The Mediterranean Soils: a quick overview

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The Mediterranean Soils: discussing the concept

Vasily Vasil'evich Dokuchaev (Russia, 1846-1903) is commonly regarded as the father of pedology, the study of soils in its natural setting. Dokutchaev, c. 1880, established the concept of zonal soils, as those showing characteristics that reflect the effect of climate in pedological processes. Examples of zonal soils were the steppe soils, the desert soils, the (coniferous) forest soils. Intrazonal and azonal were the complementary concepts.

A brief note on Dokuchaev work and legacy

Dokuchaev introduced the idea that geographical variations in soil type could be explained in relation not only to geological factors (parent material), but also to climatic and topographic factors, and the time available for pedogenesis (soil formation) to operate. Using these ideas as a basis, he created the first soil classification. His ideas were quickly taken up by a number of soil scientists, including Hans Jenny. He worked on soil science, and developed a classification scheme describing five factors for soil formation. He arrived at his theory after extensive field studies on Russian soils in 1883. His most famous work is Russian Chernozem (1883). Thanks to Dokuchaev's works a number of Russian soil terms are in the international soil science vocabulary (chernozem, podsol, gley, solonets). A crater on Mars is named in his honor. *(based on Buol et al., 2003)*

The Portuguese Soil Classification has a suborder named Mediterranean Soils – still in accordance with these concepts.

Table 1 – Soil Groups (and some Sub-Groups) of the Portuguese Soil Classification and corresponding groups is FAO / WRB system.

Group / Sub-Group (SRO)	Corresponding to FAO / WRB
Solos Incipientes	
Litossolos	Lithic Leptosols
Regossolos	Arenosols and Regosols
Coluviossolos	Regosols
Aluviossolos	Fluvisols
Solos Litólicos	Leptosols and Cambisols
Solos Calcários	Calcisols
Barros	Vertisols
Solos Mólicos	Mollisols
Solos Argiluviados	Luvisols and Alisols
Mediterrâneos Vermelhos e Amarelos	
Mediterrâneos Pardos	
Solos Podzolizados	Podzols
Solos Hidromórficos	Gleysols
Solos Salinos	Solonchacks and Solonetz
Solos Orgânicos	Histosols

The effect of other soil formation factors is, in many circumstances, much more determinant of soil characteristics than climate. It is the case for example of parent material or topography. These evidences contributed, through time, to the obsolescence of the concept of zonal soils, and the related concepts of intrazonal and azonal.

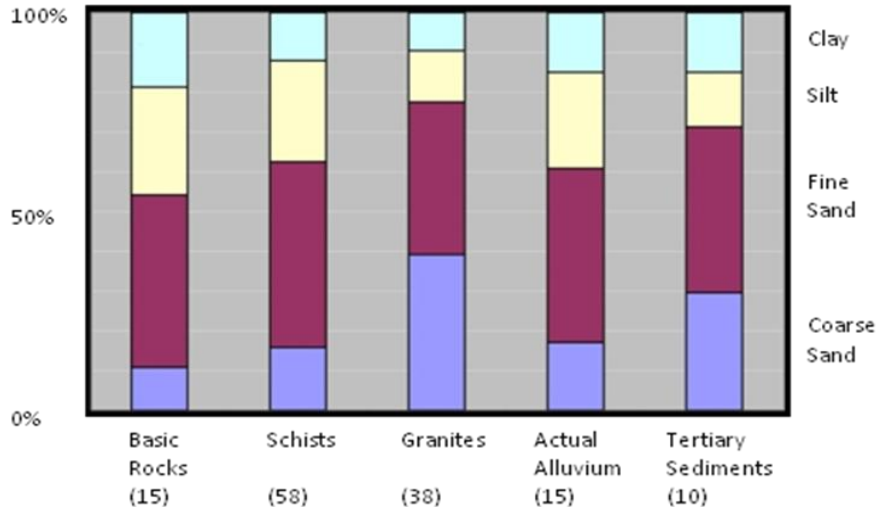

Figure 1*: Soil particle size distribution as affected by parent material in Trás-os-Montes region, NE Portugal: average values for the number of profiles in brackets (Figueiredo, 2002).*

Currently, soil scientists tend to avoid linking soil classification concepts and soil taxonomy to climate, and, by extension, to any soil formation factor. The following quotation clearly depicts the most updated conceptual orientations adopted in actual Soil Science.

