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PLANOSOLS (PL)

The Reference Soil Group of the Planosols holds soils with a bleached, light-coloured, eluvial surface horizon that shows signs of periodic water stagnation and abruptly overlies a dense, slowly permeable subsoil with significantly more clay than the surface horizon. These soils were formerly regarded as 'pseudogley soils' but are now recognized as 'Planosols' by most soil classification systems. The US Soil Classification coined the name 'Planosols' in 1938; its successor, USDA Soil Taxonomy, includes most of the original Planosols in the Great Soil Groups of the Albaqualfs, Albaquults and Argialbolls.

Definition of Planosols

Soils having

1. an eluvial horizon or materials having loamy sand or coarser textures, the lower boundary of which is marked, within 100 cm from the surface, by an abrupt textural change associated with stagnic soil properties; and
2. no albeluvic tonguing.

Common soil units:

Thionic, Histic, Gelic, Vertic, Endosalic, Gleyic, Plinthic, Mollic, Gypsic, Calcic, Alic, Luvic, Umbric, Arenic, Geric, Calcaric, Albic, Ferric, Alcalic, Sodic, Alumic, Dystric, Eutric, Rhodic, Chromic, Haplic.

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Summary description of Planosols

Connotation: soils with a degraded, eluvial surface horizon abruptly over dense subsoil, typically in seasonally waterlogged flat lands; from L. planus, flat.

Parent material: mostly clayey alluvial and colluvial deposits.

Environment: seasonally or periodically wet, level (plateau) areas, mainly in sub-tropical and temperate, semi-arid and sub-humid regions with light forest or grass vegetation.

Profile development: AEBC-profiles. Destruction and/or removal of clay produced relatively coarse-textured bleached surface soil abruptly overlying finer subsoil. Impeded downward water percolation caused stagnic soil properties in the bleached horizon.

Use: Planosols are poor soils. In regions with a warm summer season they are mostly under wetland rice. Elsewhere, Planosols are sown to dryland (e.g. fodder) crops or used for extensive grazing. Many Planosol areas are not used for agriculture.

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Regional distribution of Planosols

The world's major Planosol areas occur in subtropical and temperate regions with clear alternation of wet and dry seasons, e.g. in Latin America (southern Brazil, Paraguay, Argentina), southern and eastern Africa (Sahelian zone, East and southern Africa), the eastern United States, southeast Asia (Bangladesh, Thailand) and in Australia. Their total extent is estimated at some 130 million hectares worldwide. See Figure 1.

