SET 9
LUVISOLS
DEFINITION
SUMMARY
DISTRIBUTION
ASSOCIATIONS
GENESIS
CHARACTERISTICS
MANAGEMENT / USE
SAMPLE PROFILE
SLIDESHOW

# LUVISOLS (LV)

The Reference Soil Group of the Luvisols holds soils whose dominant characteristic is a marked textural differentiation within the soil profile, with the surface horizon being depleted of clay and accumulation of clay in a subsurface 'argic' horizon. Luvisols have high activity clays throughout and lack the abrupt textural change of Planosols, albeluvic tonguing as in Albeluvisols, a mollic surface horizon as in steppe soils, and the alic properties of Alisols. The name 'Luvisols' is already used in the legend to the FAO Soil Map of the World; elsewhere, Luvisols are/were known as 'Pseudo-podzolic soils' (Russia), 'sols lessivés' (France), 'Parabraunerde' (Germany), 'Grey Brown Podzolic soils' (earlier USA terminology) and 'Alfisols' (USDA Soil Taxonomy).

***Definition of Luvisols***

Soils
having an argic horizon with a cation exchange capacity (in 1 *M* NH4OAc at pH 7.0) equal to or greater than 24 cmol(+)kg$^{-1}$ clay, either starting within 100 cm from the soil surface, or within 200 cm from the soil surface if the argic horzon is overlain by loamy sand or coarser textures throughout.

*Common soil units*
Leptic, Vertic, Gleyic, Vitric, Andic, Calcic, Arenic, Stagnic, Abruptic, Albic, Profondic, Lamellic, Cutanic, Ferric, Hyperochric, Skeletic, Hyposodic, Dystric, Rhodic, Chromic, Haplic.

SET 9
LUVISOLS
DEFINITION
SUMMARY
DISTRIBUTION
ASSOCIATIONS
GENESIS
CHARACTERISTICS
MANAGEMENT / USE
SAMPLE PROFILE
SLIDESHOW

## Summary description of Luvisols

*Connotation:* soils in which clay is washed down from the surface soil to an accumulation horizon at some depth; from L. luere, to wash.

*Parent material:* a wide variety of unconsolidated materials including glacial till, and eolian, alluvial and colluvial deposits.

*Environment:* most common in flat or gently sloping land in cool temperate regions and in warm (e.g. Mediterranean) regions with distinct dry and wet seasons.

*Profile development:* ABtC-profiles; intergrades to Albeluvisols having an albic eluviation horizon above the argic, subsurface horizon are not rare. The wide range of parent materials and environmental conditions led to a great diversity of soils in this Reference Soil Group.

*Use:* Luvisols with a good internal drainage are potentially suitable for a wide range of agricultural uses because of their moderate stage of weathering and high base saturation.

## Regional distribution of Luvisols

Luvisols extend over 500 to 600 million hectares worldwide, for the greater part in temperate regions such as west/central Russia, the USA and central Europe, but also in the Mediterranean region and southern Australia. In subtropical and tropical regions, Luvisols occur mainly on young land surfaces. Figure 1 gives an indication of the major concentrations of Luvisols.