"Climate parameters are not applied in the classification of soils. It is fully realized that they should be used for interpretation purposes, in dynamic combination with soil properties, but they should not form part of soil definitions." (IUSS/WRB, 2006:3).

It should be stressed that the International Union of Soil Sciences and the World Reference Base for Soil Resources are, respectively, the reference organization and classification system in the Soil Science domain.

A question may then arise and it regards the title of the lecture:

The Mediterranean Soils – Does this make sense?

The answer is: No (apparently!).

Actually, it makes sense because the scope of the lecture is to provide a quick overview on the soils found in this geographical area. The above quoted orientations by IUSS and WRB are then entirely accepted. The variety of soil types to be describe will show that under this geographical setting many other effects than simply climate, contribute to soil genesis and evolution. It is exactly that pedodiversity that should be understood by students in this lecture.

The thematic of Mediterranean Soils is developed along the following sections:

- Main soil groups – comprising a short description of their characteristics and geographical distribution

- Soil formation factors – mainly focused on their relative importance to actual soil properties
- Need for soil protection – briefly indicating threats and soils under threat in the Mediterranean

The Mediterranean basin

The Mediterranean basin, draining to the Mediterranean Sea, is:

- A large mid-latitude belt, roughly ranging from 30º to 45ºN
- Geographically located between the temperate regions in the North and the desert areas in the South
- With specific climatic conditions, featuring a strong seasonal contrast of precipitation, a hot dry Summers and mild wet Winters (OMBROTÉRMICOS VER GOMES GUERREiRo)

Other Mediterranean climate areas are found in California (North America), Chile (South America), South Africa and Southern Australia.

