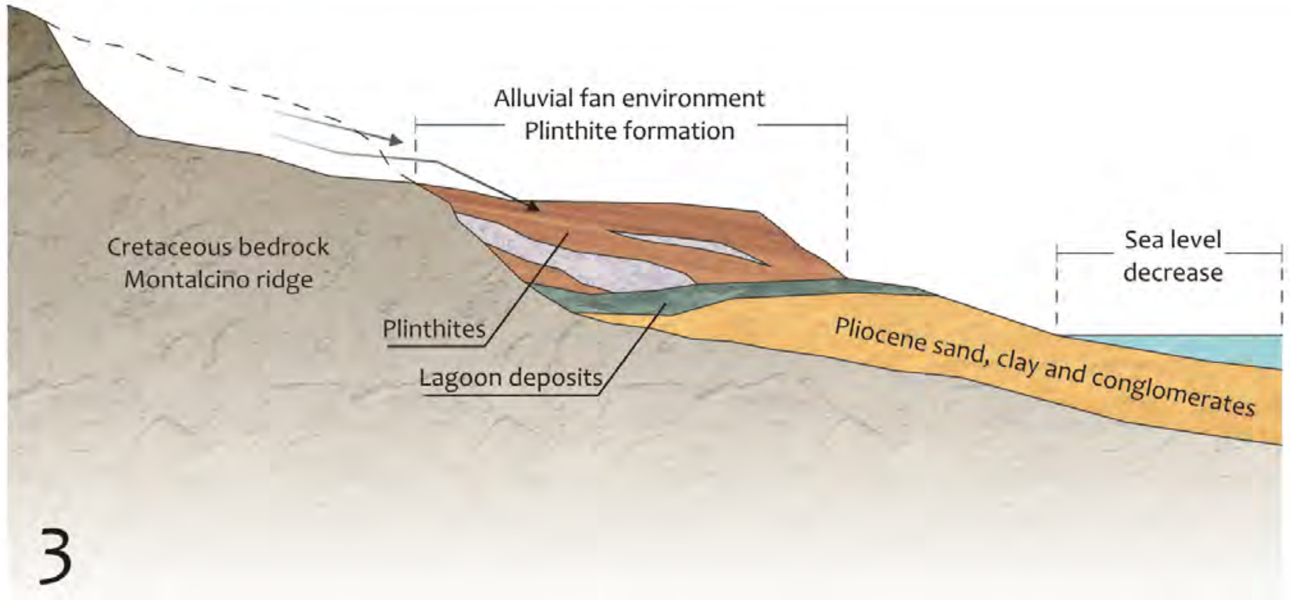
The paleoenvironmental reconstruction of the area described in the following illustrations was carried out on the basis of the data collected during this survey and from the data and results of scientific literature (Costantini and Priori, 2007).

The slope on the left side depicts the hilly ridge of Montalcino, formed by cretaceous rocks; the depression of the right side depicts the border of the Siena marine basin during early Pliocene; on which nowadays Cerretalta vineyards are located.

