COMPARATIVE MICROMORPHOLOGICAL CHARACTERISTICS OF WOODLAND SOILS" SERRA DA ESTRELA, PORTUGAL

by

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On the "Centro de Investigaçac Mesologica (Lisboa, Portugal) a Project is being developed with the main purpose to follow the influences of different forest stands on the restauration and evolution of degraded soils. Several plots were fixed in these stands for measuring the litter-fall, every season of the year, and to follow, further, its decomposition and incorporation into the soil. This study is the description of the morphological and micromorphological characteristics of representative profiles of the different plots under consideration.

I. THE AREA OF STUDY

The stands selected are placed on the hills of Serra da Estrela, which is one of the highest mountains that cross the Peninsula Iberica from Sintra, near Lisbon, until Guadarrama in the northern part of Madrid.

Estrela is a huge mountain with valleys lower than 500 m. The upper part is like a plateau with altitudes between 1800 m and 2000 m.

The dominant rocks are the granites and the schists. On the contacts, where both roks are metamorphosed, hornfels were formed. Inclusions of quartzites are seen either on granite either on schists.

The granite has as the main minerals quartz, feldspats, biotite; and as secondary minerals resulting

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of the feldspat weathering, sericite, clorite iron oxides and hidrcxides are found. The biotite and clorite often have pleocroic nucleous.

The soils of the upper part of da "Serra da Estrela" are designated, on the Soils Map of Portugal (scale 1/1. 000. 000), as Rankers.

The soils of the lower parts were included among the Cambisols. Because of its lower scale it was not possible to delimit on this map the variations within the main tipes of soils.

In fact, a more detailed observation shows that vesides a typical Ranker there are, in the higher altitudes other soils which exhibit podzolization. Bellow 600 meters, on the south and west expositions, we may see soils where rubefaction processes are acting. On the altitudes up 1200 meters the soil has a compact black iluviation horizon and an eluviation horizon with white-grayish colours. From the rubefaction of schists results soils very similar to the Red Soils of Schists already mapped on different areas south Tagus River.

Besides these, a larger part of the profiles developed on schists reveal features very similar to the ones of the Litolic Humic Soils which are a soil unity already described and mapped in the southern part of Portugal. These soils are, in general, developed on silicious substractum and at altitudes of approximately 1000 m. They have a higher content of organic matter in the A horizon and they show a transition horizon or even a thin (B) horizon of deep weathering.

The profiles herewith described were observed inside the stands of Pinus pinaster, Pinus silvestris, Pinus laricio, Pseudotsuga douglassi and Castanea sativa which are the main species used in the afforestation of Serra da Estrela. They are growing at altitudes between 550 meters and a thousand five hundred meters.

2. - MATERIALS AND METHODS

In each of the six selected stands different profiles were seen. One among them, was choosed as the representative. The age, density, altitude and the exposition of the stand were also considered.

The six stands selected were the following:

Profile number	Elevation (m)	Rock type	Stand
CO15	920	Schist	Pinus pinaster
CO16	620	Schist	Pinus pinaster
CO21	1200	Granite	Pinus laricio
CO19	1400	Granite	Pinus silvestris
CO14	1020	Metamorphic Schist	Pseudotsuga
CO22	1000	Schist	Castanea sativa Quercus tozza e Myrica faya

The samples for the micromorphological observation were colected in zinc boxes with dimensions of 0, 08x0, 065x0, 06 m.of the same model as indicated by Kubiena. The impregantion and the cut in a thin section with the standard thickness of 0, 03 cm, was performed in the Laboratory of Micromorphology of the "Instituto Nacional de Edafologia", Madrid, Espanha.

In the micromorphological descriptions we have followed the inicial nomenclatures of Kubiena and Brewer which were latter completed, for the organic materials, by Babel.

