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SOILS AND SOIL EROSION IN THE AREA OF DEBRE BIRHAN, EASTERN HIGH PLATEAU OF SHEWA, ETHIOPIA

R. BONO and W. SEILER

1 Introduction

In large parts of the Ethiopian Highlands it has become highly difficult to maintain the necessary basic food production. One of the main reasons is the occurence of severe and continuous soil erosion. On the one hand, this destroys very often the annual crops by flooding and derooting them, and on the other hand it leads to severe losses of the top-soil formerly rich in nutrients and organic material. The latter process results in increasingly degraded and poorer soils and ultimately in completely destroyed areas of the so called badlands. Depending on their stage of degradation, the degraded soils allow only very reduced agricultural production with low harvest whilst badlands are unusable.

The soil erosion is mainly caused by a high population and livestock pressure, in connection with intensive crop production, and a relatively high annual rainfall concentrated in two rainy seasons. These facts can hardly be altered in the near future. The only way to preserve the soils and to maintain the basic food production are, therefore, appropriate conservation measures which have to be taken quickly since many regions already suffer insufficient food production.

Because practices for long-term preservation of the soil are lacking, the Government of Socialist Ethiopia is currently carrying out an extensive campaign to reduce soil erosion. In order to provide the Ethiopian soil conservation efforts with necessary data for the proper implementation of conservation measures, the Soil Conservation Research Project (SCRP) was introduced. This is funded by the DCA (Swiss Directorate of Development Cooperation and Humanitarian Aid) and the Ethiopian Government. The implementing agency is the Community Forests and Soil Conservation Development Department of the Ministry of Agriculture, and the Institute of Geography of the University of Berne is the executing agency (*H. Hurni* 1984). In the four Research Units (RU) of phase I (1981 - 83), representing different agroecological zones of the Ethiopian Highlands (see Fig. 1), soil erosion processes are evaluated, and appropriate soil conservation measures developed and adapted. Findings and recommendations of the SCRP are continuously published (*H. Hurni* 1984).

Since the knowledge of soils and their properties is an important basis for various purposes, especially for conservation planning and watershed management, the SCRP also

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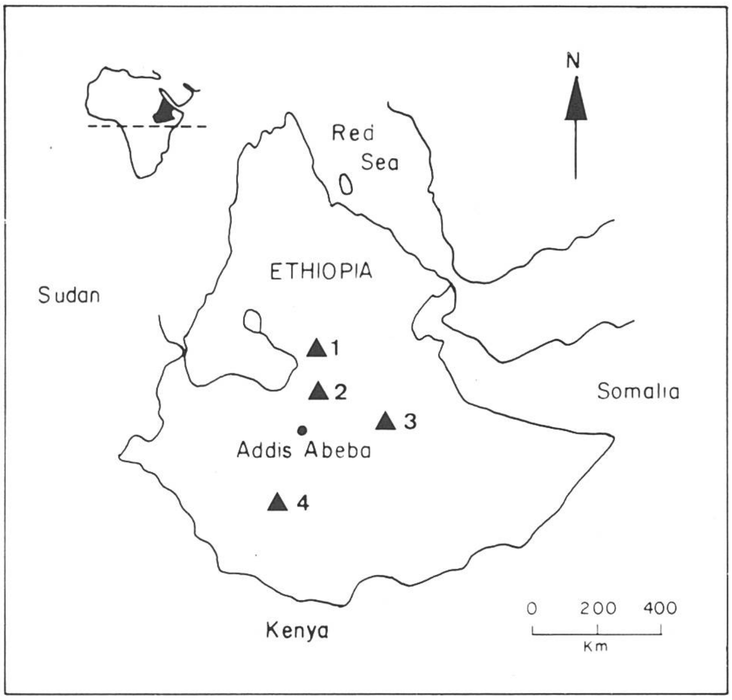


Fig. 1 Research units of phase I (1981 - 83) of the Soil Conservation Research Project (SCRP):

1. Maybar-Wello 2. Andit Tid-Shewa 3. Hunde Lafto-Harerge 4. Gununo-Sidamo

includes soil survey. In the Andit Tid-Shewa and Hunde Lafto-Harerge RU soil mapping was carried out by the authors (see *R. Bono* and *W. Seiler* 1983, 1984a, b). The main purpose of this paper is to give an account of the soils and their qualities in the strongly eroded area of the Andit Tid RU. It especially focusses on soil types and soil pattern, easily reworkable soil depth and details on the degree of soil destruction which will help planning of appropriate conservation measures. Large scale soil mapping provides, furthermore, an important base for small scale soil maps since it includes all soil types which occur as well as providing information on their typical pattern.

