13. Soil-landscape relationships in the basalt-dominated uplands of Tigray – example in May Leiba

(Summarised from Van de Wauw et al., 2008)

J. Van de Wauw[1], G. Baert[2], J. Moeyersons[3], J. Nyssen[4], Nurhussein Taha[5], Amanuel Zenebe[5,6], J. Poesen[6], J. Deckers[6]

[1] *Laboratory of Soil Science, UGent, Krijgslaan 281/S8, 9000 Ghent, Belgium*
[2] *BIOT Departement, Hogeschool Gent, Voskenslaan 270, 9000 Ghent, Belgium*
[3] *Royal Museum for Central Africa, Leuvensesteenweg 13, 3080 Tervuren, Belgium*
[4] *Geography Department, UGent, Krijgslaan 281/S8, B-9000 Ghent, Belgium*
[5] *Mekelle University, P.O. Box 231, Mekelle, Ethiopia*
[6] *Department of Earth and Environment Sciences, K.U.Leuven, Celestijnenlaan 200E, B-3001 Heverlee, Belgium.*

1. Scope

Though knowledge about the distribution and properties of soils is a key issue to support sustainable land management, existing knowledge of the soils in Tigray (Northern Ethiopian Highlands) is limited to either maps with a small scale or with a small scope. The goal of this study is to establish a model that explains the spatial soil variability found in the May-Leiba catchment, and to open the scope for extrapolating this information to the surrounding basalt-dominated uplands.

2. Study methods

A semi-detailed (scale: 1/40 000) soil survey was conducted in the catchment. Profile pits were described and subjected to physico-chemical analysis, augerings were conducted, and profiles were classified according to the World Reference Base for soil resources (WRB) (IUSS Working Group WRB, 2006). This information was combined with information from aerial photographs and geological and geomorphologic observations (**Figure 1,2**).

3. Geology

The May-Leiba catchment is a part of the Mekelle outlier which consists of sub horizontal alternating series of cliff forming and non cliff forming Antalo limestone of Jurassic age, overlain by Agula Shale (Jurassic age) in the SE corner of the study area (figure 2). At the northern side of the catchment, the unconformity of the contact between Antalo limestone and the overlying Amba Aradom sandstone may be observed in the field. The top of the table mountains consists mainly of Amba Aradam sandstone of Cretaceous age and by two series of Tertiary basalt flows (Nyssen et al., 2002). In between these basalt layers silicified lacustrine deposits (Garland, 1980) can be locally found. The Mesozoic succession of the Mekelle outlier is described by Bosellini et al. (1997).

The formation of the rift valley tectonic uplifts of about 2500 m and differential erosion resulted in stepped sub horizontal landforms. The highest point of the catchment is located on a basalt ridge at 2835 m a.s.l. At the south-east of the study area a dolerite sill outcrops, inducing an extra uplift in the higher lying sandstone and basalt.

4. Geomorphology

Important in this area are different landslides. They occur within the limestone area, but can also cause basaltic material to be deposited on down slope located limestone areas, which makes them very important for soil distribution. Research on these landslides has been done in nearby areas, including the southern fringe of the catchment (Nyssen et al., 2002 and section 14 , p. 77 in this excursion guide).

5. Soils and soil-landscape relationships

To create the soil map, different approaches are possible: the pedologic approach and the physiographic or geomorphologic approach (Wielemaker et al., 2001). The first method tries to create maps with taxonomic pure soil data or soil associations. The geomorphologic approach uses soils as part of the landscape. We have chosen for this geomorphologic approach because extrapolating the results of the soil map needs this geomorphologic information, and we believe that for most uses of the soil map will be combined with such geomorphologic information.

The main driving factors that define the variability in soil types found were: 1) geology, through soil parent material and the occurrence of harder layers, often acting as aquitards or aquicludes; 2) different types of mass movements that occupy large areas of the catchment; and 3) severe human-induced soil erosion and deposition. These factors lead to "red-black" Skeletic Cambisol–Pellic Vertisol catenas on basalt and Calcaric Regosol–Colluvic Calcaric Cambisols–Calcaric Vertisol catenas on limestone **(Figure 3).** Leading to the soil map which is shown in **Figure 4**.

The driving factors can be derived from aerial photographs. This creates the possibility to extrapolate information and predict the soil distribution in nearby regions with a comparable geology. A model was elaborated, which enables the user to predict soil types, using topography, geomorphology, geology and soil colours, all of which can be derived from aerial photographs. This derived model was later applied to other catchments and validated in the field.