To express quantitavely the organic and mineral components on the thin section six terms have been used:

rare
some
frequent
abondant
very abondant
dominant

3. DESCRIPTION OF THE PROFILES

PROFILE CO 15

MORPHOLOGY

INFORMATION ON THE SITE SAMPLED

Location. - Manteigas, Valhelas, Cantao do Gorgulhao.
Elevation. - 920 meters.
Land form. - Hilly.
Slope. - 32 %
Exposition. - North.
Land-Use. - Stand of Pinus pinaster with approximately 40 years. The upper part of many trees damaged by the snowfall.
Climate. - SAxSO - Sub-Atlantic pluvious.

DESCRIPTION OF THE INDIVIDUAL SOIL HORIZONS

0, 00/0, 02 - Litter.
0, 02/0, 04 - F + H Organic material in process of decomposition and forming a "mat".
0, 04/0, 22 - A_{11} 2, 5 YR 2/0 - black. 10 YR 3/2 - very dark grayish brown. Loam with some gravel and a few stones.

Grumb, fine and medium, weak.
Nonplastic, very friable, soft.
Gradual transition for the

0, 22/0, 50 - 10 YR 2/2 - very dark brown.

A_{12} 10 YR 3/4 - dark brown.
Loam with some gravel and a few stones.
Crumb, fine, weak.
Gradual transition for

0, 50/ - 2, 5 Y 4/3 - dark grayish brown to olive brown.

C - 10 YR 4/3 - brown to yellowish dark brown.
Sandy with abondant gravel and schist stones.

MICROMORPHOLOGICAL DESCRIPTION

Horizont F + H

Almost the whole section with humiskel, Ocasional schist fragments. In the upper part parallel bands of Pteridium leaves residues are seen. The main organic material is built up by Pinus leaves with original shapes. Some of these leaves have only a part of the mesophyll. Other only maintain the epidermis. The inner tissues are completely damaged. Many of the small roots present the same aspect. Inside the damaged tissues are found abondant excrements with ovoid shapes and a very discrete and irregular outline. Outside the leaves are also seen many of these very dark colored excrements. Some charcoal fragments still reveal their initial tissue structure. Some agregates are seen with a very irregular shape and outlines.

Horizont A_{11}

Plant residues, in general, without preserved tissues. The majority are transformed in yellow or re-

dish colored substance. Frequent small roots sections with epidermis transformed in yellowish brown substances. The whole thin sections exhibits abondant charcoal fragments very different in shape and size. Frequent planar schist fragments with roundy forms and irregular outlines. Angular quartz grains of regular granulometry are included in the whole mass. Moderate crumbly structure. Agregates connected by bridges. Open voids in the whole thin section. No vughs are visible. Agglomeratic fabric.

Horizont A_{12}

Tissue residues strongly altered and trans - formed in part, or in the total, in a red substance. Some schist and quartzite fragments. Abondant quartz grains of regular granulometry. The schist fragments have a planar shape and quartzite inclusions. Crumbly microstructure strongly developed. Roundy agregates very distinct. Agglomeratic and intertextic fabric.

PROFILE CO16

MORPHOLOGY

INFORMATION ON THE SITE SAMPLED

Elevation . - 620 m.
Landform . - Hilly.
Slope . - 45 %.
Exposition . - West.
Vegetation . - Stand of Pinus pinaster forty years old: d. b. h. between 20 and 45 cm.
Climate . - SA - Sub-Atlantic.

Description of the individual soil horizons

0, 00/0, 02 - Litter

L
0, 02/0, 04 – 10 YR 3/2 – very dark grayish brown.
F + H 10 YR 3/2 – very dark grayish brown.
Plant residues in process of decomposi – tion and forming a "mat".
0, 04/0, 22 – 10 YR 2/2 – very dark brown.
A_1 10 YR 4/3 – brown to dark brown.
Loam with abondant gravel and some stones.
Crumb, medium, moderate.
Nonplastic, very friable, soft.
0, 22/0, 35 – 10 YR 4/3 – Brown to dark brown.
A_{12} 10 YR 4/4 – Dark yellowish gray.
Loam, very gravelly, slightly stony.
Crumb, fine, moderate.
Nonplastic, very friable, soft.
0, 35/0, 50 – 7, 5 YR 4/4 – Brown to dark brown.
(B) 7, 5 YR 6/6 – Redish yellow.
Silty, very gravelly very stony.
Crumb, fine, weak.
Nonplastic, very friable, soft.
0, 50 – Fragmented schist. Very abondant gravel and soft wheathered stones.