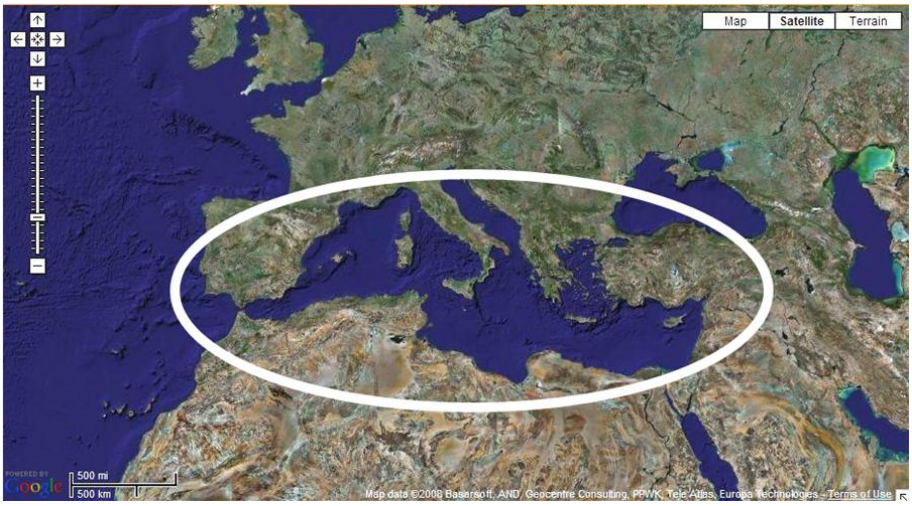

***Figure 2**: The Mediterranean Basin (image from Google Earth).*

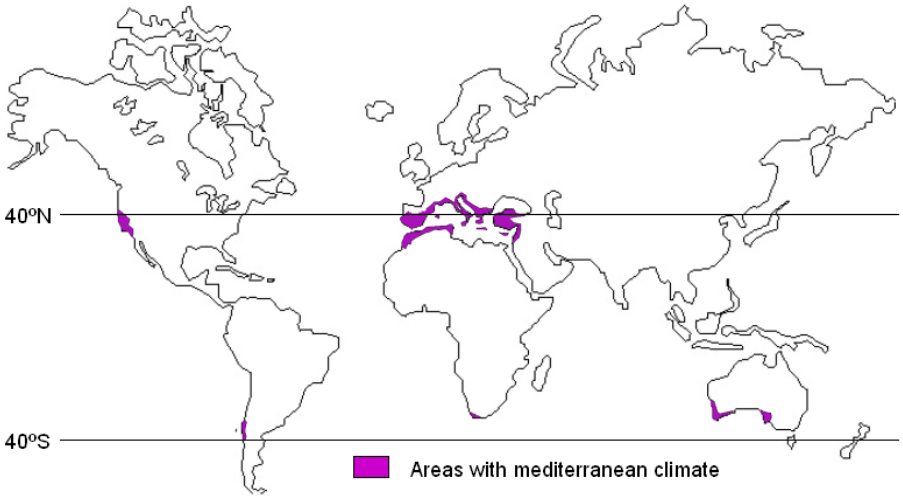

***Figure 3**: Areas with Mediterranean climates (free internet access image).*

Although geographically quite restrict, the Mediterranean has an enormous civilizational importance. Actually, there is a huge contrast between the mere 2% of the globe surface where Mediterranean climate prevails, and the long array of civilizations that arose in the Mediterranean and gave the world the most remarkable heritage and intangible values, throughout history.

Main Soil groups

1. General features

Areal distribution of main soil groups is depicted below, following the FAO system of soil classification. It can be seen that:

- Three groups cover more than 50% of the area and they are the Calcicols (20%), the Cambisols (16%) and the Luvisols (16%)
- To these Vertisols (4%) should be added, due to their areal relevance when compared with those included in Others
- Label Others comprises a large list of soil groups, including Leptsols, Regosols, Alisols, Fluvisols, Gleysls, Gypsisoils, Solonchacks, Solonetz
- Low development soils dominate, as Calcisols and Cambisols, together with those qualified as incipient due to practically no evidence of pedogenetic activity, as Regosols and Leptosols
- Calcisols reflect Carbonates importance as lithological materials in the Mediterranean
- More developed soils, as for example the Luvisols, are important in areal terms but they are far from dominant

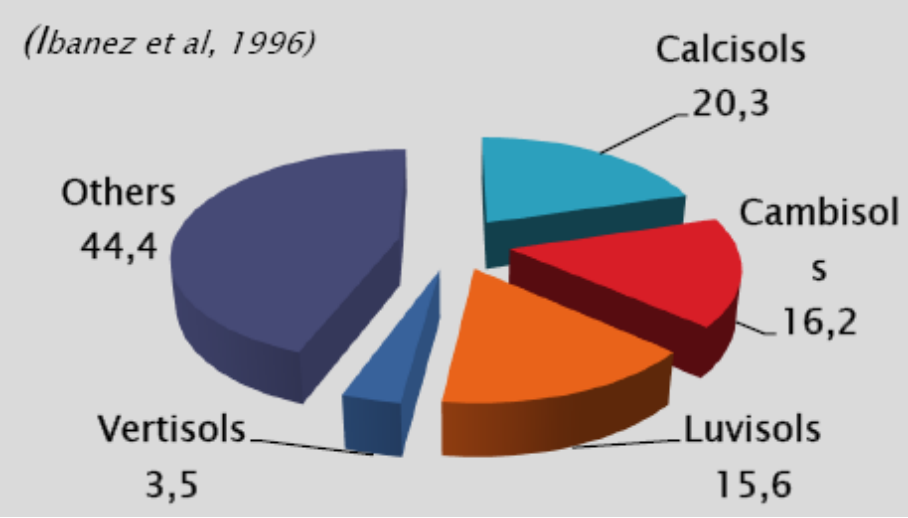

***Figure 4**: Areal distribution of main soil groups in the Mediterranean (Ibanez et al. 1996).*

"At world level, despite the small area of the Mediterranean landscapes, their pedodiversity is outstanding" (the second after Mountain climates) (Ibanez et al. 1996).

A very schematic description of each one of the main soil groups follows, simply indicating the most relevant features of these soils.

