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ALBELUVISOLS (AB)

Albeluvisols are soils that have, within 1 metre from the surface, a clay illuviation horizon with an irregular or broken upper boundary resulting from deep tonguing of bleached soil material into the illuviation horizon. Common international names are Podzoluvisols (FAO), Derno-podzolic or Ortho-podzolic soils (Russia) and several suborders of the Alfisols (USDA Soil Taxonomy).

Definition of Albeluvisols

Soils having an argic horizon within 100 cm from the soil surface with an irregular upper boundary resulting from albeluvic tonguing into the argic horizon.

Common soil units:
Histic, Gleyic, Alic, Umbric, Arenic, Gelic, Stagnic, Abruptic, Ferric, Fragic, Siltic, Alumic, Endoeutric, Haplic.

Summary description of Albeluvisols

Connotation: from L. albus, white, and L. eluere, to wash out.

Parent material: mostly unconsolidated glacial till, materials of lacustrine or fluvial origin and of eolian deposits (loess).

Environment: flat to undulating plains under boreal taiga, coniferous forest or mixed forest. The climate is temperate to boreal with cold winters, short and cool summers, and an average annual precipitation sum of 500 to 1000 mm. Precipitation is evenly distributed over the year or, in the continental part of the Albeluvisol belt, has a peak in early summer.

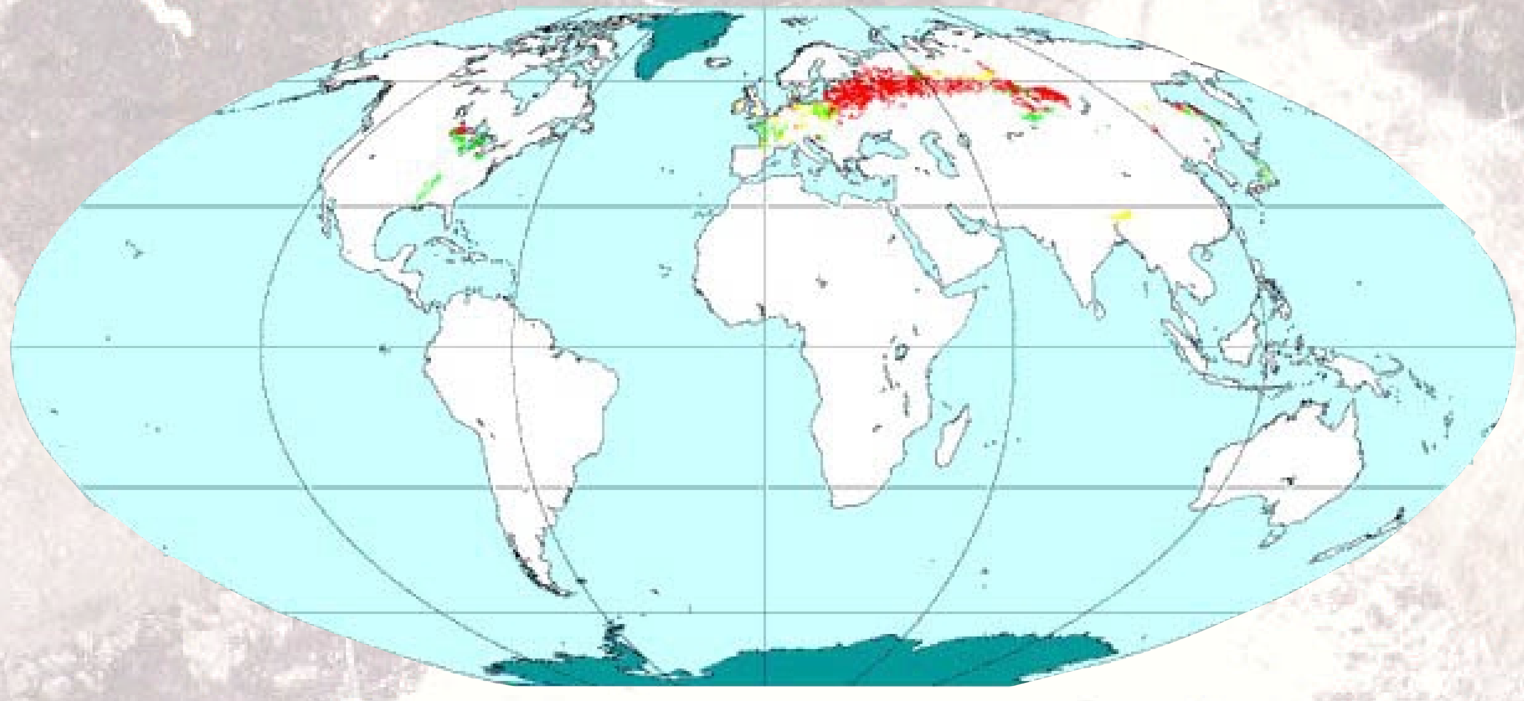
Profile development: mostly AEBtC-profiles with a dark, thin ochric surface horizon over an albic subsurface horizon that tongues into an underlying brown clay illuviation horizon. Stagnic soil properties are common in boreal Albeluvisols.