2 Andit Tid Research Unit

The Andit Tid RU is situated in the Shewa region mainly to the south of the all-weather road from Debre Birhan to Debre Sina, approximately 180 km east-northeast of Addis Abeba (see Fig. 1, 2 and 3) The eastern part of the RU partly includes the Escarpment that separates the Highlands (Plateau of Shewa) from the Awash River Basin, the latter belonging to the Rift Valley. The RU covers 12.25 km^3 and is part of the Blue Nile River Basin. Its highest elevation is found in the southeast (3 560 m a.s.l.) and the lowest elevations in the northwest (3 040 m) and the southwest (3 060 m) respectively. Most valleys within the RU start trough-shaped and become v-shaped in their downstream course, and are deeply incised with steep or very steep and partly terraced valley sides. Gullies are found on almost all steep slopes. They retain, and sometimes even increase, their depth and become much wider as the topography flattens out, particularly on alluvial fans. Moderately steep ridges with common rock outcrops can be observed especially in the higher areas but all of them are cut in the eastern part by the Escarpment which forms a striking boundary. Generally the topography is mountainous with great variations in elevation, and most of the watercourses within the RU are perennial. However, because the relatively high annual rainfall (1 200 - 1 300 mm) is concentrated in two rainy seasons, the runoff volumes vary greatly. The whole area is characterized mostly by acidic volcanic rocks (*V. Kazmin* 1975) of the Magdala group (upper Miocene – Pleistocene?) and typical rock types are rhyolites, trachytes, rhyolitic and trachtic tuffs and basalts. The petrology, however, is locally very variable.

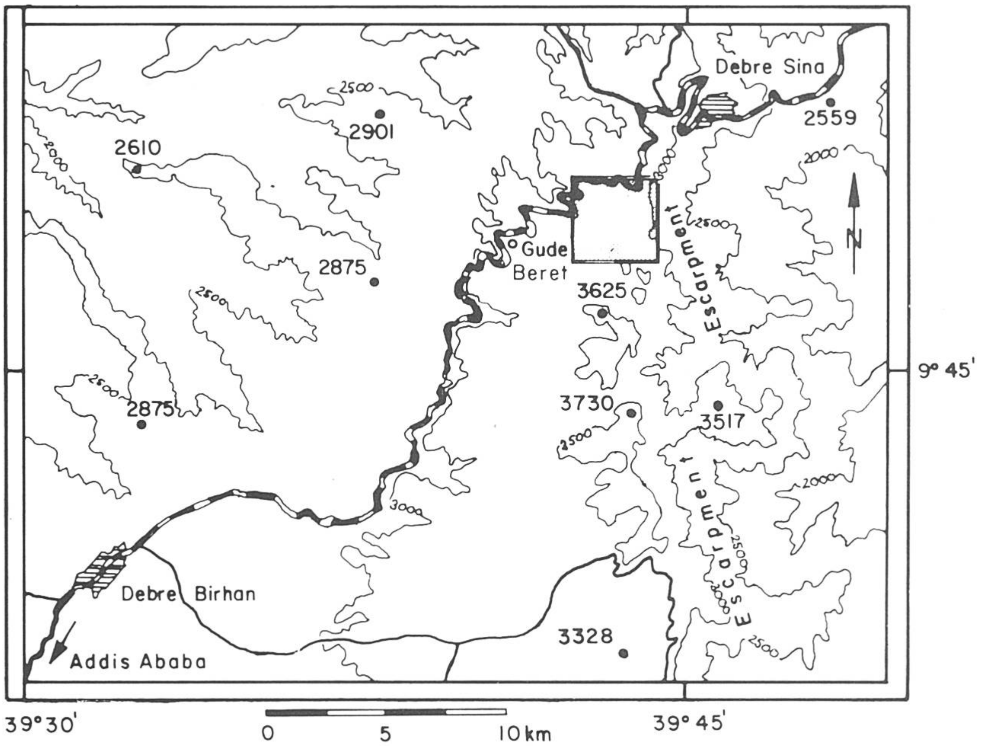


Fig. 2 Topographical situation: Andit Tid-Shewa RU
Source: Ethiopian Mapping Agency, Series EMA3, Sheet NC 37-11, Edition 1, Debre Birhan 1 : 250 000.

Fig. 3 Andit Tid-Shewa Research Unit
The northwest of the RU, showing a view of the research station (3 060 m a.s.l.). Clearly recognizable are the old terraces and the slightly or extremely damaged areas. In the foreground the road Debre Birhan - Debre Sina can be seen; in the background houses of Andit Tid with Eucalyptus trees (compare topographical map, Fig. 4).

The Andit Tid RU lies in the upper Dega and Wurch altitudinal belts within an alpine temperature region (*Daniel Gamachu* 1977, 30). The mean monthly minimum and maximum temperatures range from 5° C (March) to 12° C (May and June) and 20° C (February) to 25° C (August, November and December). This perhumid climatic moisture region (*Daniel Gamachu* 1977, 17) receives an annual rainfall of 1200 - 1300 mm with a clear maximum in the second rainy season ("Kremt": July to September) which accounts for approximately 60% of the yearly rainfall. The remaining amount falls mainly between March and May, whilst December and January are almost without rain. The relatively high precipitation is related to a high number of foggy days, which occur when warmer air-masses from the lower region behind the Escarpment rise and are subject to condensation as soon as they reach the colder top of the Escarpment.

