# NITISOLS (NT)

The Reference Soil Group of the Nitisols accommodates deep, well-drained, red, tropical soils with diffuse horizon boundaries and a subsurface horizon with more than 30 percent clay and moderate to strong angular blocky structure elements that easily fall apart into characteristic shiny, polyhedric ('nutty') elements. Nitisols are strongly weathered soils but far more productive than most other red tropical soils. Nitisols correlate with 'Terra roxa estruturada' (Brazil), kandic groups of Alfisols and Ultisols (Soil Taxonomy, USA), 'Sols Fersialitiques' or 'Ferrisols' (France) and 'Red Earths'.

## Definition of Nitisols

Soils

1 having a nitic horizon starting within 100 cm from the soil surface, **and**
2 having gradual to diffuse horizon boundaries, **and**
3 having no ferric, plinthic or vertic horizon within 100 cm from the soil surface.

*Common soil units:*

Andic, Ferralic, Mollic, Alic, Umbric, Humic, Vetic, Alumic, Dystric, Eutric, Rhodic, Haplic.

## Summary description of Nitisols

*Connotation*: deep, red, well-drained tropical soils with a clayey 'nitic' subsurface horizon that has typical 'nutty', polyhedric, blocky structure elements with shiny ped faces; from L. nitidus, shiny.

*Parent material*: finely textured weathering products of intermediate to basic parent rock, possibly rejuvenated by recent admixtures of volcanic ash. The clay assemblage of Nitisols is dominated by kaolinite/(meta)halloysite. Nitisols are rich in iron and have little water-dispersible clay.

*Environment*: Nitisols are predominantly found in level to hilly land under tropical rain forest or savanna vegetation.

*Profile development*: AB(t)C-profiles. Red or reddish brown clayey soils with a 'nitic' subsurface horizon of high aggregate stability.

*Use*: Nitisols are planted to farm and plantation crops. They are generally considered to be 'fertile' soils in spite of their low level of 'available' phosphorus and their normally low base status. Nitisols are deep, stable soils with favourable physical properties.

## Regional distribution of Nitisols

There are approximately 200 million hectares of Nitisols worldwide. More than half of all Nitisols are found in tropical Africa, notably in the highlands (>1000 m.) of Ethiopia, Kenya, Zaire and Cameroon. Elsewhere, Nitisols are well represented at lower altitudes, e.g. in tropical Asia, South America, Central America and Australia. See Figure 1.