MICROMORPHOLOGY

Horizont F + H – Leaves with damaged parenquimas but with epidermis preserved. Tissues re sidues with the cell walls transformed in a dark brown substance or in a re- dish brown substance. Some sclorotic sections. Some charcoal fragments. Groups of excrements with ovoid forms,

frequents. Other excrements with a barrel shape. Long Schists fragments with roundy outlines and gravish brown or greenish brown colours.

Horizont A_1 – Tissue fragments of different origin with the peripheral layers transfor – med in a redish substance. Some sections present mycorryhisae. Some ovoid shape excrements.
Abondant schist fragments with ferruginous deposits and black inclusions.
Rare areas of continuous plasma.
Strong microstructure. Very roundy agregates.
Aglomeratic fabric.

Horizont A_{12} – Tissue fragments without discret cell cavities and with the peripheral layer transformed in a red substance.
Frequent charcoal fragments with a very discrete countours. Some of them have still the original cell structure.
Abondant schist fragments. Rare quartzite fragments. Some parts of the section with a hematite cement.
Very discret roundy agregates with some vughs voids. Intertextic and agglomeratic fabric.

Horizont (B) – A few tissue residues transformed in a red mass. Rare charcoal fragments with roundy or subangular outlines.
Schist fragments exhibiting the original gray colours and brown colours of the weathered material.
Strong structure with very regular and

roundy agregates in some sections.
Simple grain structure in other sections.
Agglomeratic fabric.

Profile CO21

MORPHOLOGY

INFORMATION OF THE SITE

Location . - Manteigas, Covais, Ribeiro do Viveiro.
Altitude . - 1200 m.
Landform . - Steeply dissected.
Slope . - 60 %
Exposition . - Southsouthwest
Geology . - Coarse hercyanian granites.
Vegetation . - Pinus laricio stand 40 years old. d. b. h. (average) 22, 5 cm.
Climate . - SA×OA - Sub-Atlantic oroatlantic.

DESCRIPTION OF THE INDIVIDUAL SOIL HORIZONS

0, 00/0, 03 - Litter

L

0, 03/0, 08 - Organic material in decomposition.

F + H 7, 5 YR 3/2 - dark brown.
5 YR 3/1 - very dark gray

0, 08/0, 28 - 10 YR 3/2 - very dark yellowish brown
10 YR 4/4 - dark yellowish brown.
Sandy with very abondant gravel.

A Crumb, very fine, weak and simple grain.
Nonplastic, very friable, soft.

0, 28/ 7, 5 YR 3/2 - dark brown.

C 10 YR 5/3 - brown.
Sandy with very abondant gravel and many granite stones.
Nonplastic, very friable, slightly hard.

MICROMORPHOLOGY

Horizont F + H – Pinus laricio leaves with the original outlines but with the wall cell of the mesophill transformed in a redish brown substance. Vascular bundles destroyed. Some charcoal grains and excrements. Skeleton grains of quartz with a very changeable granulometry very abondant in the lower part of this layer in the contact with the A horizon. Some grains of microclina. Frequent biotite.

Horizont A – Tissue residues transformed in a red or redish brown colored substance. Some sclorotic sections skeleton grains of very changeable granulometry: Abondant quartz grains exhibiting many cracks. Some mica (biotite); ortoclase rare . On the quartz grains we may see thin cutans of mineral-organic mate - rials. Strongly organic plasma.

HorizontC – Parent material composed of coarse grain granite highly fragmented.