The land is predominantly used for traditional small-scale farming, especially for barley (up to 3400 m) and lentiles, beans and peas. However, corn and sorghum which are widespread crops in the Ethiopian highland, cannot be cultivated here because of climatic reasons. On certain slopes in the lower part of the RU no cultivation is possible because of serious damage. *H. Hurni* (1984) estimates that about 13% of the catchment has to be considered as badlands.

In the whole area there is hardly any natural vegetation left. A few remnants can be found above 3300 m and in the Escarpment, where Helicrysum, Thyme and different Festuca species and afro-alpine heather with Erica- and Philippia-bushes grow (*H. Speck* 1982, 6). In the highest parts of the RU Lobelia rhynchopetalum is found. Minor reafforestation (mainly Eucalyptus) has been carried out on artificially built terraces, and the few Eucalyptus trees around the Tukuls are used as firewood.

3 Soils and soil erosion in the Andit Tid Research Unit

3 1 A typical soil type: The Andosol

Andosol, Japanese for dark brown soil, has become a popular denomination for soils formed from materials which are rich in volcanic glass and organic matter (FAO-Unesco 1974, 16). The clay is mainly of the amorphous type such as allophane, silica, aluminia or iron hydroxides. Additionally, the Andosols are very porous and of low bulk density. They are common in volcanic regions and consequently, they commonly border the Pacific basin from New Zealand to South America (*E.C.J. Mohr, F.A. van Baren* and *J. van Schuylenborgh* [3]1972, 397 ff.). According to this fairly wide distribution, Andosols occur in a wide range of climatic environments, including cool semi-arid as well as tropical humid climates. They are soils of high agricultural significance, which can be used for food crops, Coffea arabica and tea as well as for raising livestock.

In Africa, Andosols occur in several volcanic regions in Cameroon, Zaire, Rwanda, Uganda, Kenya, Tanzania and Ethiopia. In highland regions above 1500 m altitude the common Andosols are of mollic and humic nature, whereas ochric Andosols occur at lower elevations. The southwestern Rift-Valley in Ethiopia contains an area of about 8500 km^2 with ochric Andosols (FAO-Unesco 1977, 176). *E. Frei* (1978) and *H. Hurni* (1978) also discussed Andosols in the Simen-Mountains, which have developped at elevations from 2500 - 4200 m a.s.l.

In the Andit Tid RU the Andosols are the dominant soil type in uneroded or only slightly eroded areas, particularly at altitudes above 3100 m. The typical profile, which was classified as humic Andosol in the FAO-Unesco (1974) classification system, shows a black A-horizon of variable thickness, overlying a cambic B-horizon with distinct differences in colour and texture. The B-horizon itself overlies consolidated bedrock. As it was pointed out for the Simen Mountains, the cambic B-horizon is probably the post-glacial erosion surface, which would mean that the black A-horizon is also of post-glacial age (e.g. younger than 10 000 BP, *H. Hurni* 1982b). It can be assumed that the aeolian deposit of volcanic ashes in the eastern High Plateau of Shewa occurred at the same time as in the Simen Mountains, although there has been no comparable research carried out in the Andit Tid RU.

Three profile sites were selected to represent the typical Andosol soil types of the Andit Tid RU (see Table 1). The humic Andosols, typical of the little eroded areas in the upper part of the RU, have a black A-horizon with a maximum thickness of 70 - 80 cm if the profile is not truncated. The content of organic matter can be more that 10%, and the occurrence of widespread soil burning[1] may produce a brighter colour in the uppermost horizon of humic Andosols. On the top of ridges and on very steep slopes, humic Andosols with stony and/or lithic phase can be found. Their solum is clearly thinner since continuous hard rock is usually found within 50 cm of the surface. The cambic B-horizon may be absent, and in areas below 3400 m which are strongly influenced by soil erosion ochric Andosols occur. These are lighter in colour, have a distinct lower content of organic matter in the topsoil and show a cambic B-horizon. The fact that they occur in lower altitudes than the humic Andosols may be a consequence of different genesis such as different climatic conditions. There may also be an altitude limit to the natural occurence of volcanic ashes at 3000 - 3200 m a.s.l. Ochric Andosols can also have aquired at least some of their properties by processes of redeposition in areas affected by soil erosion. In these areas it can be assumed from the gentle slope gradients of the ochric Andosols that these soils were first to be used for crop production.

The Andosols of the Andit Tid RU show excellent soil water characteristics (field capacity > 550 mm; plant available water > 300 mm) as well as good nutrient status. There is no deficiency in nutrients with the exception of phosphorus. To maintain the soil fertility of the Andosols, soil burning and a rotating system with periods of fallow are applied. During fallow the fields serve as pasture.