2. Brief description

a. Calcisols

- Soils with secondary CaCO3 accumulation (Bk or Ck horizons)
  - Calcic, hypercalcic or petrocalcic horizon at less than 100cm depth
  - Calcic horizon has more than 15% CaCO3 equivalent
  - Hypercalcic horizon has more than 50% CaCO3 equivalent
  - Petrocalcic is a hardned hypercalcic horizon (Bkm, Ckm)
- Mostly clayey, high pH
- Occurrence in dry environments (dominant in South Mediterranean)
- Mostly cultivated

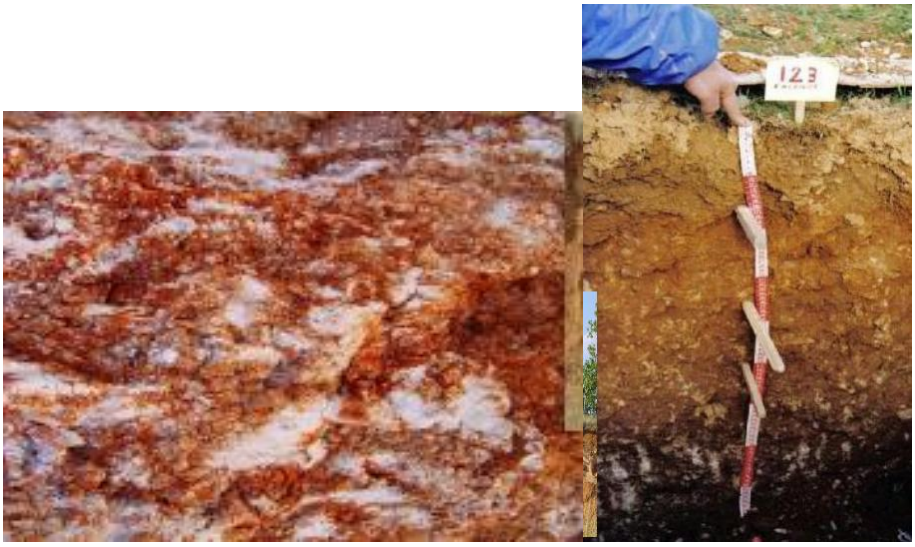

***Figure 5**: Calcisols profile (internet free access images).*

b. Cambisols

- Soils that show soil formation features by either:
    - Colour change compared to parent material
    - Soil structure development
    - Leaching of carbonates
    - Formation of silicate clays and sesquioxides as a result of weathering of primary minerals
    - But lack sufficient soil development to classify otherwise
- Varied physical-chemical characteristics
- One of the most widespread soils
- Mostly cultivated

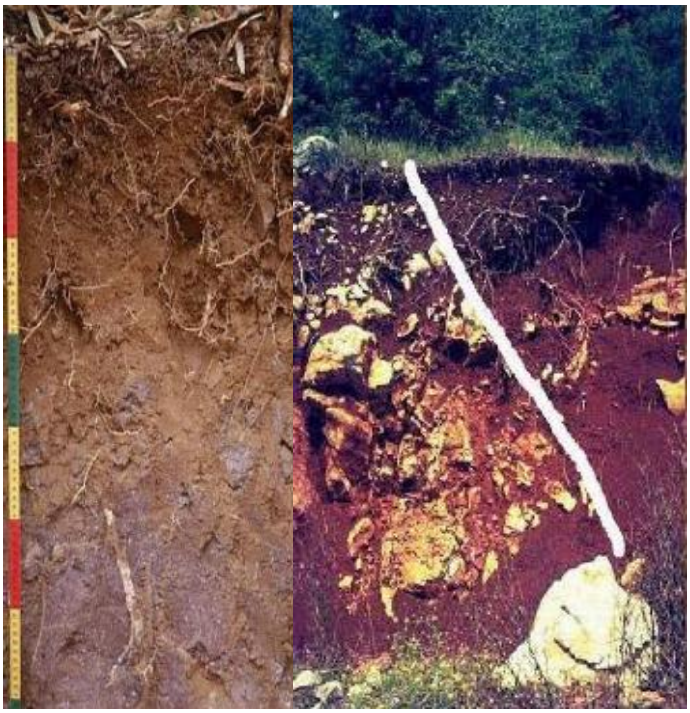

***Figure 6**: Cambisols profile (internet free access images).*

c. Luvisols

- Soils well-developed, with argic subsurface horizon (Bt), due to illuvial clay accumulation
- Mostly chromic (reddish) in drier areas
- Fertile soils, mostly cultivated (also forested)

d. Vertisols

- Soils moderately developed, clayey in the entire profile, shrink-swell clays (montmorillonite)
- Poorly structured (prismatic aggregates), badly drained, chemically fertile
- Grazing or cultivated areas