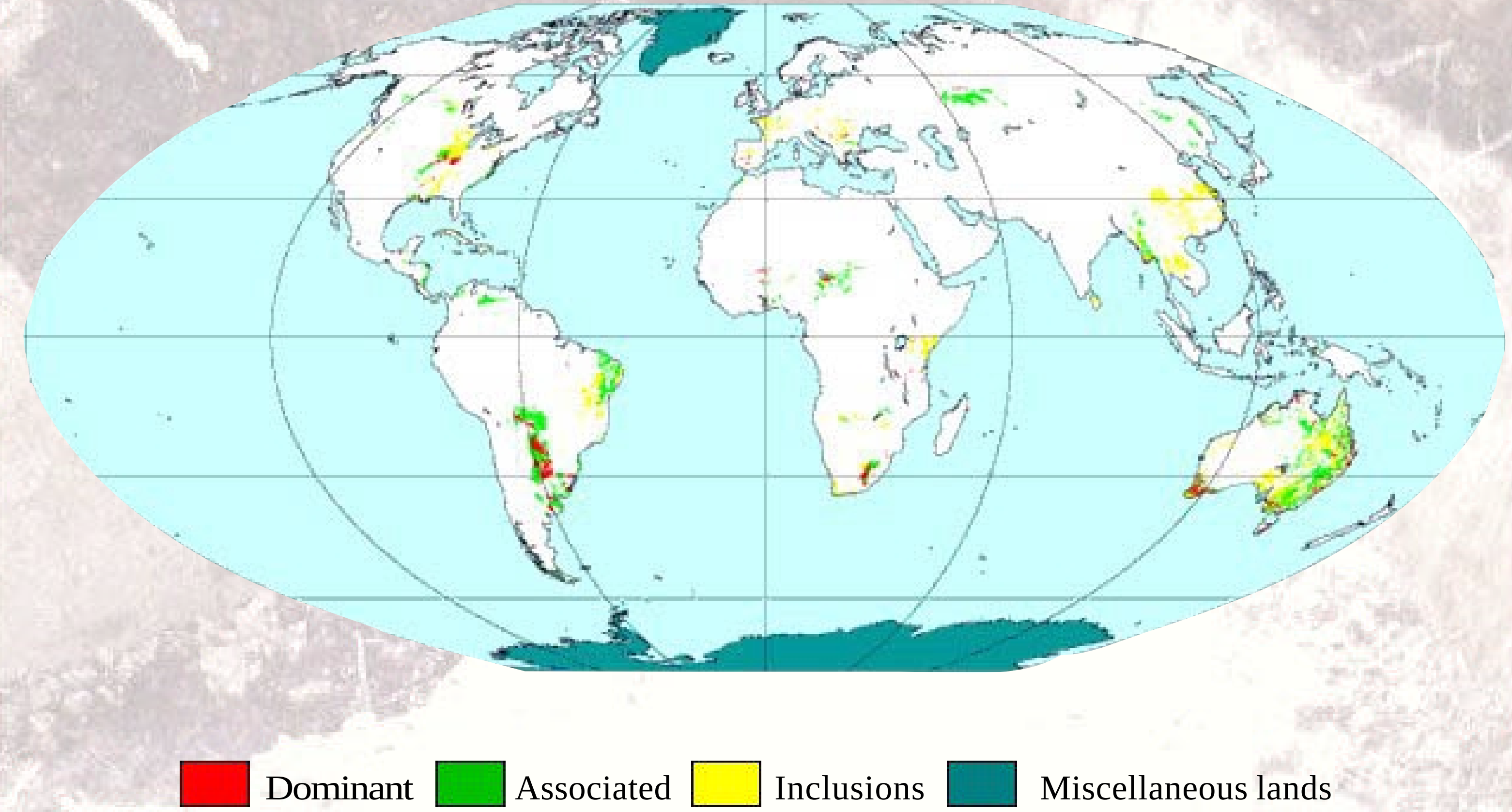

Figure 1. Planosols worldwide.

Associations with other Reference Soil Groups

Planosols occur predominantly in flat lands but can also be found in the lower stretches of slopes, in a strip intermediate between uplands, e.g. with Acrisols or Luvisols, and lowland (plain or basin) areas, e.g. with Vertisols. Planosols occur also in terraces or somewhat higher up, together with Acrisols or other soils with an argic subsurface horizon. In the Ethiopian Highlands, Planosols occur in association with Vertisols in lower parts of the landscape and with Nitisols in higher reaches.

Genesis of Planosols

Planosols have typically a weakly structured ochric or umbric surface horizon over an albic horizon with ' stagnic soil properties'. The texture of these horizons is markedly coarser than that of deeper soil layers; the transition is sharp and conforms to the requirements of an ' abrupt textural change'. The finer textured subsurface soil may show signs of clay illuviation; it is only slowly permeable to water. Periodic stagnation of water directly above the denser subsurface soil caused the typical stagnic soil properties in the bleached, eluvial horizon (and in many soils also mottling in the upper part of the clayey subsoil). The 'abrupt textural change' from coarse textured surface soil to finer subsoil can be caused by:

1 *'Geogenetic processes'* such as sedimentation of sandy over clayey layers, creep or sheet wash of lighter textured soil over clayey material, colluvial deposition of sandy over clayey material, or selective erosion whereby the finest fraction is removed from the surface layers, and/or
2 *'Physical pedogenetic processes'* viz. selective eluviation-illuviation of clay in soil material with a low structure stability, and/or
3 *'Chemical pedogenetic processes'* notably a process proposed under the name 'ferrolysis', an oxidation-reduction sequence driven by chemical energy derived from bacterial decomposition of soil organic matter (Brinkman, 1979).

Ferrolysis is thought to proceed as follows:

In the absence of oxygen (e.g. in water-saturated soils with reducing organic matter), ferric oxides and hydroxides are reduced to Fe^{2+}-compounds which go into solution:

$$CH_2O + 4\ Fe(OH)_3 + 7\ H^+ = 4\ Fe^{2+} + HCO^{3-} + 10\ H_2O$$

During this 'reduction phase' H^+-ions are consumed and the soil-pH rises. Fe^{2+}-ions are produced and replace adsorbed basic cations and aluminium at the exchange complex; the replaced ions are partly leached out (together with some of the Fe^{2+}). Once the soil-pH has risen to about pH 5 to 5.5, Al^{3+}-ions and OH^--ions polymerize to hydroxy-Al-polymers with ring structures. It is surmised that part of the polynuclear Al-polymers are 'trapped' in the interlayer spaces of lattice clays thereby changing the properties of the clay (lower CEC, water content, swell-shrink properties). Remaining polymers are leached out of the soil.