3 2 Soils and soil pattern

The vertical distribution of the soil types in the Andit Tid RU is represented in Fig. 4. It can be clearly seen that the soils of the Andosol type dominate above an altitude of approximately 3300 m. At lower altitudes Regosols and few Cambisols, two typical soils in the Central Ethiopian Highlands, prevail (FAO-Unesco 1977). According to the large-scale soil map of the RU (see Fig. 5) the following regularities can be established:

Tab. 1 Andosols in the Andit Tid RU: profile descriptions and laboratory analyses (A, B, C).

The profiles are described and classified according to the FAO/UNESCO (1974) and FAO systems (1977). The exchangeable cations, the exchange capacity and the base saturation are determined according to the BaCl2-Triaethanolamin method (*Mehlich*).

A. *Humic Andosol*

Profile 72: 3400 m a.s.l.
Steep linear to convex slope
Pasture
Well drained

Ah 1 0-15 cm Dark brown (7,5 YR 3/2) moist and black (5 YR 2.5/1) moist; traces of soil burning; silt loam; weak fine granular and subangular blocky; friable moist; very frequent fine and very few medium roots; gradual wavy boundary;

Ah 2 15-80 cm Black (5 YR 2.5/1) moist; silt loam; moderate fine subangular blocky, friable moist; frequent fine roots; very few gravel; abrupt wavy boundary;

BC 80 + cm Dark brown (10 YR 3/3) moist; silty clay; weak fine subangular blocky; firm moist; few fine roots; frequent decomposed basaltic gravel;

Horizon	Depth	Texture (% weight)			b.d	Organic matter			
	in cm	Sand	Silt	Clay	g/cm^3	%C	%N	C/N	% O.M.
Ah 1	0-15	8	75	17	0.70	6.0	0.72	8	10.3
Ah 2	15-80	6	67	27	0.72	6.4	0.30	21	11.0
BG	80 +	7	51	42	0.93	1.1			2.0

Depth	pH	P_2O_5	Exchangeable cations (me/100g)					
in cm	H_2O	ppm	Ca	Mg	K	Na	C.E.C	% B.S.
0-15	5.8	5.4	9.7	2.7	0.6	0.2	29.5	45
15-80	5.2	10.6	5.4	1.0	0.2	0.1	34.3	20
80 +	5.4	18.8	3.8	0.6	0.2	0.1	29.1	16

B. *Humic Andosol*
(lithic phase)

Profile 71: 3505 m a.s.l.
Strongly sloping, near a top
Arable land, fallow
Well drained

Ah 1 0-20 cm Dark brown (7.5 YR 3/2) moist; silty clay loam; weak fine subangular blocky, partly granular; friable moist; very frequent fine roots; gradual wavy boundary;

Ah 2 20-35 cm Black (5 YR 2.5/1) moist; silty clay; moderate fine subangular blocky; friable moist; common fine roots; gradual wavy boundary;

A/C 35 cm + Dark brown (10 YR 3/3) moist; silty clay loam; moderate fine subangular blocky; firm moist; few fine roots; very frequent boulders (ø 50 cm); soil skeleton > 80% by volume (gravel, stones and boulders);

Horizon	Depth	Texture (% weight)			b.d	Organic matter			
	in cm	Sand	Silt	Clay	g/cm^3	%C	%N	C/N	% O.M.
Ah 1	0-20	11	55	34	0.77	7.8	0.68	12	13.5
Ah 2	20-35	11	45	44	0.86	1.6	0.48	3	2.7
A/C	35 +	19	51	30	0.97	2.0	0.24	8	3.4

Depth	pH	P_2O_5	Exchangeable cations (me/100g)					
in cm	H_2O	ppm	Ca	Mg	K	Na	C.E.C	% B.S.
0-20	5.0	17.2	9.4	2.1	0.6	0.3	35.4	39
20-35	5.5	7.0	13.6	3.2	0.3	0.3	46.4	37
35 +	5.1	17.8	7.8	1.8	0.2	0.3	28.6	35

C. *Ochric Andosol*

Profile 56: 3115 m a.s.l.
Middle of steep, convex slope
arable land
Well drained

Ap 0-20 cm Dark brown (7.5 YR 3/2) moist; silty clay loam; moderate medium crumb and fine subangular blocky; friable moist; slightly plastic wet; frequent fine roots; gradual wavy boundary;

AB 20-35 cm Dark brown (7.5 YR 3/2) moist; silty clay loam; medium crumb and fine subangular blocky; friable moist; frequent fine roots; clear smooth boundary;

B 1 35-85 cm Dark brown (10 YR 3/3) moist; silty clay loam; moderate fine subangular and angular blocky; firm moist; few fine gravel; diffuse boundary;

B 2 85 cm + Dark brown (10 YR 3/3) moist; silty clay; moderate fine angular blocky; firm moist; very few fine gravel and roots;