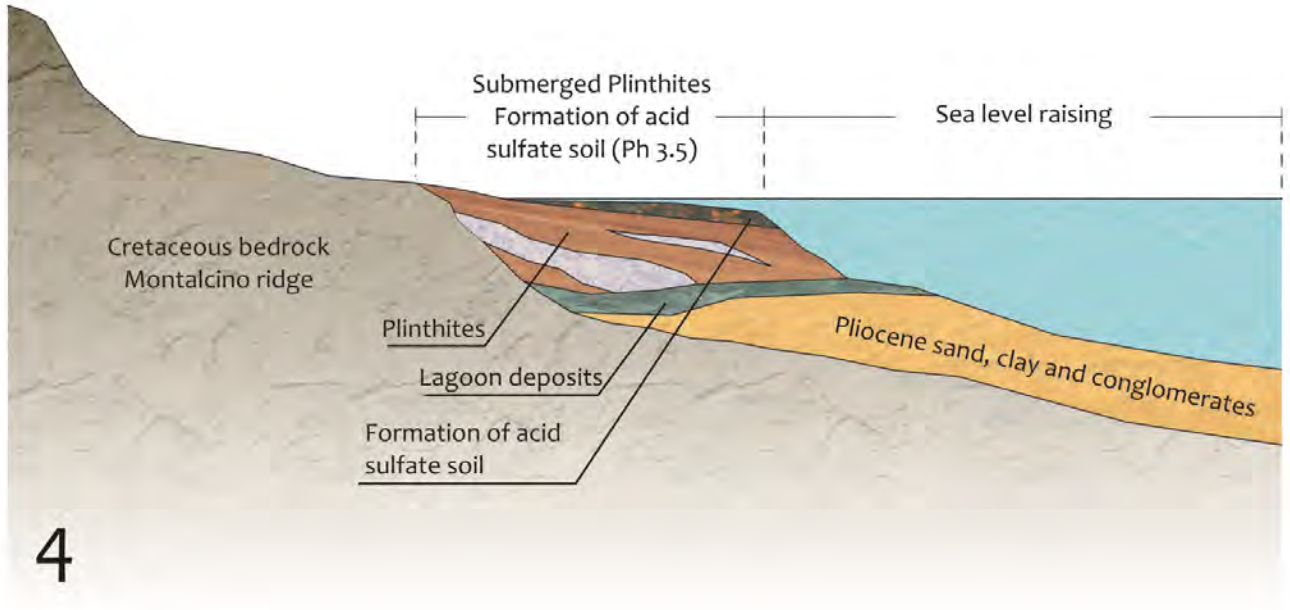
1. Since Late Miocene, a series of quick marine transgressions and regressions sediment succession of clay, sand and conglomerate on tectonic basins.



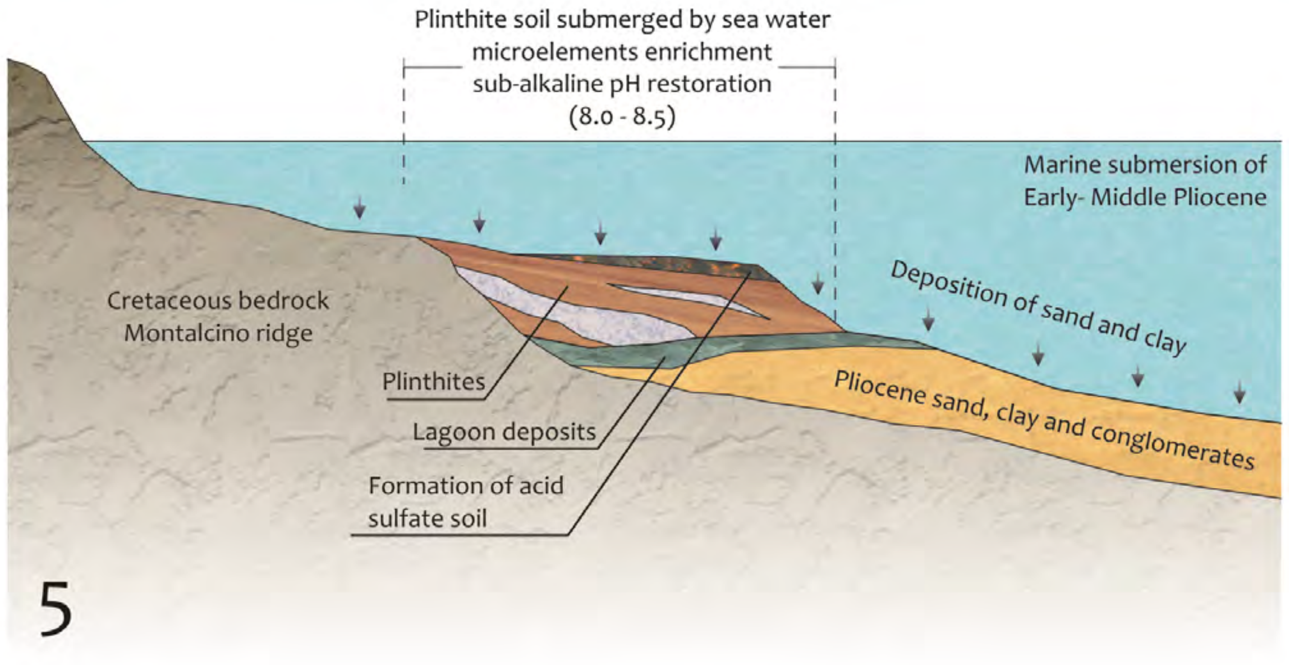
2. Around 4.8 Million years B.P., in the Early Pliocene, the Siena basin underwent gradual sea retreat, with a consequent formation of transitional lagoon environment close to Montalcino ridge. Such environment was characterized by quick but moderate sea level fluctuations, which caused an alternation of land submersion and emersion. During emersion phases, pedogenetic processes altered the sediments, but they were influenced by presence of marine water table and elevated temperature that enrich the soils with sodium and magnesium salts (individuated in elevated concentration on CER5 profile).