Use: short growing season (frost!), acidity, low nutrient status, tillage and drainage problems are serious limitations of Albeluvisols. Most Albeluvisols are under forest; livestock farming ranks second; arable cropping plays a minor role. In Russia, the share of arable cropping increases towards the south and west of the Albeluvisol belt, especially on relatively nutrient-rich Endoeutric Albeluvisols.

Regional distribution of Albeluvisols

Albeluvisols cover an estimated 320 million hectares in Europe, North Asia and Central Asia, with minor occurrences in North America. Figure 1 shows that Albeluvisols are concentrated in two regions, each having a particular set of climatic conditions:

- cold continental regions of NE Europe, NW Asia and SW Canada, which constitute by far the largest areas of Albeluvisols, and
- loess and cover sand areas and old alluvial areas in moist temperate regions such as France, central Belgium, the south-eastern Netherlands and western Germany.



Dominant Associated Inclusions Miscellaneous lands

Figure 1. Albeluvisols worldwide.

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Associations with other Reference Soil Groups

Albeluvisols have diagnostic horizons and properties in common with Luvisols and Podzols. They differ from Luvisols by having 'albeluvic tonguing'. Luvisols may have small penetrations of the overlying horizon into the argic subsurface horizon ('interfingering') but these do not have the dimensions of the albeluvic tongues of Albeluvisols. Podzols differ from Albeluvisols by their spodic subsurface horizon. Some Albeluvisols have an eluvial horizon with sub-horizons that show characteristics of a spodic horizon. If these features become so pronounced that the sub-horizon qualifies as a spodic horizon, the soil is classified as a Podzol.
Albeluvisols in cold continental areas border on Podzols to the north and east. At the interface between both soil groups, podzolization takes place in the strongly clay and iron depleted eluvial horizon overlying the argic horizon. These are '*bisequum soils*', with a recent A/E1/Bh solum overlying an older E2/Bt solum.

Albeluvisols in temperate regions may also occur together with Podzols, particularly where the latter developed in sandy eolian deposits. Large parts of the original Albeluvisol belt of Western Europe have now become Luvisols as a direct result of ploughing and man-induced erosion of the upper decimetres of the soil. The upper 50-80 cm of the original Albeluvisol have changed and its morphological characteristics, e.g. the albeluvic tonguing, have disappeared after centuries of human intervention. Agricultural activities, notably liming/manuring, have also increased the activity of burrowing animals such as earthworms and moles and have raised the base saturation of the soils to the extent that these soils key out as Luvisols. It is a common to find Luvisols under agriculture adjacent to Albeluvisols under forest.

Genesis of Albeluvisols

The genesis of Albeluvisols has elements of '*argilluviation*' (i.e. translocation of clay as discussed in the chapter on Luvisols) and elements of present-day or paleo-periglacial thermal soil factors. The typical albeluvic tongues, which penetrate deep into the compacted top of the argic horizon, are the result of periglacial freeze-thaw sequencing during last glacial period.