Horizon	Depth in cm	Texture (% weight) Sand	Silt	Clay	b.d. g/cm^3	Organic matter %C	%N	C/N	% O.M.
Ap	0-20	14	55	31	0.81	3.1	0.35	9	5.4
AB	20-35	8	56	36	0.95	1.7	0.23	7	2.9
B 1	35-85	8	55	37	1.29	0.3			0.6
B 2	85 +	8	41	51	1.28	0.3			0.6

Depth in cm	pH H_2O	P_2O_5 ppm	Exchangeable cations (me/100g) Ca	Mg	K	Na	C.E.C	% B.S.
0-20	5.5	4.4	14.7	4.4	1.4	0.1	39.1	52
20-35	5.9	8.8	12.9	3.9	0.6	0.2	35.0	50
35-85	5.1	26.8	11.2	4.5	0.4	0.3	24.0	68
85 +	5.9	10.6	11.6	5.9	0.5	0.3	27.7	66

Abbreviations:

b.d. = bulk denisty (g/cm^3)
O.M. = organic material (%)
CEC = cation exchange capacity (me/100 g)
BS = base saturation %

Andosols: Subdivided in humic and ochric Andosols; dominant soil type in the upper part of the RU (above approx. 3300 m). Andosols occur on slopes and ridges as well as on low ground, and they can also be observed in the lower part of the RU on flat and broad ridges. Andosols with a totally eroded A-horizon were classified as Cambisols if the eroded topsoil is underlain by a cambic B-horizon.

Cambisols: Eutric Cambisols dominate in depressions on slopes and in the lowest and flatter part of the RU; Cambisols cover only small areas in the RU. Only soils with an in situ development of the pedon are classified as Cambisols.

Fluvisols: Eutric Fluvisols are strongly connected with the narrow v-shaped valleys. They cover broader areas in flatter valleys with wide valley bottoms.

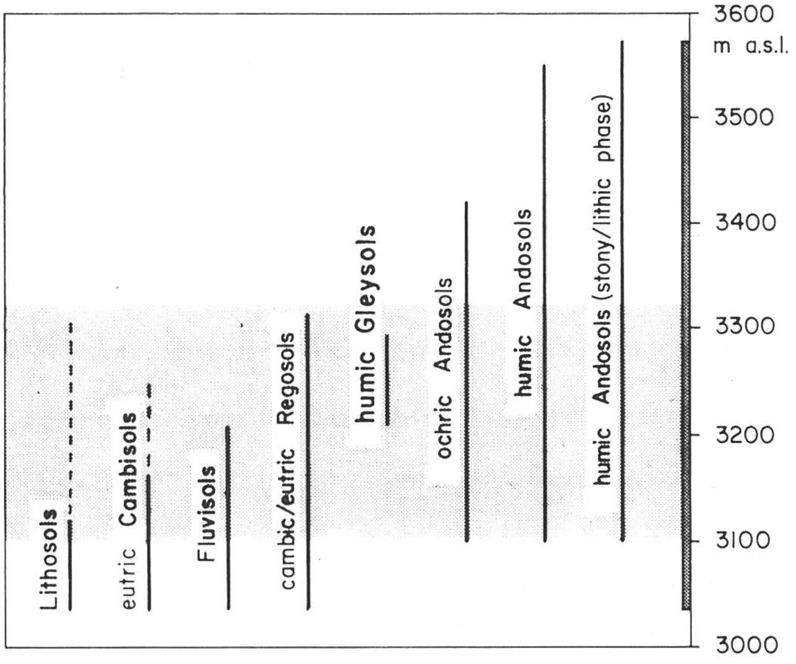


Fig. 4 Vertical distribution of the soils of the Andit Tid RU. The shading indicates the presence of soils in the heavily damaged areas.

Regosols: Eutric and cambic Regosols were classified, the latter being a Regosol with cambic B-horizon properties. Regosols are typical for large sections of the strongly eroded areas in the lower part of the RU where the soils do not show an in situ development of the pedon.

Fig. 5 Topographical situation, soil types, degree of soil degradation and soil depths in one area of the Andit Tid RU.

This particular area is situated in the northwest of the RU (see photo) at an altitude of 3040 till 3280 m a.s.l.
Topography: Andit Tid-Shewa Region, Bassona Werana – Teguletna Bulga Awraja 1 : 10 000, 1983, by *Max Zurbuchen*, Institute of Photogrammetry and Engineering Survey, Berne. Reproduced with permission of the Institute of Geography of the University of Berne.

Legend:

(1) *Topography:*
Chosen patterns:
1. Spot height, 2. All-weather road, 3. Local trail, 4. Hedge, 5. Perennial/seasonal stream, 6. Local houses, 7. Forest (newly planted: P); contours are at 10 m intervals.