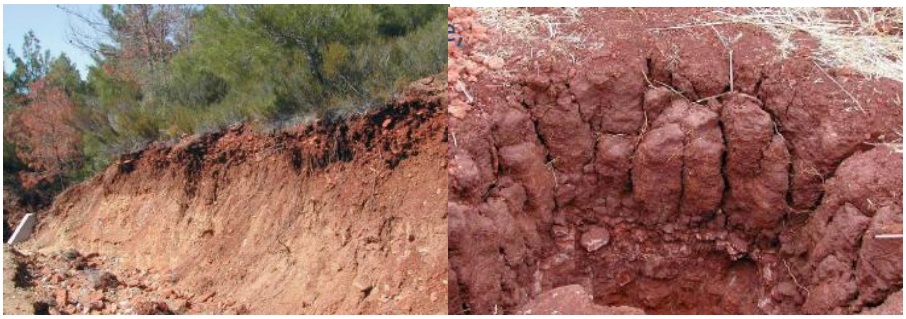

***Figure 7**: Luvisols and Verti sols profile (internet free access images).*

Other soil groups

- Leptsols (shallow, stony, over hard-rock) – mountainous steep areas
- Regosols (coarse material, lacking B horizon) – sometimes colluvial deposits
- Alisols ("leached Luvisols") – wetter or more acid environments than Luvisols
- Fluvisols (deep, fine textured, fertile) – alluvial plains
- Gleysls (hydromorphic, gray colours) – poorly drained areas (depressions or alluvial plains)
- Gypsisoils (secondary gypsum accumulation) – drier areas than Calcisols
- Solonchacks / Solonetz (excess Na) – brackish water or drier areas than Gypsisols

***Figure 8**: Salt marsh where saline soils develop (internet free access images).*

Soil formation factors

After describing the main soil groups identified, following a rank in areal importance, addressing to soil formation factors helps explaining their geographic distribution.

Since Jenny, in 1940, the soil, as characterized by its properties, is taken as a function or the outcome of combined effects of the soil formation factors. Soil formation factors are climate, parent material, topography, organisms and time. In practical terms, organisms are restricted to the most visible group acting to form soil – vegetation. In cultivated areas, man acts also as a soil formation factor. The effects of man in soil are a result of continued and long lasting land use systems. As so, land use may be taken as a soil formation factor in areas where the soils are cultivated since long, as it is the case of very many in the Mediterranean.

In this section soil formation factors contributing to characteristics and distribution of soils in the Mediterranean are treated as follows:

- Climate – climatic features relevant for soil formation
- Relief – geological and physiographic features
- Parent material – main lithologies
- Vegetation, land use, man and time – a long history of land use and misuse

Figures below illustrate the effect of soil formation factors on selected soil properties, taking as an example the soils of NE Portugal.

1. Climate

Climatic features relevant for soil formation in the Mediterranean are:

- Sesonal contrast of precipitation

  Driving seasonal (not continuous) leaching, favouring eluviation-illuviation mechanisms, with development of argic horizon (Bt, typical of Luvisols and Alisols).
- Summer drought

  Conditioning rock weathering and pedgenesis, limited to winter when chemical and biological activies are lowest.
- Precipitation amount

  Mostly low (below 600mm annual average), limits depth range of salts leaching and secondary precipitation, favouring calcic (Ck) and gypsic (Cy) horizons (or even their hardened version: petrocalcic and petrogypsic).
- Precipitation concentration

  Promotes erosion (a selective particle entrainment process) and, together with the previously mentioned low precipitation amounts, limits rock weathering rates, favouring tony soils.