Albeluvisols occur in regions that had, or still have, a harsh climate, which explains why there is little biological activity in their surface horizons. The sudden change in texture from the eluviation horizon to the illuviation horizon hinders the internal drainage of Albeluvisols. Periodic saturation of the surface soil and reduction of iron compounds (enhanced by dissolved organic compounds) cause strong bleaching of the eluvial horizon. The eluvial horizon extends into the underlying argic horizon along root channels and cracks (the characteristic 'tonguing'). This penetration of clay and iron-depleted material into the underlying horizon is distinctly different from the type of tonguing in (some) Chernozems or Podzols.

Albeluvic tongues have the colour and the coarser texture of the eluvial horizon from which they extend. Tongues must be wider than 5 mm in clayey argic horizons, 10 mm or wider in loamy and silty argic horizons and 15 mm or wider in coarser (silt, loam or sandy loam) argic horizons. The tongues must be deeper than wide and occupy more than 10 % of the volume of the upper 10 cm, or the upper quarter (whichever is less), of the argic horizon, both in vertical and horizontal sections.
Albeluvisols are closely related to Albic Luvisols. The main difference is that the eluvial horizon does not extend so prominently into the argic horizon. In most instances the tongues have the same colour as the argic horizon and are less easily detected in the soil profile. (Their lower penetration resistance can be ascertained by piercing them with a knife.)

Periodic saturation with water causes segregation of iron compounds in mottles or concretions of iron (hydr)oxides. Vertical transport of iron compounds may lead to accumulation of iron compounds in a deeper horizon or the iron may be discharged to the subsoil, leaving the soil matrix increasingly depleted. See Figure 2.