(2) *Soil map:*

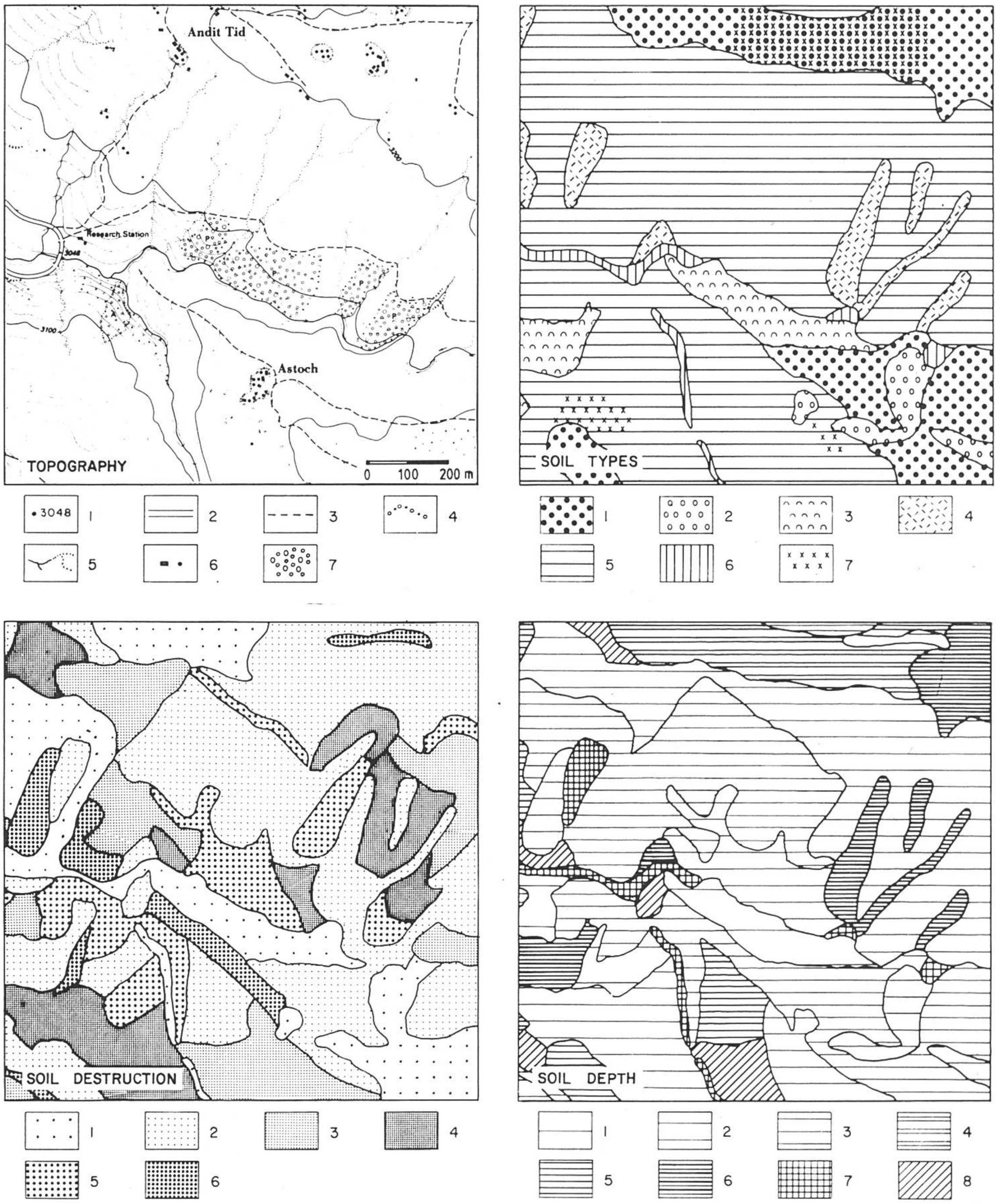
Specification of the main soil types. The map units can be very inhomogeneous (see text).
1. humic Andosol, 2. humic Andosol stony/lithic phase, 3. ochric Andosol, 4. eutric Cambisol, 5. cambic/eutric Regosol, 6. Fluvisol, 7. stony phase.

(3) *Soil destruction:*

Estimated percentage of areas with soil depths shallower than 10 cm.
1. $<$ 5%, 2. 5 - 20%, 3. 20 - 40%, 4. 40 - 60%, 5. 60 - 80%, 6. $>$ 80%.

(4) *Soil depth:*

Indication of the average soil depth (easily reworkable). The map units can be inhomogeneous with deviations until $\pm$ 20 cm.
1. 30 cm, 2. 50 cm, 3. 70 cm, 4. 90 cm, 5. 110 cm, 6. 130 cm, 7. $>$ 150 cm, 8. 20 - 100 cm.


Andit Tid
Research Station
3048
3100
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TOPOGRAPHY
0 100 200 m
3048 1
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8

In addition to these soil types, Lithosols and soils with hydromorphic properties (humic Gleysols) can be found in small areas within the Andit Tid RU. In general it has to be stressed that the map units are very inhomogeneous since morphodynamic processes are responsible for variations in soil types over small distances. Consequently, the map units consist of an association of soil types including dominant and associated soils as well as inclusions (FAO-Unesco 1974). The degree of inhomogenity depends on the influence of soil erosion. The stronger this influence is, the more inhomogeneous the map units are. Such inhomogenity occurs even on large-scale soil maps. Fig. 5 shows that the Regosol map unit including Regosols as dominant soil types as well as Lithosols, Cambisols and ochric Andosols as inclusions, is usually the most inhomogeneous.