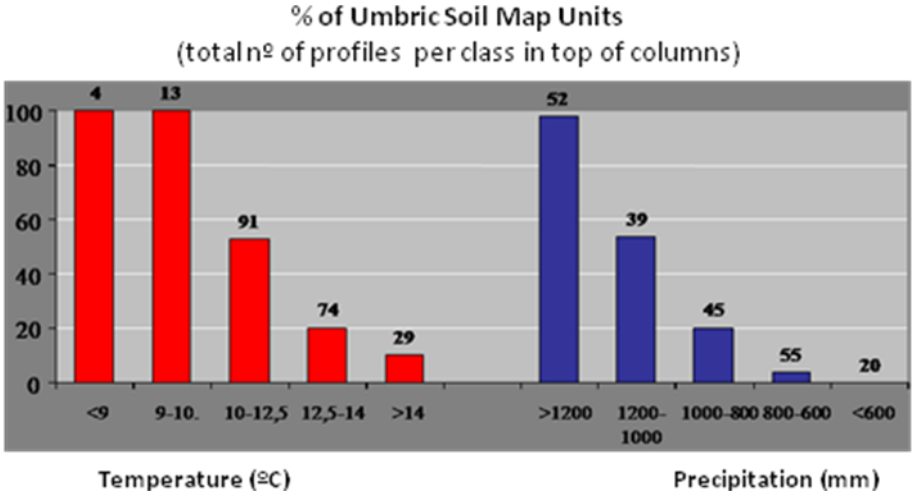

***Figure 9**: Effect of Temperature and Precipitation (annual averages) on soil organic content as assessed by the presence of a Umbric (A organic rich) horizon in NE Portugal soils (Figueiredo 2002).*

2. Relief

Relief addresses to physiographic features and these are strongly dependent on the geological history. The following aspects are relevant to soil genesis:

- Recent orogenic movements – Mediterranean higher mountain ranges rised under Alpine orogeny and tectonic activity persists due to the position and movement of plate margins (African and Eurasiatic)
- Polygenetic landscapes – recent and ancient land forms co-exist
- Main morphological features – denuded hillslopes, extensive floodplains, torrential dissection by ephemeral streams, combine to display
- Diverse but dominantly vigorous relief – sloping land is the major part of Mediterranean, favouring erosion instead of weathering and pedogenesis, outcoming shallow and stony soils in steeper areas

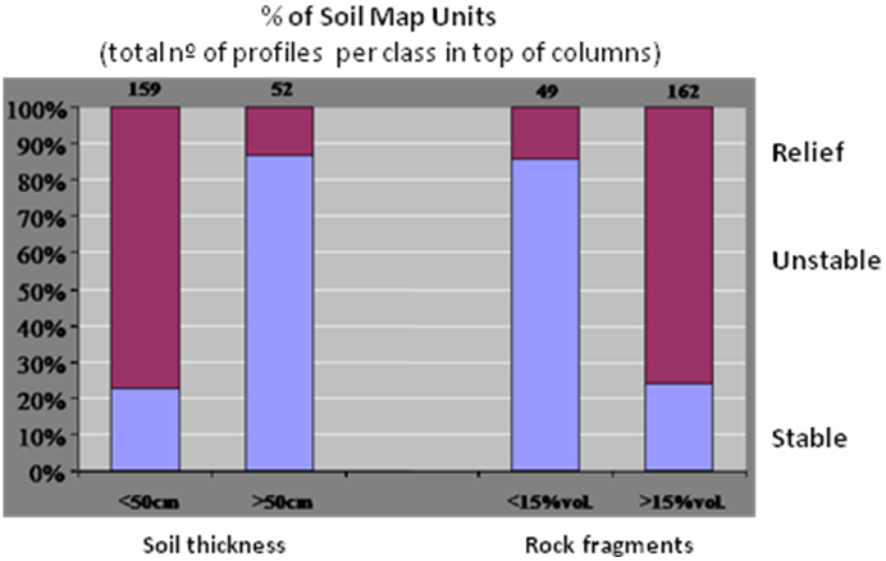

***Figure 10**: Effects of geomorphological stability (associated to relief) on soil thickness and stoninesss in NE Portugal soils (Figueiredo 2002).*