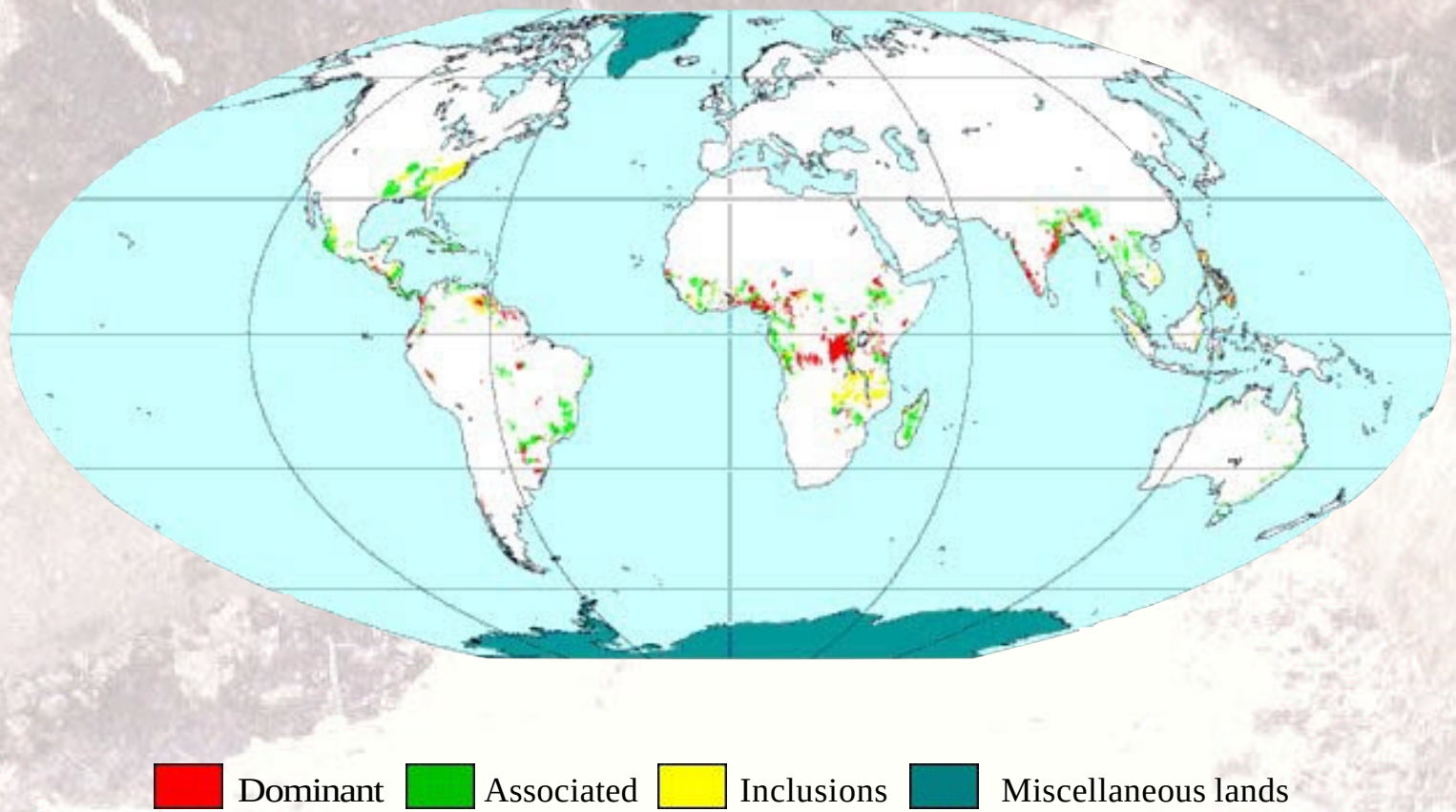


**Figure 1**. Nitisols worldwide.

## Associations with other Reference Soil Groups

Relationships between Nitisols and other Reference Soil Groups are quite diverse because they are conditioned by a score of (localized) factors. Figure 2 presents common lateral linkages between Nitisols and other Soil Groups.

1 In *undulating landscapes*, Nitisols are mostly found on basic and ultra-basic rock types in upper and middle slope positions; they grade into Vertisols or vertic units of other Reference Soil Groups towards lower slope sections and/or bottom lands.

2 In *volcanic landscapes*, Nitisols occur typically in mid-slope positions, between Andosols at higher elevation and more profoundly weathered 'red tropical soils' on lower slope sections.

3 In *uplifted and dissected landscapes* on old surfaces, Nitisols are found on slopes in association with Ferralsols on flat and level plateaus.

4 In *landscapes on limestone*, Nitisols may occur in pockets, in association with reddish soils such as Chromic Cambisols and Luvisols.

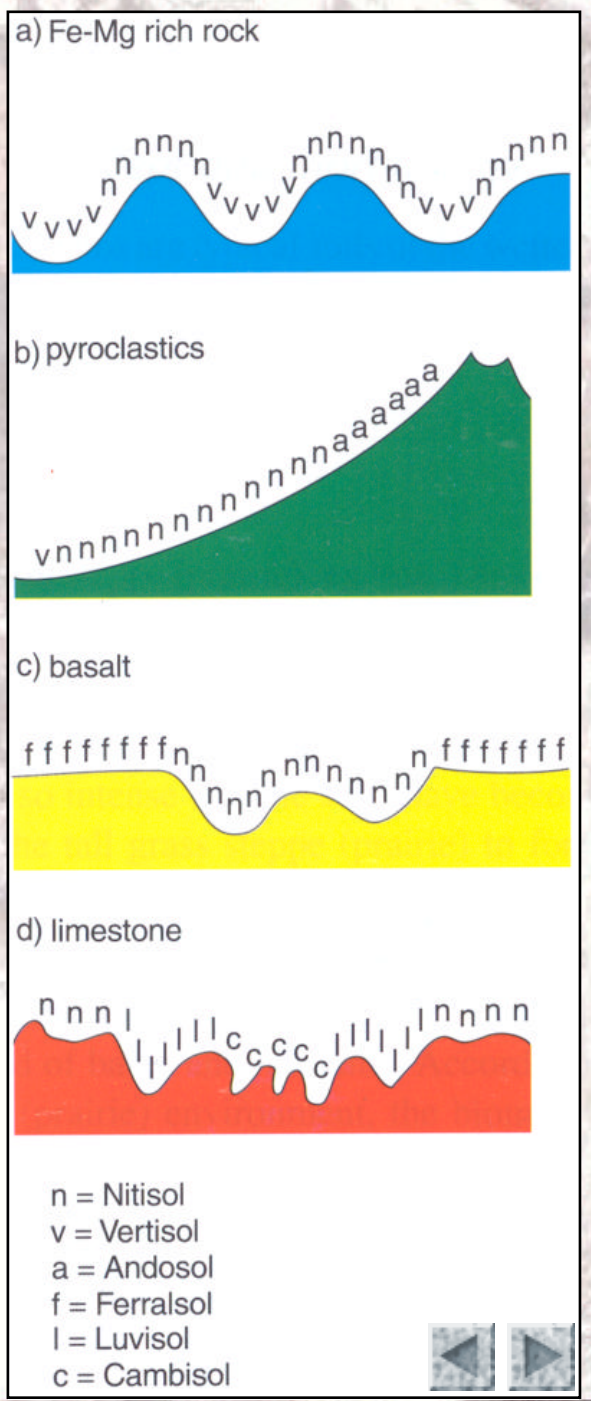


**Figure 2** Some common lateral linkages between Nitisols and other soils.

## Genesis of Nitisols

The formation of Nitisols involves the following processes:

1 '*ferralitization*', i.e. intensive hydrolysis of weathering minerals combined with leaching of silica and bases, and relative accumulation of (meta)halloysite, kaolinite and sesquioxides. The process is the same as described for Ferralsols but it is still in an early stage.