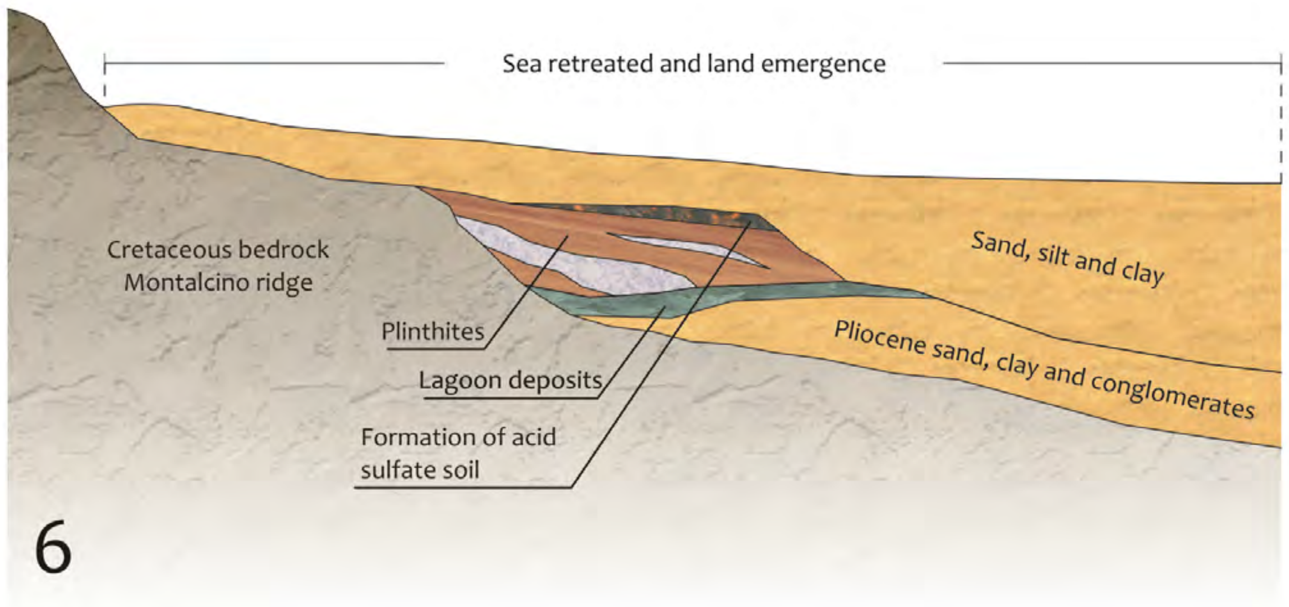
3. With the gradual sea level decrease, the Montalcino ridge footslope remained in a continental environment, with continuous sediments supply, due to the decay of the Montalcino ridge rocks. The environment was the typical alluvial fan, with periodic deposition of coarse deposits (debris flow) during strong climatic events and prolonged period of fine sedimentation (clay and silt). The long standstill between depositional events allowed strong weathering of the sediments and formation of strongly developed soils. The warm and humid climate allowed the release of iron from the minerals, the iron oxidation and the strong soil reddening. The deposits, situated on the footslope, were subjected to periods of waterlogging, due to the shallow water table, and then reduction environment. These reduction conditions are testified by large grey mottles within red soil mass, due to iron leaching, observable in the profiles CER2, CER3 and CER4. The profile 2 and 3, belonging to "CDN1" unit, represent the strongest developed and weathered soils, formed on finer soils. The profile CER4, belonging to "CDN2" unit represents the soils formed on gravelly deposits. In both the soil units, coatings of clay and iron oxides are frequent along the pores and on the aggregate faces, testifying a climate with seasonality. During dry season the clays dried out, whereas during rainy season the clays percolate along soil pores. Such cycles of drying and hydration provided to these soil horizons the typical characteristics of plinthites.