3. Parentmaterial

Main lithologies found in the Mediterranean basin support the following synthetic elements:

- Diverse lithologies, although sedimentary material prevails
- Limestones – widespread, in all topographic positions
- Detritic origin common – sandstone, clay, mainly flatter areas
- Metamorphic and magmatic – respectively, schists and granite or volcanic, steeper and higher areas
- Gypsic and saline parent material – drier and lowlands

Parent material affects soil depth, texture, clay mineralogy, cation exchange capacity and base saturation, pH, and may also influence the physical properties of soil. In fact, loose sediments allow development of deep soils, as it is the case of Fluvisols, while soil derived from harder parent materials may vary widely in

depth, according to weathering rates and topographic position. Over acid magmatic or metamorphic rocks, as granites and schists, respectively, soils are generally acid with low in base saturation. On the contrary, either over basic magmatic rocks or over sedimentary materials as carbonates and sulfates, pH and base saturation are both high.

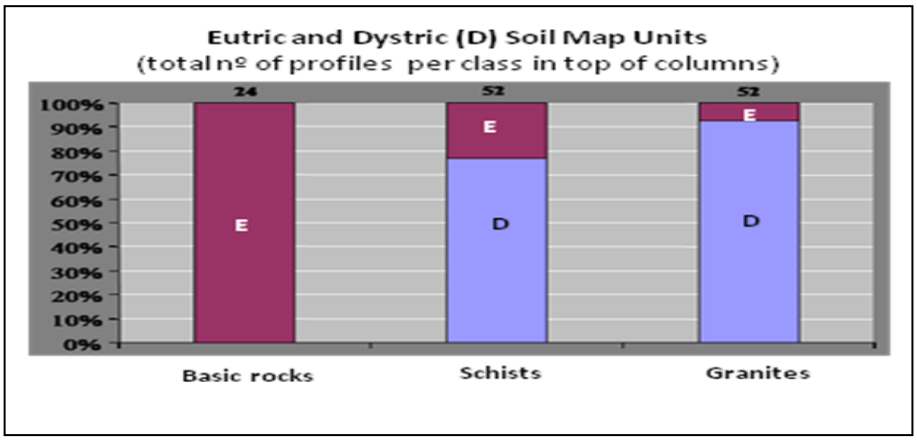

***Figure 11**: Occurrence of Eutric (non or slightly acid) and Dystric (acid or very acid) secondary units as affected by the lithology of parent material in Trás-os-Montes NE Portugal soils (Figueiredo 2002).*

4. Vegetation, landuse, time and man

The Mediterranean has a long history of good land use examples but has also striking misuse examples, with highly degraded soils as a result. Together with these strongly humanized landscapes, areas of natural or semi-natural vegetation concur to increase pedodiversity in the Mediterranean basin. The role of vegetation and land use systems in the Mediterranean as regarding soil genesis and development, may be stated as follows:

- Vegetation and water – very strong dependence of soil cover density and biomass on summer watershortage and climate aridity.
- Long term land use – ancient as actual civilizations need land to cultivate for food production.
- Low carbon contents – lowbiomass, high mineralization and low humification rates (driven by climate and man), low nutrient pool, weak structure, high erodibility.
- Erosion cycle – less vegetation cover, more erosion, less soil depth, less soil nutrient and water storage, less vegetation (and control mechanisms).