Profile CO19

MORPHOLOGY

INFORMATION ON THE SITE

Location . - Manteigas, Alto da Serra, Covao de Jorge.
Altitude . - 1400 m.
Landform . - Convex slope; hilly.
Geology . - Hercynian granites.
Vegetation . - Pinus silvestris with d. b. h. average of 13, 7 cm.
Climate . - Sub-atlantic oroatlantic.

DESCRIPTION OF INDIVIDUAL SOIL HORIZONS

0, 00/0, 02 - Litter
L

0, 02/0, 06 - Organic material in process of decomposition forming a dense "mat".

0, 06/0, 12 - 10 YR 3/1 - very dark gray.
A_1 10 YR 3/2 - very dark grayish brown.
Sandy with abondant gravel.
Crumb, fine, weak.
Nonplastic, loose, soft.

0, 12/0, 24 10 YR 4/2 - dark grayish brown.
A_2 10 YR 5/2 - grayish brown.
Sandy with very abondant gravel.
Simple grain.
Nonplastic, very friable, loose.

0, 24/0, 48 10 YR 3/2 - very dark grayish brown.
B 10 YR 5/2 - grayish brown.
Sandy with abondant gravel.
Crumb, medium, weak.
Nonplastic, very friable, slightly hard.

0, 48/ Coarse granite.

Micromorphology

Horizont F + H – Some leaves with the original shapes. Abondant tissue residues exhibiting peripheral dark red colored layers. Some of these leaves include dark colo red ovoid shape excrements with very discret outlines.
Loose excrements are also visible in the whole section with circular shape and brown colours. Quartz grains are rare. Strong microstructure. The main agregates are built up by the excrements. Excremental fabric dominant. Some intertextic sections.

Horizont A_1 – Frequent tissue residues altered in a dark red substance. Some charcoal fragments.
Very abondant skeleton grains. Some altered grains of mica showing the separation of their different elements along the cleavage plans. Agglomeratic fabric.

Horizont A_2 – Small roots and stems sections only exhibiting the peripheral layers already altered in a brown red substance.
Very abondant skeleton grains: craked quartz grains dominant. Some ortoclase, frequent microclina. Some mica (biotite) showing pleocroic halos with the separation of the component elements along the cleavage plans.

Horizont B – Rare tissue fragments transformed, in general, in a red substance. Skeleton grains with very changeable granu

lometry and configuration. Angular out lines. Quartz grains with craks, do - minant. Some plagioclase, microclina ortoclase and biotite. Dark colored agregates visible in the whole section. Some parts of the section showing coun tinuous plasma. Many grains are surro unded by cutans of changeable thickness.

Profile CO14

MORPHOLOGY

INFORMATION ON THE SITE:

Location. - Manteigas, S. Lourenço
Altitude. - 1020 m.
Landform. - Steeply dissected.
Slope. - 45 %
Exposition. - West.
Vegetation. - Pseudotsuga stand 32 years old; d. b. h. average 22, 5 cm. Density 976/ha.
Climate. - SAxOA. - Rainy sub-atlantic.

DESCRIPTION OF INDIVIDUAL SOIL HORIZONS

0, 00/0, 02 - Litter.
L

0, 02/0, 05 - 7, 5 YR 3/2 - Dark brown.
A 7, 5 YR 4/4 - Brown to dark brown.
Sandy loam.
Crumb, fine to medium, moderate.
Nonplastic, very friable, soft.

0, 34/0, 56 10 YR 3/4 dark yellowish brown.
10 YR 4/4 dark yellowish brown.
AC Sandy loam with many gravel fragments.
Crumb, fine to medium, moderate.

	Nonplastic, very friable, soft.
0, 56/0, 86 C	Dar yellowish brown sandy loam with abon dant gravel and platy stones having very sharp borders.
0, 86/ R	Hard metamorphic schist.

MICROMORPHOLOGY

Horizont F + H — Rare leaves with the original shape but often with a part of the parenquima transformed in a red substance. Abon dant tissue residues with a black peri pheral layer. Charcoal with and whit- out visible cell . Some schist and quart zite fragments. Small roundy agregates. Intertextic and aglomeratic fabric.