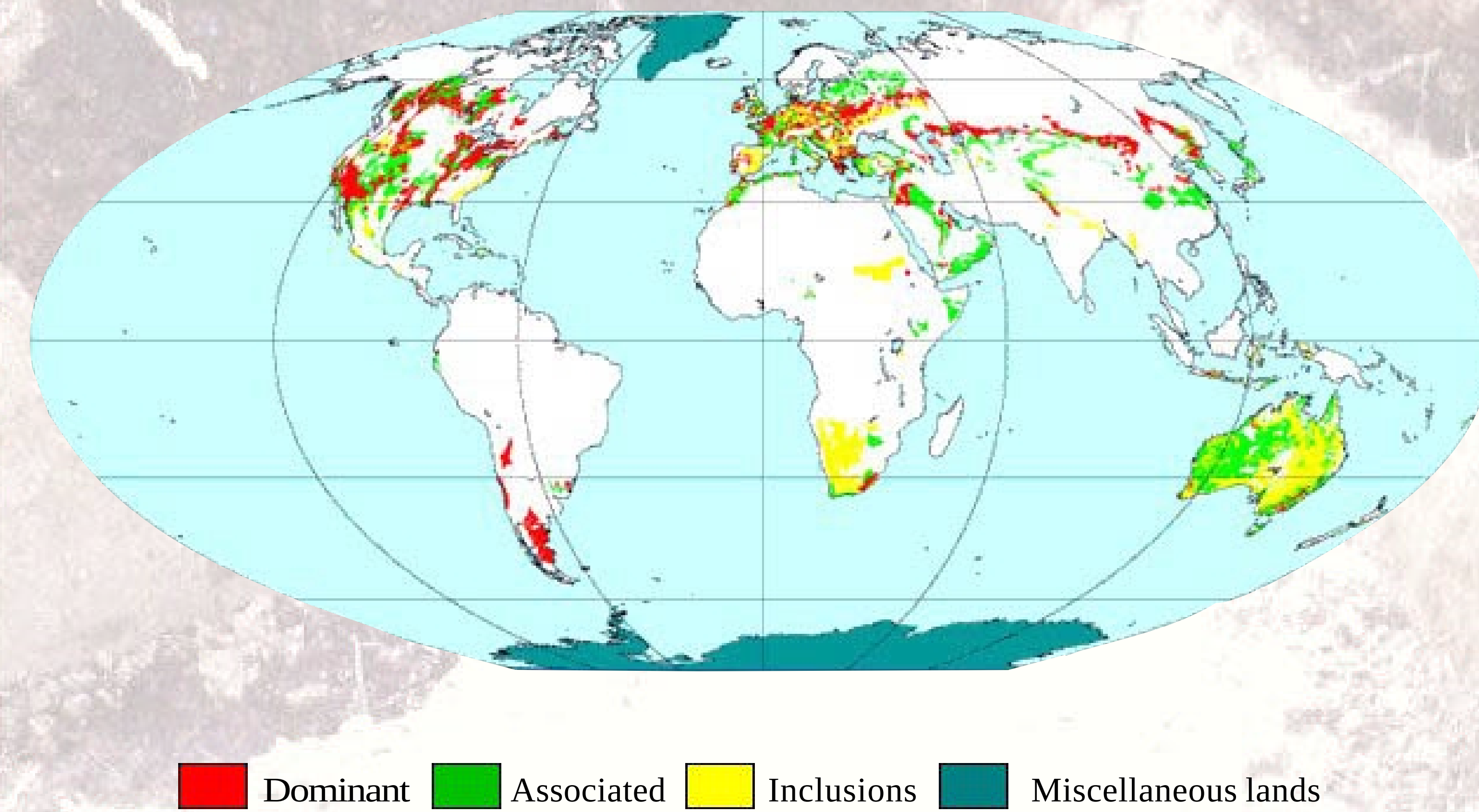


**Figure 1**. Luvisols worldwide.

SET 9
LUVISOLS
DEFINITION
SUMMARY
DISTRIBUTION
ASSOCIATIONS
GENESIS
CHARACTERISTICS
MANAGEMENT / USE
SAMPLE PROFILE
SLIDESHOW