4. About 4.1 million years B.P., the sea level started to raise again, and the area was slowly submerged, forming a sub-tropical delta environment. This environment was strongly reducing and allowed the precipitation of large amount of pyrite and manganese oxides, which because of weathering increase the soil acidity (acid sulfate soils, pH 3.5).

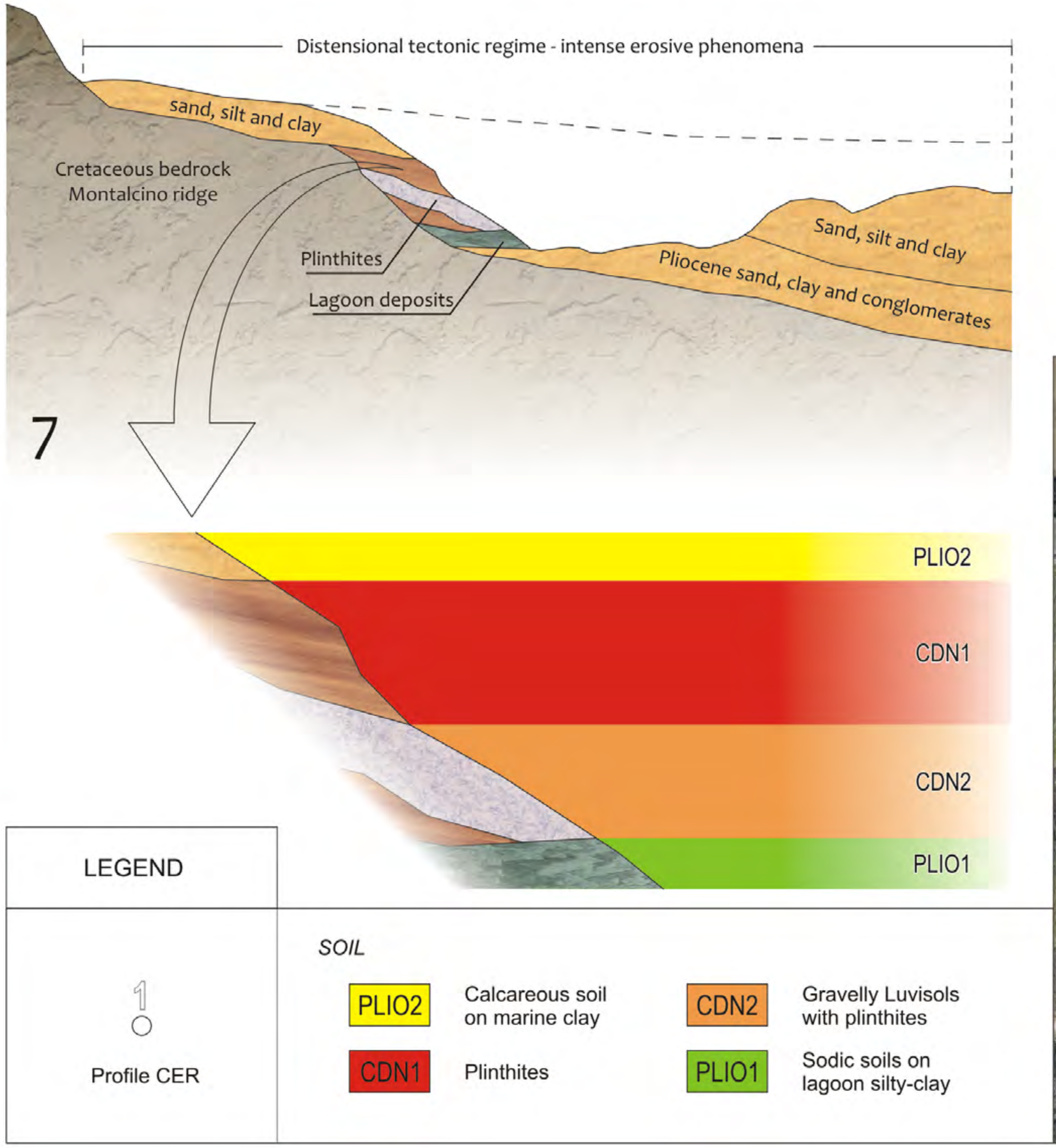


5. The sea increased its depth, submerging completely the alluvial fan deposits and the footslope of Montalcino ridge. The plinthite soils, generally acid and scarce in nutrients, was submerged by marine water that enrich such soils of macro and microelements like calcium, sodium, magnesium and potassium; the pH became sub-alkalin (pH 8-8.5). At the same time, a second marine depositional cycle sedimented material gradually finer.



