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Revisiting ferrolysis processes in the formation of Planosols for rationalizing the soils with stagnic properties in WRB

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ABSTRACT

Planosols have been recognized as a Major Soil Group right from the beginning in the legend of the FAO/Unesco Soil Map of the World. Also in WRB system it maintained that position at Reference Soil Group level on the account that a major pedogenetic process, ferrolysis, is underlaying the severe stagnic properties that characterize this group. With the introduction of Stagnosols in WRB in 2006, it appears that a serious overlap has been introduced at Reference Soil Group level. This paper aims to throw new light on the genesis of Planosols, drawing from new soil surveys conducted in the south-western Ethiopian highlands. Representative soil profiles were sampled and analyzed for their physico-chemical, mineralogical and micromorphological properties, and a hypothesis has been forwarded to explain the formation of these Planosols. The conclusion is that it is highly unlikely that 'ferrolysis' can be called upon to explain the genesis of Planosols in the Ethiopian highlands, and an alternative geogene hypothesis is put forward to explain the formation of these duplex soils. As Ethiopia is one of the mainstays of Planosols, it is suggested that WRB rethinks its strategy on soils with stagnic properties as there is room for rationalization in view of a generally felt overlap between Planosols and Stagnosols. WRB could rationalize by sub-dueing either the Planosols or the Stagnosols to a lower level.

1. Introduction

The Reference Soil Group of Planosols holds soils with surface horizons that are bleached and light-colored or have a stagnic color pattern, show signs of periodic water stagnation and abruptly overly a dense, slowly permeable subsoil with significantly more clay than the surface horizons (Driessen et al., 2001; IUSS Working Group WRB, 2007). They typically occur in seasonally or periodically wet plateau areas, often above normal flood levels or nearby rivers or estuaries. Occasionally they occur on gentle or very gentle slopes, but usually the geographical extent is limited in these landscape positions.

In the old European literature, these soils are mainly referred to as pseudogley soils or as clayey Podzols, however, neither of these soil groupings required an abrupt textural change from the bleached horizon to the underlying dense horizon (Dudal, 1971). The U.S. classification of 1938 (Baldwin et al., 1938) was the first to use the term Planosols; the present Soil Taxonomy (Soil Survey Staff, 2010) includes most of the original Planosols in the Albaqualfs, Albaquults and Argialbolls. Planosols are occurring as major soil unit in the Legend of the FAO-Unesco Soil Map of the World (FAO-Unesco, 1974). In the revised legend of the Soil Map of the World (FAO-Unesco, 1990), Planosols are recognized as a major soil grouping at highest level and so they were in the first ISSS-endorsed version of WRB (FAO/ISRIC/ISSS, 1998). Also in the World Reference Base for Soil Resources (IUSS Working Group WRB, 2007), Planosols are accommodated under the set of soils with stagnating water together with the Stagnosols.

The WRB (IUSS Working Group WRB, 2007) accommodates four Reference Soil Groups at the highest level, which have an assemblage of soil features indicative for water stagnation within the soil profile: in key order they are the Solonetz, the Planosols, the Stagnosols and the Albeluvisols. It is acknowledged that water stagnation is not part of the key definition in Solonetz and in Albeluvisols, however in most cases it is a major feature in these soils. Stagnosols had a turbulent history in the WRB. In the first draft of WRB in 1994 (FAO/ISRIC/ISSS, 1994) they were proposed as a reference group, however they did not make it in the 1998 version (FAO/ISRIC/ISSS, 1998). The Working Group WRB at that time did recognize the importance of water stagnation as an important soil feature. The rationale for not keeping the Stagnosols in was the fact that water stagnation as such is only a consequence rather than a major pedogenetic process. This was in conflict with one of the basic principles of WRB to follow as much as possible a soil-genetic approach in the delineation of major soil groupings.