3 3 Effects of soil erosion

The continuously increasing population, in connection with the extension and the too intensive usage of the agricultural area have caused a severe encroachment of erosion on all soils without natural vegetation. When the vegetation is undisturbed the Andosols are usually not erodible. They show high porosity, high rates of rainfall acceptance as well as water-stable aggregates. Consequently, they are considered to be more resistant to erosion than almost any other soil (*P.D. Jungerius* 1975). However, erosion starts as soon as the Andosols are used for agricultural purposes. In the Simen Mountains (Jinbar-Valley) *H. Hurni* (1982b) estimated that a 70 cm thick A-horizon, cultivated with barley, would be totally eroded within the short period of 200 - 300 years. The occurrence of strongly eroded areas in the Andit Tid RU, at present limited to altitudes below 3300 m, is clearly a consequence of the intensity and duration of man's activities.

As it was hardly possible to find a soil formed in situ in strongly eroded areas and soil type and soil depth varied considerabely within short distances, it was necessary to supplement the soil map with additional information. This was achieved by mapping soil depth as well as the degree of soil destruction (see Fig. 5). Soil depth in this connection was defined as the actual mean depth of the easily reworkable soil (see *H. Hurni* 1981), indicated by the most frequent soil depth values in a unit area. The degree of soil destruction is the estimated percentage in a unit area having either no, or only very thin, soil left (soils are shallower than 10 cm, e.g. Lithosols). This estimated percentage was reduced to five classes ranging from slightly to extremely damaged. Although this additional information is essentially independent of soil type, there is obviously a link between soil depth and the degree of destruction since the more damaged an area the shallower the soils. Only in severaly damaged areas the degree of destruction is directly related to the dominant soil type since the proportion of nonsoil areas and Lithosols in the unit area increases with the degree of destruction.

In the Andit Tid RU approximately 11% of the agricultural land (map area minus area of the Escarpment) is classified as strongly or extremely damaged (percentage of soil destruction $>$ 40%), which means that these areas are badlands; 8% of the area is moderately damaged (degree of destruction 20 - 40%) and 23% is slightly damaged (degree of destruction 5 - 20%). The remaining area of 58% has a degree of destruction of less than 5%. The most severely damaged areas lie below 3300 m and are linked to the steep valley sides (see Fig. 6). Since areas above this limit show a significantly lower degree of destruction, agricultural landuse is supposed to have started later there. Not only the degree of soil destruction but also the reworkable soil depth is influenced by erosion. In the RU, soils of the Andosol group are usually 80 - 90 cm deep, except if there is a lithic or stony phase, where soil depth is diminished to less than 50 cm. Cambisols and Fluvisols are usually deeper than Andosols and can have a depth of more than 120 cm on average. Regosols are remarkably more shallow and they have rarely a pedon thicker than 60 cm. Lithosols, finally, are by definition thinner than 10 - 15 cm.

3 4 Soil sequence on a terrace

In the heavily damaged areas hardly any genuine Andosols occur. Erosion has influenced and changed the whole pedon. Regosols dominate whereas to a certain extent Cambisols, Andosols and, according to the degree of destruction, Lithosols can also be found. Soil pattern and especially soil depth are very inhomogeneous within short distances, as can be demonstrated on an ancient, man-made terrace (Fig. 6). Such terraces often have an almost non-reworkable soil surface especially in the upper part, where erosion still occurs. Ploughing is only possible if the underlying pyroclastic rock is not coherent but strongly weathered and therefore reworkable. Soil conditions are better in the accumulation area of the terrace where deeper soils are developed. As soil depth is a very important factor in terms of both water and nutrient storage capacity, such shallow soils do not guarantee sufficient water and nutrient supply. Whereas Andosols can have more than 350 mm of plant available water[2] in a 70 - 80 cm thick pedon, this storage capacity is dramatically reduced to less than 50 mm in the Lithosol and to 70 mm and 150 mm in the Regosols on the terrace (see Fig. 6). There is no doubt that a similar reduction applies to the nutrient level. Consequently, these shallow soils can only support crops with a short growing time and the productivity is low. According to FAO recommendations (FAO 1979, 25) a minimum of 50 - 60 cm of soil depth is the limit that arable short-term seasonal crops can grow under good conditions. This shows clearly the difficulties that confront the Ethiopian farmers when producing crops in strongly eroded areas.