6. Around 3.5 - 4.0 Million years B.P., during middle Pliocene, the sea completely retreated from the Siena basin.

7. During Quaternary, from 2.5 Million years B.P. to today, the whole area has been subjected to tectonical raising and formation of faults and intense erosive phenomena, which modelled the territory. Such raising and erosion allowed to bring back to the surface these paleosols (plinthite), previously buried from the marine deposits, unique in the Montalcino territory.



4 – THE TYPICAL TERROIR OF THE CERRETALTA VINEYARDS

From the investigations, it was possible to observe that about 80% of the vineyards surface is made up of paleosols that were formed between 4.8 and 4.1 million years on alluvial fan sediments, very close to the coast and in a sub-climate tropical.

The Pliocene was a transitional period, in which a climate generally warmer than now evolved towards rather fluctuating temperatures (middle-upper Pliocene) and then the colder climate of the lower Pleistocene. At our latitudes, in the lower-middle Pliocene the temperature should be higher between +1 and +5 ° C than today. Thus, a climate with average annual temperatures ranging between 17 and 21 ° C was set, and precipitation probably much greater than 1000 mm per year, if not even 1500 mm. Climates similar to those present in Tuscany during the lower-middle Pliocene are currently present in sub-tropical regions such as southern China, the South-East of the United States (Lousiana, Georgia, Florida), the southern Australian coasts and the northern zone of the South Africa.

The soil units individuated during the survey was called "CasanovadiNeri1" and "CasanovadiNeri2", distinguished on the basis of the coarse fragments content (higher in CDN2), the pedogenetic weathering degree and the iron osides release (higher in CDN1).

These soils have clayey or clay-loam texture, with coarse fragments of various sizes (from small gravel to boulders) and variable percentage (from almost absent in CDN1 to 30-40% by volume in CDN2). They are originally sub-acid soils, very poor because of strong leaching of macronutrients (Calcium, Potassium, Magnesium), and strong residual accumulation of Iron, Aluminum and Silica. They also tend to harden and cement irreversibly and are also used as bricks. It is not a coincidence that the plinthite is also known as laterite.

In this case, however, plinthite pedogenesis has not been so evolved because of the climate, which is not as aggressive as the tropical one. The irreversible hardening is limited only to a few nodules and small iron concentrations. Furthermore, the main peculiarity of the Cerretalta soils is that they were later submerged by sea water during the Pliocene.

This allowed the supply of elements such as Calcium, Magnesium, Potassium, Sodium to the soil, which was already extremely rich in iron, aluminum and silica, and to restore a sub-alkaline pH (8.0-8.5).

Presumably, if this marine event had not happened, these plinthite soils would be difficult to use for viticulture or, more generally, for agricultural purposes.

On the contrary, this succession of events has allowed the formation of very rich soils both in iron and in microelements, also characterized by the low presence of organic matter and nitrogen, and no limitations to the rooting exploration of the vines, such as cemented levels, rock or unfavorable soil chemistry.

In Montalcino territory, relict soil sections of this type have been detected only around the area of Loc. Cerretalta, and they are still very rare even in the national context. Paleosols with plinthite outcrop in few small areas in Italy, but post-genetic submersion of sea water was not found in any case. This unique succession of pedogenetic and sedimentary events made the soils of Cerretalta vineyards, and then the viticultural terroir unique.

These extremely peculiar characteristics allow the vine root system to deepen and explore the soil, limiting water and nutritional stress, with the qualitative and quantitative availability of macro and micro-elements necessary for vine growth, are not found anywhere in the Montalcino viticultural ditrict.

Montalcino, September 2019 Geol. Marco Antoni