When air re-enters the soil in a subsequent dry period, an ‘oxidation phase’ sets in; exchangeable Fe^{2+} is oxidized again to insoluble Fe^{3+}-hydroxide. This produces two H^+-ions for each Fe^{2+}-ion oxidized:

$$4\,Fe^{2+} + O_2 + 10\,H_2O = 4\,Fe(OH)_3 + 8\,H^+$$

The clay turns into hydrogen clay, which converts to aluminium-magnesium clay as adsorbed hydrogen ions are replaced by aluminium and basic cations dissolved from the clay structure. Silica is dissolved from the clay lattices at the same time; it may partly be removed and partly re-precipitate in amorphous form when the eluvial horizon dries out.

During the next wet season, a new cycle starts with another ‘reduction phase’.

Note that the abrupt change in clay content and, in some Planosols, in the nature of the clay, can only develop and persist if there is little homogenization of the soil. There are reports of established Planosols that were later transformed to Phaeozems because of intense soil homogenization by termites.

Characteristics of Planosols

Morphometric characteristics

A typical horizon sequence of Planosols consists of an ochric or umbric surface horizon over an albic subsurface horizon, directly on top of an argic B-horizon. In very wet locations, the surface horizon may even be a dystric histic horizon whereas in more arid regions surface soils contain very little organic matter. The albic eluviation horizon is invariably greyish and has a sandy or loamy texture and a weak structure of low stability.

The most prominent feature of Planosols is the marked increase in clay content on passing from the degraded eluvial horizon to the deeper soil. The latter may be a slowly permeable argic illuviation horizon, mottled and with coarse angular blocky or prismatic structural elements, or massive and structureless. In most Planosols however, the abrupt change in texture appears to be due to geogenetic differentiation or strong weathering in situ in combination with clay destruction in the topsoil.

Mineralogical characteristics

Destruction of clay reduced both the cation exchange capacity of the clay fraction and the soil's moisture retention capacity.

Hydrological characteristics

Planosols are subject to water saturation in wet periods because of stagnation of rain or floodwater. Stagnic soil properties directly above the slowly permeable subsurface layer are telltale signs even in the dry season.

Physical characteristics

The upper soil horizons of Planosols have weakly expressed and unstable structural elements; silty soils in particular become hard as concrete in the dry season and turn to heavy mud with very low bearing capacity when they become waterlogged in the wet season. Sandy surface soil material becomes hard when dry but not cemented. The poor structure stability of the topsoil, the compactness of the subsoil and the abrupt transition from topsoil to subsoil all impair the rooting of crops.

Chemical characteristics

Mature Planosols are chemically strongly degraded. The surface soil has become acidic and lost (much of) its clay; ion exchange properties have deteriorated as a consequence.

Biological characteristics

The natural vegetation of areas with Planosols is light forest and/or herbs or grasses. Where trees grow, it concerns species with extensive, shallow root systems that are capable of withstanding both severe drought and seasonal or occasional water logging. The soil fauna is not very diverse and population densities are low.

Management and use of Planosols

Natural Planosol areas support a sparse grass vegetation, often with scattered shrubs and trees that have shallow root systems and can cope with temporary water logging. Land use on Planosols is normally less intensive than that on most other soils under the same climatic conditions. Vast areas of Planosols are used for extensive grazing. Wood production on Planosols is much less than on other soils under the same conditions.

Planosols in the Temperate Zone are mainly in grass or they are planted to arable crops such as wheat and sugar beet. Yields are only modest, even on drained and deeply loosened soils. Root development on natural, unmodified Planosols is severely hindered by oxygen deficiency in wet periods, dense soil at shallow depth and toxic levels of aluminum in the root zone. The low hydraulic conductivity of the dense subsurface soil makes narrow drain spacing inevitable.

Many Planosols in Southeast Asia are widely planted to a single crop of paddy rice, produced on bunded fields that are inundated in the rainy season. Efforts to produce dryland crops on the same land during the dry season have met with little success; the soils seemed better suited to a second crop of rice with supplemental irrigation. Fertilizers are needed for good yields. Paddy fields should be allowed to dry out at least once a year to prevent or minimize microelement deficiencies or toxicity associated with prolonged soil reduction. Some Planosols require application of more than just NPK fertilizers and their low fertility level may prove difficult to correct. Where the temperature permits paddy rice cultivation, this is probably superior to any other kind of land use.

Grasslands with supplemental irrigation in the dry season are a good land use in climates with long dry periods and short infrequent wet spells. Strongly developed Planosols with a very silty or sandy surface soil are perhaps best left untouched.