Horizont A_1 – Frequent tissue residues transformed in a red-brown substance. Some char coal fragments. Some roundy dark grey colored excrements. Frequent quartzite fragments exhibiting ferrugi nous material depositions. The whole thin section presents plasma. Fine agregates without discret outlines. Fa bric: some sections present intertex - tic, other agglomeratic.

Horizont AC – Some tissue residues only exhibiting a peripheral layer altered in a redish brown substance. Schist and quartzite fragments with ferruginous deposits. Angular and subangular quartz grains. Plasma only visible in some parts of the section. Some crumb agregates.

Profile CO22

MORPHOLOGY

INFORMATION ON THE SITE :

Location . - Cantao da Cabeça Alta, Fragusto.
Elevation . - 1.100 m.
Landform . - Plateau with hilly surrounding areas.
Slope . - 15 %.
Exposition . - West.
Vegetation . - Mixed stand of Castanea sativa, Quercus Tozza and Fagus silvatica. Forty years old; d.b.h. between 5 cm and 25 cm for the C. sativa, between 5 cm and 15 cm for the Quercus tozza and of 10 cm for the F. silvatica. Density of the stand 2080 trees/ha.
Climate . - SAxOA sub-atlantic oroatlantic.

DESCRIPTION OF THE INDIVIDUAL SOIL HORIZONS

0,00/0,03 - Litter.
L

0,03/0,09 - Fermentation plus humification layer presenting a difuse transition for the next horizon.
F + H

0,09/0,28 10 YR 2/2 - very dark brown.
A_{11} 7,5 YR 3/2 - dark brown.
Silty or fine sandy with very abondant gravel and some platy and angular stones.
Crumb, fine and mediu, weak.
Nonplastic, very friable, soft.
Difuse boundary.

0,28/0,50 10 YR 3/2-2/2 - Grayish dark brown to very dark brown.
A_{12} Silty and fine sand with abondant gravel and without stones.

Crumb, fine, weak.
Nonplastic, very friable or loose, soft or loose.
Abrupt boundary.

0, 50/ 10 YR 4/4 – Yellowish dark brown material.
Fine sandy or silty with some gravel and
G some platy and very angular stones and bloks of schist.
Crumb, fine weak.
Nonplastic, friable or firm, slightly hard.

MICROMORPHOLOGY

Horizont F + H Some tissue residues transformed, in generai, in a yeliowish brown substance with the periphery darker than the interior. Rare with the original cell structure. Some charcoal fragments in part with the original cell structure. Abondant uniform black colored charcoal. Skeleton grains composed of some schist fragments, rare quartzite and frequent quartz grains of very changeable granulometry. Strong microstructure. Agregates of different size, roundy outlines and, some, with a higher sphericity.

Horizon A_{11} Some tissue residues transformed in a brown substance. Frequent charcoal fragments. Some still with the original cell structure.
Frequent gray fragments. Some with a brown ring of altered material. Some quartzite fragments. A very well developed plasma. Frequent planes and vughs. Strong microstructure. Agregates with angular outlines. Agglomeratic fabric.

Horizon A_{12} — Tissue residues transformed in a brown and black substance. Frequent schist fragments of changea - ble granulometry exhibiting a progressi ve transformation of the original gray to brown colour material. Abondant - quartz grains of very regular granulome try. Some parts of the thin section with abondant plasma. Strong microstructu- re. Some agregates with very regular outlines, other very irregular. Intertex t ic and agglomeratic fabric.

CONCLUSIONS OF THE OBSERVATIONS

The macro and micromorphology of the consi dered profiles reveal the following main features:

1. - The presence, either on the stands of evergreens either on the mixed stand, of a layer of litter with a thickness which varies between 2-3 cm.
2. - The presence of a fermentation /humification layer, F + H, with a thickness between 2-8 cm. Has the as - pect of a "mat" very adherent to the organic-mineral A_1 horizon. This layer is not a very discret on the soils under mixed stands. (CO22).
3. - The soils of a larger part of the studied areas re- veal the same features indicated for the unit of the soils map of Portugal (scale 1/50. 000) designated as Humic Litolic Soils, that is, soils with a profile A_1, AC, C, or A_1, (B), C.
4. - The soils under a stand of Pinus silvestris, and at altitudes of approximately 1400, developed on a grani te rock, exhibit an B iluvial horizon with a heavy accu mulation of organic material.