## Associations with other Reference Soil Groups

Luvisols in upland areas are commonly associated with Cambisols; those in lowlands occur often together with Gleysols or Solonetz. However, Luvisols are linked with many other Reference Soil Groups with which they share common properties. For example, Luvisols occurring together with Vertisols may have slickensides in the argic horizon but not meet the other criteria of a vertic horizon. Luvisols may be associated with Gypsisols and Calcisols that have an argic subsurface horizon; the dominant presence of gypsum and/or calcium carbonate in the argic horizon sets these soils apart from Luvisols. Steppe soils with a dark, base-rich surface horizon that (just) does not qualify as a mollic horizon may be Luvisols and occur in association with Chernozems or Phaeozems. Luvisols with an umbric surface horizon may well grade into Umbrisols. Land use history can affect lateral linkages. Well-known examples are the Albeluvisols under forest in the Belgian loess belt that lie adjacent to enriched Luvisols under agriculture. The latter evolved from Albeluvisols but lost albeluvic tonguing (through increased bioturbation) and acquired a higher base saturation in the argic horizon after years of liming and fertilization.

## Genesis of Luvisols

The dominant characteristic of Luvisols is their argic illuviation horizon formed by translocation of clay from the surface soil to the depth of accumulation. The process knows three essential phases:

1 *mobilization* of clay in the surface soil;
2 *transport* of clay to the accumulation horizon;
3 *immobilization* of transported clay.

Normally, clay in soil is not present as individual particles but is contained in aggregates that consist wholly of clay or of a mixture of clay and other mineral and/or organic soil material. Mass transport of soil material along cracks and pores, common in cracking soils in regions with alternating wet and dry periods, does not necessarily enrich the subsoil horizons with clay.
For an argic horizon to form, the (coagulated) clay must disperse in the horizon of eluviation before it is transported to the depth of accumulation by percolating water.

***Mobilization of clay***
Mobilization of clay can take place if the thickness of the electric 'double layer', i.e. the shell around the individual clay particles that is influenced by the charged sides of the clay plates, becomes sufficiently wide. If the double layers increase in width, the bonds between negatively charged sides and positive charges at the edges of clay particles become weaker until individual clay particles are no longer held together in aggregates. The strength of aggregation is influenced by:
- the ionic strength of the soil solution,
- the composition of the ions adsorbed at the exchange complex, and
- the specific charge characteristics of the clay in the soil.

At high electrolyte concentrations in the soil solution, the double layer is compressed regardless of the nature of the adsorbed ions so that clay remains flocculated. A decrease in ion concentration, e.g. as a result of dilution by percolating rain water, can result in dispersion of clay and the collapse of aggre-

SET 9
LUVISOLS
DEFINITION
SUMMARY
DISTRIBUTION
ASSOCIATIONS
GENESIS
CHARACTERISTICS
MANAGEMENT / USE
SAMPLE PROFILE
SLIDESHOW

gates. If the exchange complex is dominated by polyvalent ions, the double layer may remain narrow even at low electrolyte concentrations and consequently the aggregates may remain intact.

Soil-pH may influence both the concentrations of various ions in the soil solution and the charge characteristics of the clay. Dispersion of clays is thus, to some extent, a pH-dependent process. At $pH_{(H2O,1:1)}$ values below 5, the aluminium concentration of the soil solution is normally sufficiently high to keep clay flocculated ($Al^{3+}$ is preferentially adsorbed over divalent and monovalent ions in the soil solution). Between pH 5.5 and 7.0, the content of exchangeable aluminium is negligible. If concentrations of divalent ions are low, clay can disperse. At still higher pH values, divalent bases will normally keep the clay flocculated unless there is a strong dominance of $Na^{+}$-ions in the soil solution.

Certain organic compounds, especially polyphenols, stimulate mobilization of clay by neutralizing positive charges at the edges of clay minerals. As iron-saturated organic complexes are insoluble, this process might be of little importance in Fe-rich Luvisols (particularly common in the subtropics).

