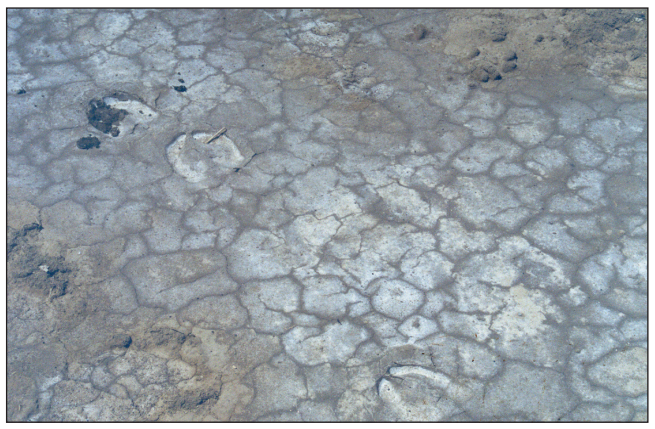
Soil of the Mediterranean Region

The presence of a *Salic* horizon is essential to differentiate Solonchaks from other soil types such as Gleysols. Mollic, Calcic and Gypsic Solonchaks may be associated with Kastanozems, Phaeozems, Calcisols and Gypsisols. Saline Vertisols occur very occasionally in the semi arid parts of southern Europe.

On the other hand, Solonetz (see figure below), rich in exchangeable sodium and magnesium ions, are confined to flat lands and are found with Gleysols and Solonchaks. In coastal areas, they can be associated with Fluvisols. The transition of Solonetz to Gypsisols and Calcisols occurs due to the accumulation of gypsum and calcite below the diagnostic *Natric* horizon, as found in semi arid conditions of Spain and Turkey. Extensive areas of saline soil occur in Morocco, Tunisia, Algeria, Egypt and throughout the Middle East. One dominant factor for the expansion of saline soil in the Mediterranean is the introduction of irrigation and the intensification of crop production.



The polygonal development on the surface of a Solonetz in southern Turkey (HO).

Solonchaks and Solonetz are very difficult soil types to manage and require extensive effort to be productive. However, they are widely used for arable farming and extensive grazing. The production of salt tolerant crops (*Atriplex*) on unused grasslands seems to be a highly profitable and environmentally friendly practise used in several countries of the Mediterranean region.

Andosols

Andosols occur in the volcanic regions of southern Europe, primarily in Italy, France and with minor distributions in the undulating mountainous of Turkey. They are associated with Cambisols, Podzols and Luvisols in France, Cambisols in Italy whereas in Turkey with Calcisols, Leptosols and adjacent Fluvisols. Identification of Andosols has been highly controversial within the Mediterranean context due to the lack of the bulk density requirement (0.9 g/cm3), organic matter content as well as morphological-field characteristics such as thixotropy (the smeary feeling that develops due to the sol-gel transformations under pressure).

Andosols of the western slope of Mount Etna in Sicily, Italy formed by lava flows with tephra – fragmented rocks deposited by pyroclastic flows from an erupting volcano (CD).

Andosols are cultivated for a variety of crops. They represent soil ecosystems that are vulnerable to disturbances, especially to soil sealing, which may lead to the development of landslides (southern Italy and eastern Turkey) and erosion. The unavailability of phosphorous is their main chemical constraint of soil fertility.

Kastanozems and Phaeozems

The distribution of Kastanozems in southern Europe is very limited and mainly associated with Leptosols, Cambisol, Calcisols and Fluvisols. They occasionally associate with Gypsisols, Solonchaks and Solonetz in depressions of warmer and drier areas. Some Kastanozems are covered by forests or are used for grazing. Other areas are cultivated for cereals and occasionally for irrigated crops. The build up of salts may be a problem for these fertile and productive soil types if water is not well managed during irrigation.