References:

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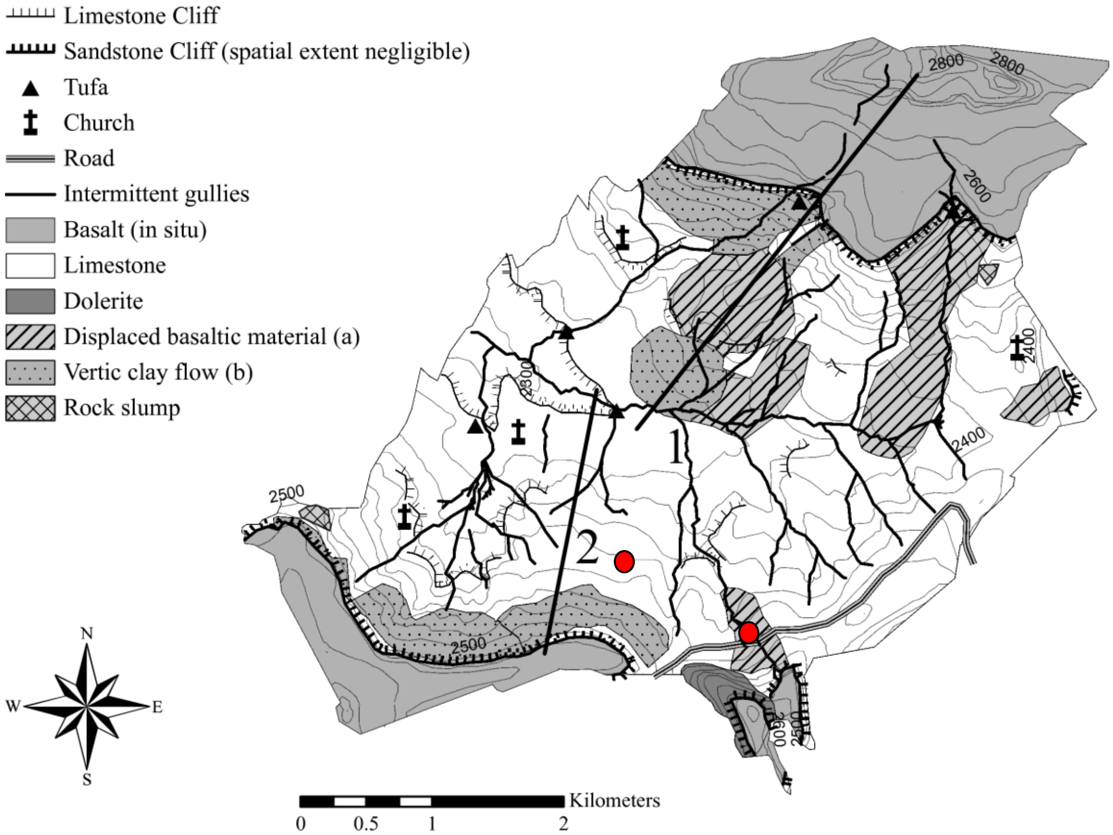

Figure 1: *Geologic and geomorphic map of the May Leiba catchment. The two bold lines indicate the position of the transects shown in Fig. 3. Red dots indicate location of excursion stops.*