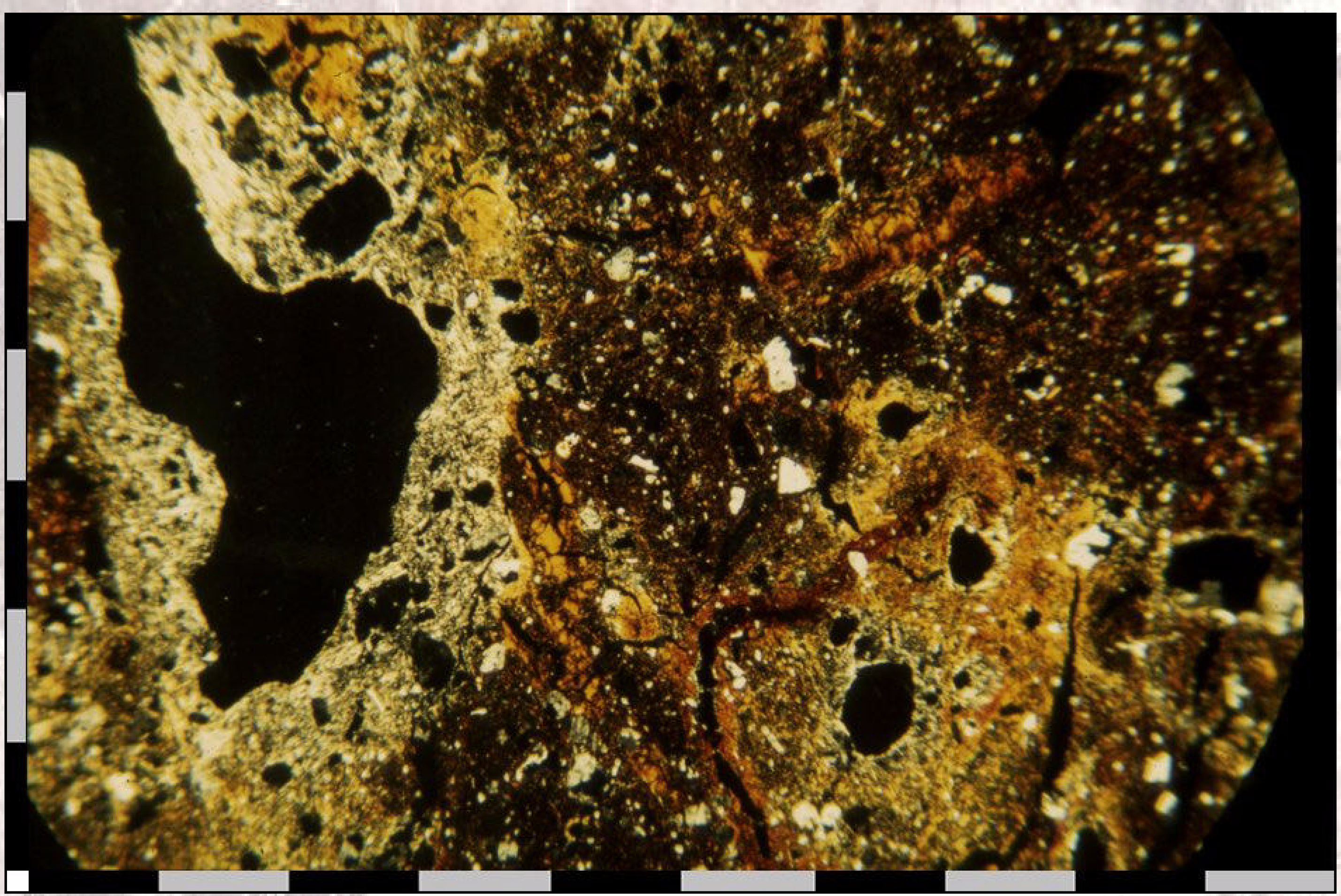

Figure 2. Iron depletion along voids in a Stagnic Albeluvisol in the Netherlands (cross-polarized light; 1 unit = 0.5 mm). Source: Miedema, 1987.

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The upper part of the argic horizon can assume the characteristics of a ferric horizon. Stagnic properties are present in many Albeluvisols; gleyic properties are much less common. In the absence of percolation, iron will remain in the soil where it concentrates in 'discrete nodules'. These nodules form upon repeated drying-wetting of the soil because of the hysteresis that exists between the rate of precipitation of iron compounds in the oxidative phase and the rate of (re)dissolution when the soil is reduced again.

Repeated saturation and leaching of the eluvial horizon cause acidification of the horizon and loss of bases. Ultimately loss of clay and sesquioxides from the eluvial horizon may become so pronounced that only a sandy surface layer remains in which even a micro-Podzol may form. The low organic matter and iron contents of the leached surface soil explain why this layer has low structure stability and low resistance to mechanical stress and why it is normally somewhat compacted. Alternate wetting and drying promotes clay decomposition. In the extreme case, an acid, seasonally wet Planosol may be formed.

At the interface between the eluvial and the illuvial horizons, a '*fragipan*' (from L. fragere, to break) can form, commonly overlapping with the argic horizon. A 'fragipan' is a natural, non-cemented subsurface horizon through which roots and percolating water can pass only along preferential paths, e.g. along ped faces. The natural character of the fragipan excludes plough pans and surface traffic pans. The penetration resistance of a fragipan, measured at field capacity, exceeds the reach of most field instruments (50 kN/m).

Characteristics of Albeluvisols

Morphological characteristics

Most untouched Albeluvisols are under forest vegetation. A raw litter layer tops a dark, thin A(h)-horizon over a distinctly bleached eluvial E-horizon that extends into a brown argic illuvial horizon. The top of the argic horizon is normally dense. Clay coatings in the upper half of the argic horizon are invisible to the naked eye. Microscopic examination of thin sections will normally reveal disturbed clay coatings and clay papules within structure elements.

Where the eluvial horizon is not periodically saturated with (ground)water, the eluvial horizon has a brown to yellowish brown colour and contains a fair amount of roots. In the more temperate part of the distribution belt, the eluvial horizon may meet the diagnostic requirements of a cambic horizon. Such a horizon is sometimes referred to as a "biologically active B-horizon" because thin sections show that the entire soil mass is composed of pellets and earthy excrements of soil (micro)fauna. In the colder part of the distribution belt, a thin layer with all features of a spodic horizon may be found in the upper part of the eluvial horizon.