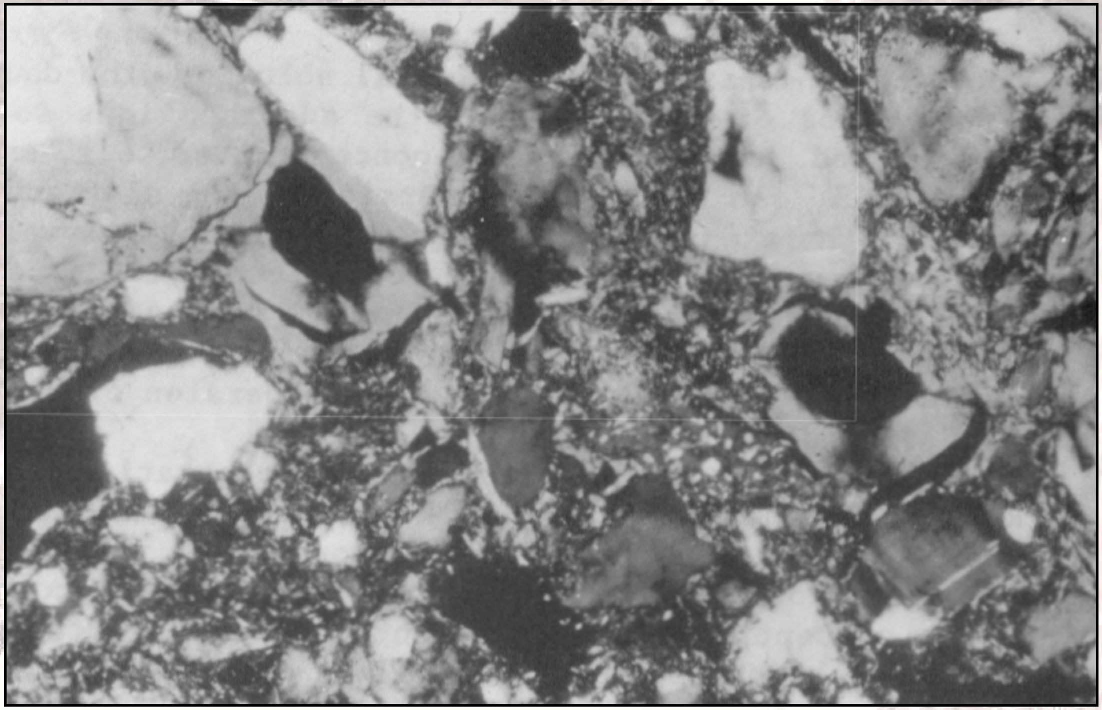

**Figure 2**. Cutans ('channel ferri-argillans') in the argic horizon of a Luvisol in The Netherlands. Source: Miedema, 1987.

SET 9
LUVISOLS
DEFINITION
SUMMARY
DISTRIBUTION
ASSOCIATIONS
GENESIS
CHARACTERISTICS
MANAGEMENT / USE
SAMPLE PROFILE
SLIDESHOW

***Transport of clay through the soil body***

Transport of peptized clay particles requires downward percolation of water through wide (>20 µm) pores and voids. Clay translocation is particularly prominent in soils that shrink and crack in the dry season but become wet during occasional downpours.

Note that 'smectite' clays disperse more easily than non-swelling clays; smectite clays are a common constituent of Luvisols.

***Precipitation and accumulation of clay***

Precipitation of clay particles takes place at some depth in the soil as a result of

- flocculation of clay particles, or
- (mechanical) filtration of clay in suspension by fine capillary pores.

*Flocculation* can be initiated by an increase in the electrolyte concentration of the soil solution or by an increase in the content of divalent cations (e.g. in a $CaCO_3$-rich subsurface horizon).

*Filtration* occurs where a clay suspension percolates through a relatively dry soil mass; it forces the clay plates against the faces of peds or against the walls of (bio)pores where skins of strongly oriented clay ('cutans') are formed (see Figure 2). With time, the cutans may wholly or partly disappear through homogenization of the soil by soil fauna, or the cutans may be destroyed mechanically in soils with a high content of swelling clays. This explains why there is often less oriented clay in the argic subsurface horizon than one would expect on the basis of a budget analysis of the clay profile. There could also be more illuviated clay than expected, if (part of) the eluviated surface soil is lost through erosion.