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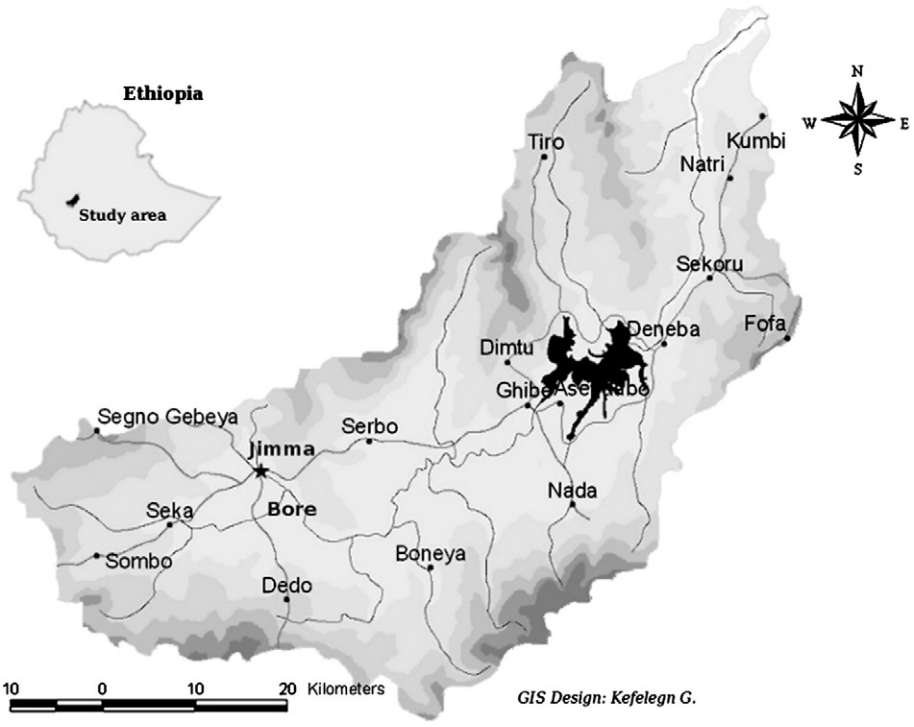

Fig. 1. Location of the Gilgel Gibe catchment and the Bore valley where the profile discussed in detail in this paper is located.

In line with the above-sketched rationale, the following pedogenetic processes were considered important for recognizing the soils with stagnic properties: (1) *Solonetz*: sodification, peptisation of the clay minerals which move into a very compact argic horizon. Upon solodisation of the Solonetz, it is hypothesized that the distinct textural change and the water stagnation is enhanced by a ferrolysis process at the fringe between the E and the B horizon hence the whitish silt-capping on top of the columns of the natric horizon; (2) *Planosols*: the 'abrupt textural change' from the coarse textured surface soil to the finer subsoil can be a result of (a) '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 (b) 'physical pedogenetic processes', such as selective eluviation–illuviation of clay in soil material with a low structural stability, and/or (c) '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, 1970); and (3) *Albeluvisols*: the genesis of Albeluvisols roots back to Late Glacial times, more particularly to the Middle and the Younger Dryas periods and its respective interstadials: argilluviation (mobilization and translocation of clay) during interglacials and formation of polygonal albeluvic tonguing during the last glacial period, including compaction of the outer sphere of the soil polygons leading to the so-called 'closed box system' which eventually results in strongly expressed water stagnation on top of the compacted argic horizon. It was also inferred that the process of ferrolysis could have enhanced the textural contrast in Albeluvisols, however this claim was refuted by Van Ranst and De Coninck (2002), who proved that this process does not take place in soils with albeluvic tonguing (Albeluvisols) and in soils with stagnic color pattern in Western Europe.

During the international conference on soil classification in 2004, at Petrozavodsk (Russian Federation, organized by the Institute of Biology, Karelian Research Centre), the decision was taken to take the Stagnosols on board again in WRB. This decision was implemented in the published 2006 and 2007 (electronic) versions of WRB during the IUSS congress at Philadelphia, USA. At the same time a call was made for fundamental research which should elucidate the above-mentioned pedogenetic processes and especially the process of ferrolysis.

Fig. 2. A typical Vertic Planosol of the Gilgel Gibe catchment showing sub-soil gilgai and nicely developed slickensides (see inset) in the subsoil.