Hydrological characteristics

The configuration of an eluvial horizon on top of an illuvial horizon is, as such, indicative of downward water flow through the soil during at least part of the year. The diagnostic features of an Albeluvisol (viz. iron depletion and tonguing or, alternatively, iron nodules in an eluvial horizon) may or may not be strong enough to meet the specifications of ‘stagnic properties’ (gley-like features caused by perched water on top of a slowly permeable subsurface horizon).

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Mineralogical characteristics

Most Albeluvisols have formed in quartz-rich parent material. The sandier the soil material is, the more pronounced the albeluvic tonguing. Many of these parent materials were once calcareous but the upper limit of the calcareous subsoil has since shifted to more than 2 metres below the surface, if it can be found at all. The (clay) mineralogical assembly, which was originally mixed, shows pedogenic differentiation: smectites and interstratified smectites have disappeared from the eluvial horizon and from the albeluvic tongues, where chloritic or degraded chloritic clay minerals have formed. The proportion of smectitic minerals is higher in the argic horizon than in the original parent material.

Physical characteristics

The eluvial horizon is normally sandy. The horizon is typically somewhat compacted; many eluvial horizons have a platy structure. The low organic matter content of the surface soil and its high susceptibility to structure deterioration demand that tillage is done at the proper soil moisture content. The dense argic horizon and/or permafrost may hinder rooting and uptake of water, either directly or indirectly because of its poor internal drainage and inadequate aeration.

Chemical characteristics

The surface horizon of Albeluvisols contains typically between 1 and 10 percent organic carbon; the C/N ratio of the accumulated organic matter is normally greater than 15. The eluvial subsurface horizon contains rarely more than 1 percent organic C and a similar amount is present in the illuvial horizon. Natural, not cultivated, Albeluvisols are moderately to strongly acid; $pH_{(1M\ KCl)}$ values range from less than 4 to 5.5 or slightly higher. The Cation Exchange Capacity is typically some 10 to 20 cmol(+)/kg, exclusive of the contribution by organic matter. Base saturation varies from a mere 10 percent in Haplic Albeluvisols with high contents of exchangeable aluminium and Al-interlayered clays to values between 60 and 90 percent in cultivated Endoeutric Albeluvisols with little Al-interlayering.
Note that the distinction between Endoeutric and Haplic Albeluvisols is based on the base saturation of the argic horizon; the eluvial horizon is always very low in bases.

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Biological characteristics

Burrowing animals of the macro- and meso-fauna are scarce in Albeluvisols, or absent altogether. Biological activity is accordingly slow and it takes several years before leaves in the litter layer are decomposed to the extent that the original plant tissue is no longer recognisable (i.e. until a *mor* or *moder* type of terrestrial humus has formed). Fungi and actinomycetes account for most of the organic matter decomposition. Another consequence of the low rate of biological activity is that mixing of organic colloids with the mineral soil is slow and the humiferous surface horizon of Albeluvisols is normally only a few centimetres thick. Many Albeluvisols in forest areas in Western Europe, where little or no cattle grazing is practised, have a fragipan overlapping with the argic horizon. In such soils root penetration and water percolation are limited to the albeluvic tongues. If these soils are taken into cultivation, '*bioturbation*' is initiated and this can remove the fragipan in a few centuries.

Management and use of Albeluvisols

The agricultural suitability of Albeluvisols is limited because of their acidity, low nutrient levels, tillage and drainage problems and because of the climate, with its short growing season and severe frost during the long winter. The Albeluvisols of the northern taiga are almost exclusively under forest; small areas are used as pastureland or hay fields. In the southern taiga zone, less than 10 percent of the non-forested area is used for agricultural production. Livestock farming is the main agricultural land use on Albeluvisols (dairy production and cattle rearing); arable cropping (cereals, potatoes, sugar beet, forage maize) plays a minor role.

In Russia, the share of arable farming increases in southern and western directions, especially on Endoeutric Albeluvisols. With careful tillage, liming and application of fertilisers, Albeluvisols can produce 25-30 tons of potatoes per hectare, 2-5 tons of winter wheat or 5-10 tons of dry herbage.