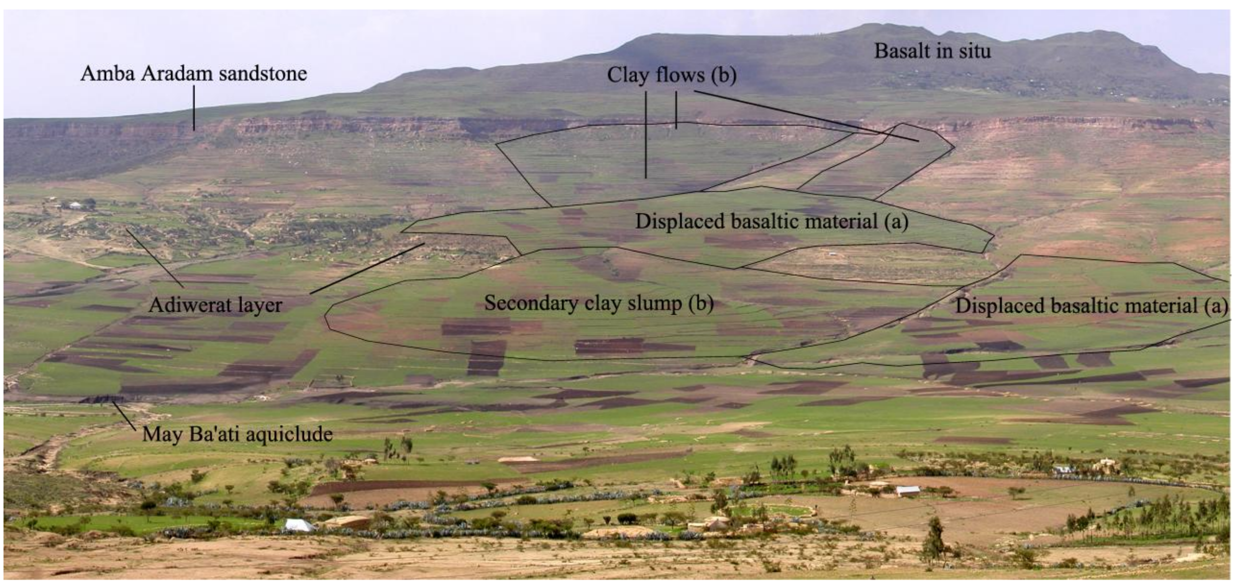

Figure 2: *Overview of the northern side of the May-Leiba catchment. Different kinds of mass movements are depicted: (a) large scale landslides which move basaltic parent material downslope; and (b) flows of vertic clays, deposited at the foot of the sandstone cliff, or similar secondary flows at the foot of large scale landslides.*