5. - The majority of the organic residue show a total or parcial loss of their inicial collular structures. Leaves with the original shape are very rare. The peripheral layers are often changed in a plasmatic substance with a yellow, red yellow or dark red colours. Some tissue fragments are completely transformed in a red plasmatic substance.
Charcoal fragments are common in the majority of the horizons. Some are very angular and still have remanescents of the cellular structure. The majority have irregular shape and roundy outlines.
Excrements with elipsoidal shapes and discret outlines are common in the organic horizons F + H. These excrements have a similar shape of the Acaros found on the decomposing leaves of the Abies of the Black Forest (1). They form groups which fill in part, or in total, the inner part of the leave or are seen disseminated among other materials.
In the F + H are also found excrements of larger dimensions with a barrel shape. Both tipes of dejections are built up by materials of uniforme colour and are compact.

6. - The different organic mineral horizons exhibit a crumbly, or excremental microstructure, combined with the simple grain structure. The agregates are moderately or strongly separated. Continuous plasma is seldon seen.

7. - The dominant fabric is of agglomeratic type. Some sections show the intertextic fabric. The excremental fabric is also seen in some sections.

SUMMARY

Morphological characteristics of soil profiles on forest stands of Serra da Estrela (Portugal) are described. These stands are found at different altitudes and their dominant trees are the Pinus pinaster, the Pinus laricio, the Pseudotsuga and the Castanea sativa.

The evergreens stands of Pinus and Pseudotsuga exhibit organic layers of fermentation + humification (F+H) very distinct from the L layer and from the horizon A. On the stand of Castanea sativa (mixed with Quercus tozza and Fagus silvatica), although with very high quanti ty of litter, however, the layer of fermentation humifica tion is not so contrasting either with L or with A.

The micromorphological study indicates in general, very strong microstructure in every horizon and an agglom agglomeratic fabric. Excrements of two distinct shapes are common. Charcoal is also common.

Organic cutans of iluviation were observed on the mineral grains of the soil B horizon on the Pinus silvestris stand (at the altitude of 1380 meters).

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REFERENCES

BABEL, U. 1975. Chapter 7, "Micromorphology of Soil Organic Matter" in "Soil Components", Vol 1 edited by John E. Gieseking, Spring-Verlag, Berlin.

BREWER, R. 1964. "Fabric and Mineral Analysis of Soils", John Wiley & Sons, New York, London.

CARDOSO, J.V.C. - BESSA; M. TEIXEIRA, & MARADO; M. BRANCO. 1973. "Carta dos Solos de Portugal", Separata da "Agronomia Lusitana". Vol. XXXIII, Tomos 1-IV, Estaçao Agronomica Nacional, Oeiras, Portugal.

CARDOSO, J.V.C. 1965. "Os Solos de Portugal", Sua Classificaçao, Caracterizaçao e Genese, 1- A Sul do Rio Tejo, Lisboa.

KUBIENA, W.L. 1938 - "Micropedology", Collegiate Press., Ames, Iowa, U.S.A.

KUBIENA, W.L. 1952 - "Claves sistematicas de suelos" Consejo Superior de Investigaciones Cientificas, Madrid. 1952.

LAUTENSACH, H. 1932. - "Estudo dos Glaciares da Serra da Estrela", "Memorias e Noticias". Publicaçoes do Museu Mineralogico e Geologico da Universidade de Coimbra, Portugal.

SERVIÇOS GEOLOGICOS DE PORTUGAL. - 1966- "Carta Geologica de Portugal" na escala de 1/50. 000 Noticia Explicativa da Folha 17-D, Gouveia.