SET 9
LUVISOLS
DEFINITION
SUMMARY
DISTRIBUTION
ASSOCIATIONS
GENESIS
CHARACTERISTICS
MANAGEMENT / USE
SAMPLE PROFILE
SLIDESHOW

## Characteristics of Luvisols

***Morphological characteristics***

Luvisols have typically a brown to dark brown surface horizon over a (greyish) brown to strong brown or red argic subsurface horizon. In subtropical Luvisols in particular, a calcic horizon may be present or pockets of soft powdery lime in and below a reddish brown argic horizon. Soil colours are less reddish in Luvisols in cool regions than in warmer climates. In wet environments, the surface soil may become depleted of clay and free iron oxides to the extent that a greyish eluviation horizon forms under a dark but shallow A-horizon. Many Luvisols in Western Europe have evolved from Albeluvisols that underwent substantial morphological changes when they were taken into cultivation. Some causes:

- increased erosion led to truncation of the Ah-horizon, E-horizon and the larger part of the albeluvic tongues, and
- increased homogenisation by soil fauna, notably worms, after a long period of liming and/or fertilization.

Consequently many intergrades exist between Luvisols and Albeluvisols; they reflect the time and intensity of agricultural land use. Examples are Luvisols with a compact argic horizon or with remnants of albeluvic tonguing, or Luvisols with an acid soil reaction in the argic horizon.

***Mineralogical characteristics***

Luvisols are moderately weathered soils; they contain less Al-, Fe- and Ti-oxides than their tropical counterparts, the Lixisols, and have an $SiO_2/Al_2O_3$ ratio in excess of 2.0. Luvisols tend to become richer in swelling and shrinking clays towards the dry end of their climatic zone. As a consequence, pressure faces and parallelpiped structure elements become more and more prominent.

***Physical characteristics***

Luvisols have favourable physical properties; they have granular or crumb surface soils that are porous and well aerated. The 'available' moisture storage capacity is highest in the argic horizon (15 to 20 volume percent). The argic horizon has a stable blocky structure but surface soils with a high silt content may be sensitive to slaking and erosion.

SET 9
LUVISOLS
DEFINITION
SUMMARY
DISTRIBUTION
ASSOCIATIONS
GENESIS
CHARACTERISTICS
MANAGEMENT / USE
SAMPLE PROFILE
SLIDESHOW

Most Luvisols are well drained but shallow groundwater may occur in Luvisols in depression areas that develop gleyic soil properties in and below the argic horizon. Stagnic properties are found where a dense illuviation horizon obstructs downward percolation and the surface soil becomes saturated with water for extended periods of time

***Chemical characteristics***

The chemical properties of Luvisols vary with parent material and pedogenetic history. Surface soils are normally wholly or partly de-calcified and slightly acid in reaction; they contain a few percent organic matter with a C/N ratio of 10 to 15. Subsurface soils tend to have a neutral reaction and may contain some lime.

## Management and use of Luvisols

With the possible exception of Leptic, Gleyic, Vitric, Albic, Ferric and Dystric soil units, Luvisols are fertile soils and suitable for a wide range of agricultural uses. Luvisols with a high silt content are susceptible to structure deterioration if tilled in wet condition and/or with heavy machinery. Luvisols on steep slopes require erosion control measures.
The eluvial horizon of some Luvisols are depleted to the extent that an unfavourable platy structure formed with 'pseudogley' (stagnic properties) as a result. This is the reason why truncated Luvisols are in many instances far better soils for farming than the original, non-eroded soils.

Luvisols in the temperate zone are widely grown to small grains, sugar beet and fodder; in sloping areas, they are used for orchards and/or grazing. In the mediterranean region, where Chromic, Calcic and Vertic Luvisols are common in colluvial deposits of limestone weathering, the lower slopes are widely sown to wheat and/or sugar beet while (eroded) upper slopes are in use for extensive grazing or planted to tree crops.