2 '*nitidization*', i.e. formation of strongly angular, shiny peds in the nitic subsurface horizon. Nitidization is probably the result of alternating micro-swelling and shrinking leading to formation of strong, shiny pressure faces.

3 '*homogenization*' of the soil by termites, ants, worms and other soil fauna (‘*biological pedoturbation*’). This process is particularly prominent in the top 100-cm soil layer where it leads to crumb and/or subangular blocky soil structure and gradual or diffuse soil horizon boundaries.

## Characteristics of Nitisols

***Morphological characteristics***

Nitisols are normally deeper than 150 cm and dusky red or dark red in colour. They are well-drained soils with a clayey subsurface horizon that is deeply stretched and has typical nutty or polyhedric blocky structure elements with shiny ped faces. The relative decrease of the clay content of this 'nitic horizon' is gradual (less than 20 percent from its maximum at 150 cm below the surface). Horizon boundaries are typically gradual or diffuse. Laterally, the nitic horizon may wedge out or decrease in thickness, or dip below a ferralic or argic horizon. It may replace either one of these or change into a cambic horizon. It also may acquire properties found in vertic or ferric horizons. Such lateral transitions are gradual and hardly perceptible within distances of 5 to 10 metres.

***Mineralogical characteristics***

The clay assemblage of Nitisols is dominated by kaolinite and (meta)halloysite. Minor quantities of illite, chloritized vermiculite and randomly interstratified clay minerals may be present, alongside hematite, goethite and gibbsite. Nitisols contain 4.0 percent or more 'free' iron ($Fe_2O_3$ by dithionite-citrate extraction) in the fine earth fraction and more than 0.2 percent 'active' iron (by acid oxalate extraction at pH 3). The ratio of 'active' to 'free' iron is 0.05 or more. The mineralogical composition of the sand fraction depends strongly on the nature of the parent material. Although weathering-resistant minerals (notably quartz) predominate, minor quantities of more easily weathering minerals, e.g. feldspars, volcanic glass, apatite, or amphiboles, may (still) be present indicating that Nitisols are less strongly weathered than associated Ferralsols.

***Hydrological characteristics***

Nitisols are free-draining soils and permeable to water (50–60 percent pores). Their retention of 'plant-available' moisture is only fair (5-15 percent by volume) but total moisture storage is nonetheless satisfactory because the rootable soil layer extends to great depth, commonly deeper than 2 m. Most Nitisols can be tilled within 24 hours after wetting without serious deterioration of the soil structure.

***Physical characteristics***

Nitisols are hard when dry, very friable to firm when moist and sticky and plastic when wet. Gravel or stones are rare but fine iron-manganese concretions ('shot') may be found.

***Chemical characteristics***

The cation exchange capacity of Nitisols is high if compared to that of other tropical soils such as Ferralsols, Lixisols and Acrisols. The reasons are:

1 Although the clay assemblage is dominated by low-activity clays, the clay content is high (more than 30 percent and not seldom more than 60 percent), **and**

2 Soil organic matter makes a considerable contribution to the overall CEC, especially in mollic or umbric soil units.

Base saturation varies from less than 10 to more than 90 percent. The soil-$pH_{(H2O)}$ is typically between 5.0 and 6.5; P-fixation is considerable but acute P-deficiency is rare.

***Biological characteristics***

Intense faunal activity is held accountable for the typical gradual horizon boundaries of Nitisols. Termites are particularly effective in homogenizing soil; volcanic glass deposited on the (present) surface was found back at a depth of 7 meters in Nitisols in Kenya.

## Management and use of Nitisols

Nitisols are among the most productive soils of the humid tropics. The deep and porous solum and the stable soil structure of Nitisols permit deep rooting and make these soils quite resistant to erosion. The good workability of Nitisols, their good internal drainage and fair water holding properties are complemented by chemical (fertility) properties that compare favourably to those of most other tropical soils. Nitisols have relatively high contents of weathering minerals and surface soils may consist for several percent of organic matter, in particular under forest or tree crops. Nitisols are planted to plantation crops such as cocoa, coffee, rubber and pineapple, and are also widely used for food crop production on small holdings. High P-sorption calls for application of P-fertilizer, usually provided as slow release, low-grade ‘rock phosphate’ (several tons/ha with maintenance doses every few years) in combination with smaller applications of better soluble ‘super phosphate’ for short-term response by the crop.