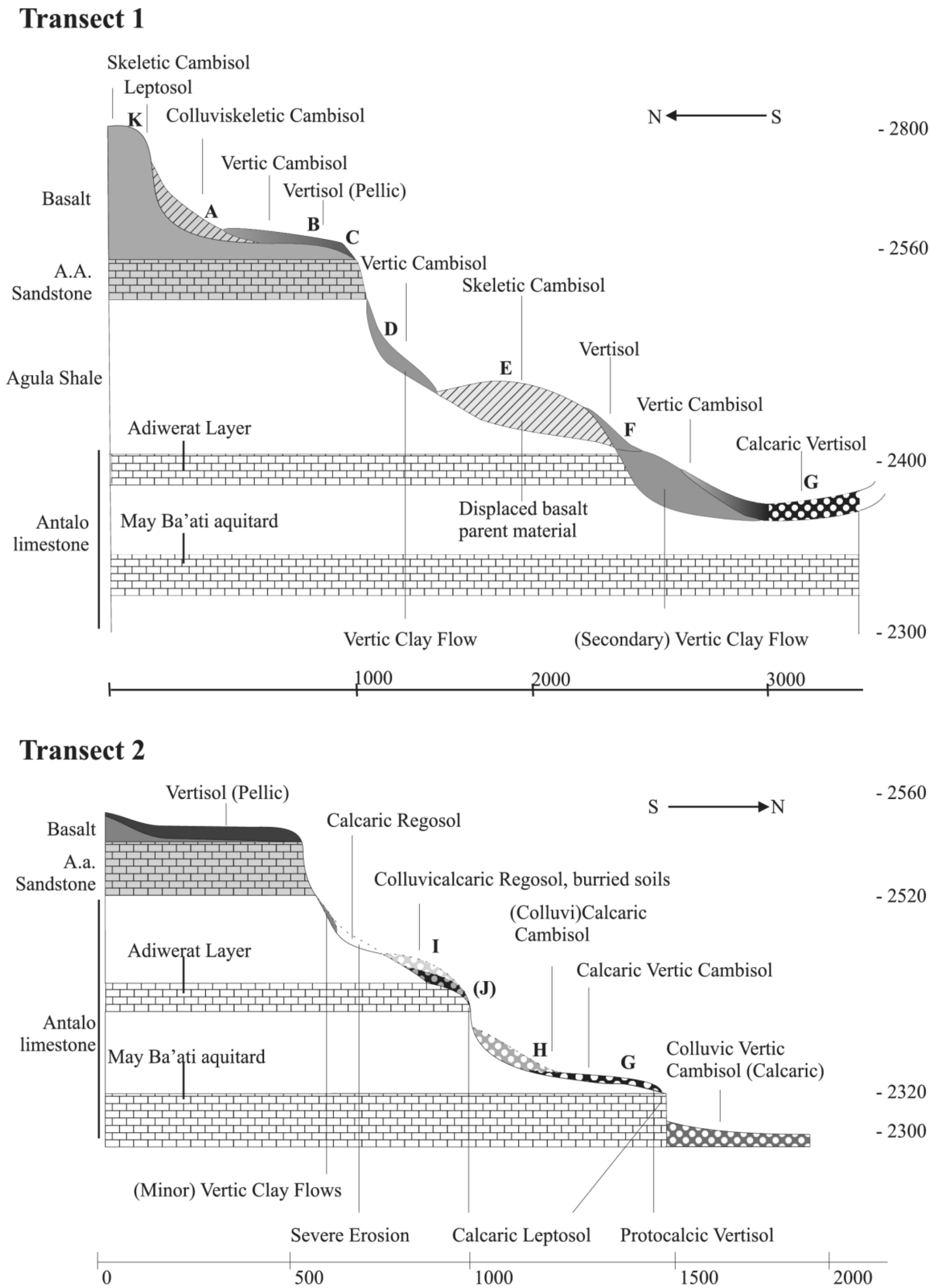

Figure 3*: Catena on basalt and basaltic mass movement deposits (transect 1) and on limestone (transect 2). Hatched greys show displaced basaltic parent material. Dark grey denotes vertic clays, white dots calcaric properties.*

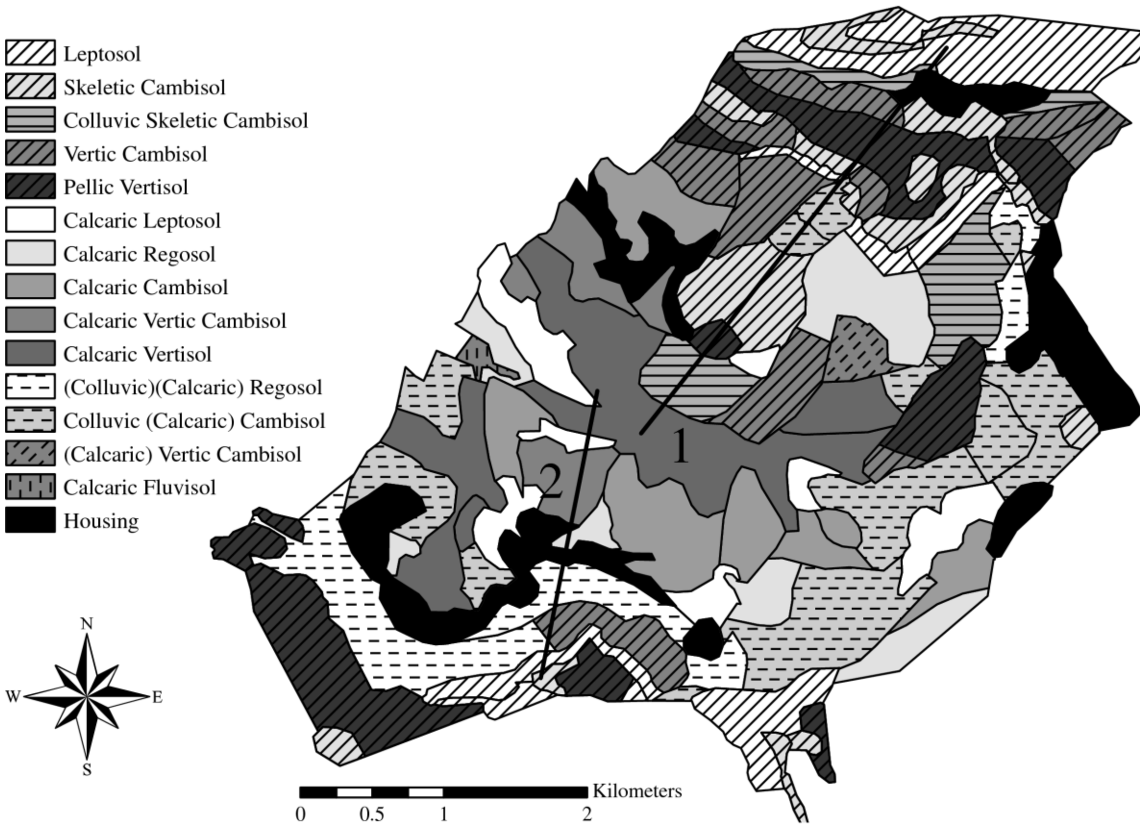

Figure 4: *Soil map of the May-Leiba catchment. Within the soilmap full lines indicate basalt parent material. Dashed lines indicate a complex of limestone and basalt parent material. The grey-value determines the degree of profile development. The horizontal pattern indicates colluvial deposits. The two bold lines indicate the position of the transects shown in Figure 3.*