Phaeozem is a soil with a distinct dark surface colour and high organic matter content. In the Mediterranean region *Leptic, Vertic, Gleyic, Luvic, Pachic, Calcaric, Skeletic, Siltic, Dystric, Chromic,* and *Haplic* represent the most common soil units. They are found in Spain, France, Italy, the Western Balkans, Albania, Greece, Turkey, Israel, Lebanon, Syria, and Morocco. Phaeozems in rain fed, flat or gently undulating environments, become very productive especially for cereals. Under irrigation, a great variety of crops, including sugar beet, vegetables or fodder, may be cultivated. In sloping mountain areas, they are suitable for forestry or managed grazing. If mismanaged, Phaeozems in mountainous regions could be seriously threatened by erosion. The lack of the *Mollic* horizon in many parts of the Mediterranean mountains is the best evidence of historic soil erosion.

Umbrisols

Umbrisols occur mainly in the northwest of Portugal and Spain with smaller patches in the Balkans. Umbrisols are associated with moist but free-draining conditions, namely Phaeozems, which ultimately integrate by cultivation to Anthrosols. Cambisols and Leptosols may also be associated to Umbrisols as well as being adjacent in the landscape.

Regions of cleared forests, converted to short grasses, widely used as grazing lands, dominate Umbrisols in the northwestern part of the Mediterranean. Thus, the management in this context has aimed at the introduction of improved pasture and correction of soil acidity by liming. Cambisols, Luvisols and Leptosols at higher elevations face similar problems as Umbrisols.

Gypsisols, Durisols and Calcisols

These are the typical soil types that form under arid or semi-arid conditions. With the exception of Calcisols, their extension is limited in the northern Mediterranean areas but highly visible in the southern countries. In the arid regions of North Africa and the Middle East, mud and debris floods formed the so-called *"wadis"* located in areas of low relief. Many *wadis* were formed during the Late Pleistocene to Early Holocene period between between 13,000 and 8,000 years ago. Consecutive mudflow occurrences have been responsible for the development of Calcisols with variable contents of secondary carbonate (lime) accumulation, leading to the development of *Calcic* and *Petrocalcic* horizons within a depth of 100 cm or deeper and often grading to *'calcrete.'*

Gypsisols are characterised by the substantial accumulation of secondary gypsum (CaSO4). The natural vegetation is made of xerophytic plants (cacti are xerophytic shrubs) and ephemeral grasses. The largest concentration of Gypsisols in the Mediterranean occurs in the Libyan Desert, Jordan, Syria, parts of Central Anatolia and Cyprus. The agricultural use of Gypsisols depends on the gypsum content in the upper topsoil layer. If the gypsum content is low they can be used for production of small grains, cotton, and forage crops. In the Gypsisols of alluvial plains, irrigation and drainage are necessary for the cultivation of crops, fruit trees, and grapes. However large areas are used only for extensive grazing.

Durisols contain cemented secondary silica (SiO2) in the upper one meter of the soil. Their typical feature is the presence of a hard-cemented layer identified as the "*duripan* phase". In the Mediterranean, they occur on level and slightly sloping alluvial plains, terraces and gently sloping piedmont plains mainly in Jordan, Syria, Morocco, Tunisia, and Algeria. They are often found in association with Gypsisols, Calcisols, Solonchaks, Solonetz, Vertisols, Arenosols, and Cambisols.

Tabular gypsum (calcium sulphate) crystals in Gypsisols viewed in a polarizing microscope at x100 magnification (EA & SK).

A Gypsisol profile from Spain (JB).

Pedogenetically, *Gypsisols* are characterised by the presence of *Duric* and *Petroduric* horizons that practically limit the effective soil depth available to plant roots. In fact, the *Petroduric* horizon can vary between 10 cm to 4 m in depth. In addition, Durisols could have an *Argic, Cambic* or *Calcic* horizon above the *Petroduric* horizon. The agricultural use of Durisols is limited to extensive grazing.

Calcisols occupy large areas in Spain while in Turkey and Cyprus where they are ranked the second most dominant soil after Leptosols. Minor distributions are also found in Italy, France, Greece and Albania. The major soil units include the *Vertic, Luvic, Petric,* and *Haplic* categories. *Petric* and Luvic Calcisols represent the dominant calcretes of Turkey, Cyprus, Spain as well as North Africa and the Middle East. Calcisols are associated with Leptosols at higher elevation and with Gleysols, Vertisols, and Solonchaks in lower depressions.

A striking example of a calcrete. The picture shows a massive secondary accumulation of soft lime forming this Calcic horizon (the white zone) in the hilly areas of Central Albania (PZ).