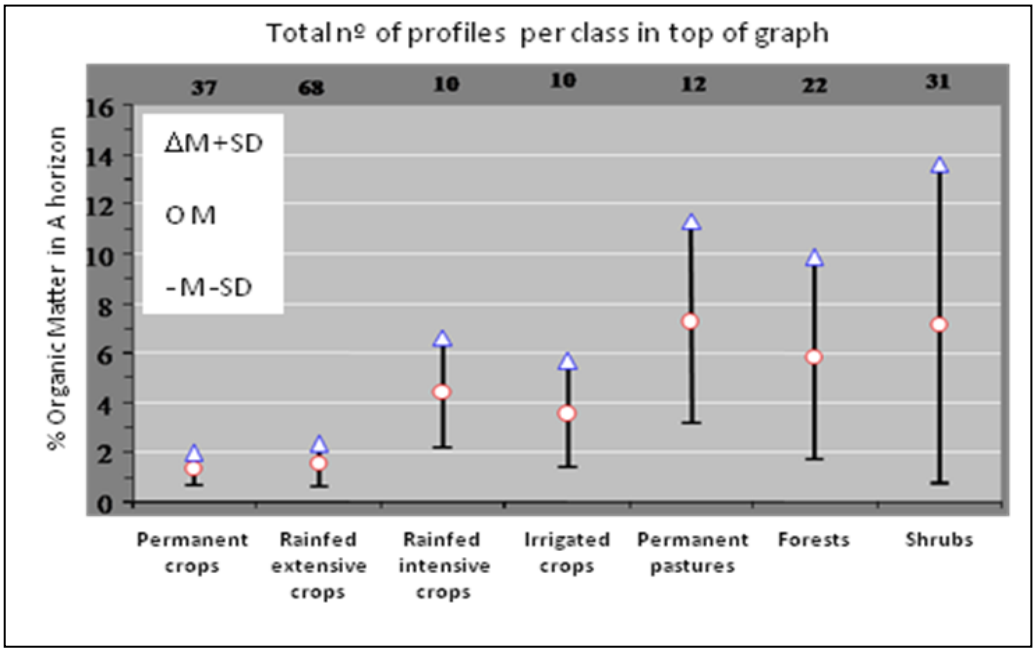

***Figure 12**: Organic content of soils as affected by vegetation and land use in NE Portugal: average (M) and range (SD, standard deviation) in A horizon (Figueiredo 2002).*

The Mediterranean: need for soil protection

The European Thematic Strategy for Soil Protection states:

- main threats for European soils are erosion, organic matter decline, compaction, salinisation, landslides (all occuringin specific risk areas), contamination and sealing (and flooding).
- erosion (12%) and organic matter decline (45%) are, by far, those that affect larger areas (percent of Europe's surface).
- Mediterranean sloping agri-environments are central for Europe's soil protection strategy, as they are:(i) threatened by erosion and a low organic status(ii) very sensitive to land use changes(iii) hosting production systems that support people, quality.

On this section, and as a synoptic closing statement of the lecture, it is worthy to call back part of the text of the Foreword of this book, also the Welcome word of this Erasmus Intensive Programme (see SPinSMEDE website for the full text):

In the Mediterranean, its long history records striking examples of successes and failures of land use models and management, which, in the latter case, are a heavy heritage for the soil resource in this basin. At present day, many forms of soil degradation threaten Mediterranean soils as, for instance salinization, pollution, structural degradation and erosion. There is a geographical pattern of distribution of these forms of soil degradation and soil erosion is first in rank as far as sloping areas are concerned. Corresponding to a very large surface of Mediterranean land, these are especially sensitive areas, where soils are a qualitatively scarce resource. They heir a very significant part of cropping systems, crops and products traditional of the Mediterranean, vineyards and olive groves being the most relevant ones. Improvements in productivity and economic income of these areas are imperative to reduce population depletion and its impacts on territory sustainability. On the other hand, the long-term cultivated and highly eroded slopes ask for alternative land use models and management options that allow recovery of already much degraded environments. The importance of sloping areas, their land uses and misuses, comes also from their hydrological key role, that, in the Mediterranean, has large consequences for water conservation, flood hazard and off-site effects of soil erosion. To cope with threats to soil resource highlighted, soil protection initiatives are needed.

The thematic strategy for soil protection in Europe clearly sets, at policy level, the topic in high priority, as the need for soil protection is there stated in specific terms. This new political background encourages defining specifically oriented rationale in view soil protection measures design and implementation. Actually, expertise acquired in the last couple of decades throughout Europe, as part of the European strong research efforts in the topic, shows the high level of specialization necessary to tackle with soil protection issues. The still growing research-borne information has to be converted into technically useful tools for real world problem solving. The thematic strategy for soil protection in Europe asks for such a challenge and problems posed on Mediterranean sloping areas are certainly important test-subjects.

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