4 Observations on the potential agricultural use

The Andosols in the upper parts show excellent physical and chemical soil properties but the climatic conditions (high altitudes) and soil erosion damages are diminishing the amount of yield. The soil degradation in the lower parts has severe consequences for the crop production. The soil water storage capacity in the shallow soils is low to extremely low and plants, therefore, are easily damaged or, during longer periods of dryness, at least heavily stressed. Additionally, the available nutrient amount is very low and this reduces the size and speed of growth. Furthermore, the shallow soils cause great difficulties with ploughing and in certain cases it is almost impossible to plough at all because hardly any reworkable soil is left.

Conservation with contour bunds is very labour-intensive and, therefore, only worth carrying out in the flatter and still relatively undisturbed areas. In the already heavily damaged areas where the reworkable soil is too thin and the slopes are too steep, other conservation measures have to be used. In these areas the aim should be to preserve as much soil as possible with the lowest work input, i.e. by strengthening the old terraces so that they can serve as erosion protection as long as possible.

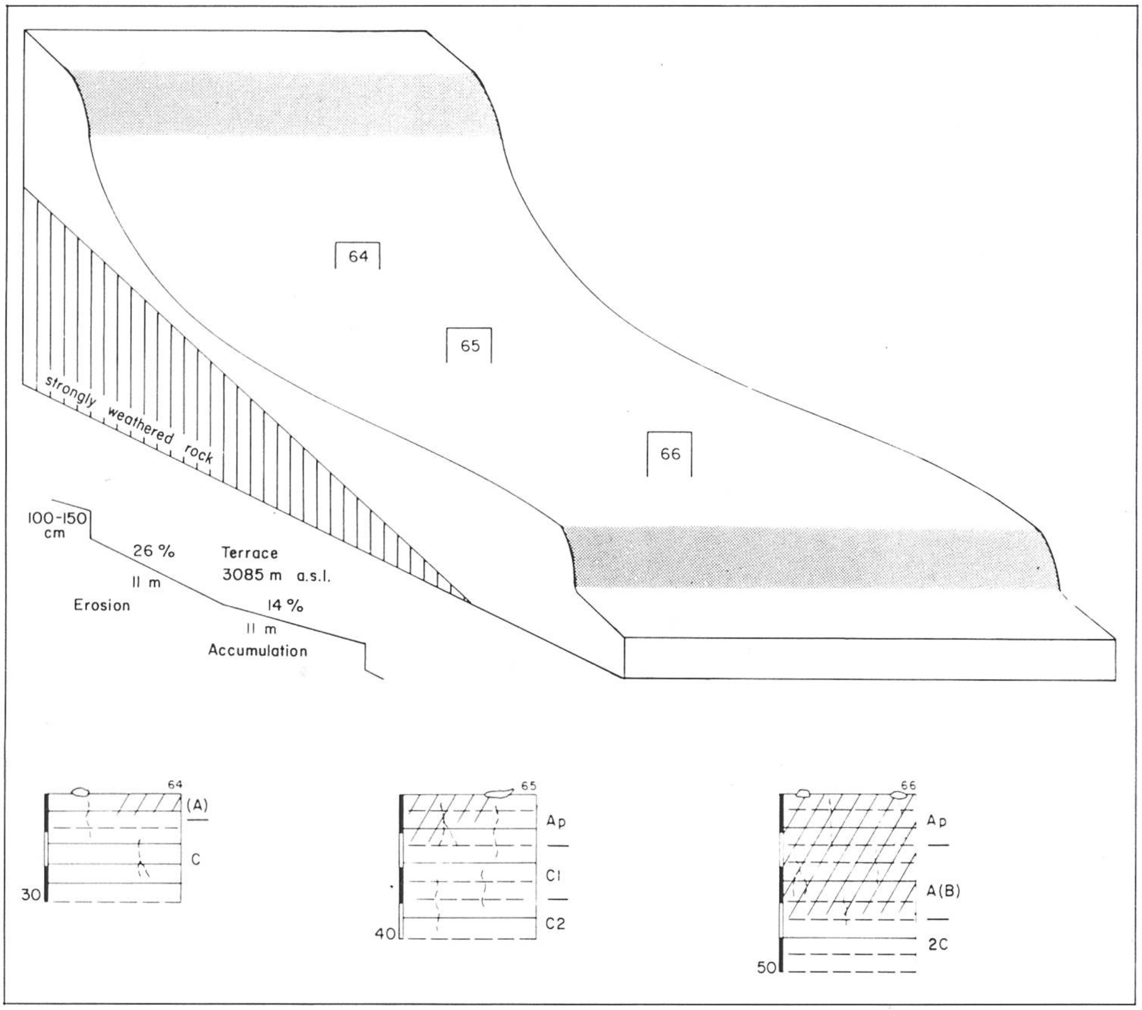

Fig. 6 Soil sequence on a typical old terrace in the Andit Tid RU.

Legend: Eutric Regosol, shallow 64

Profile description

(A) 0-2/5 cm Initial stage of A-horizon; no laboratory data available;

C 5 cm + Very dark grayish brown (10 YR 3/2) and mixture of dark gray (2.5 Y 4/0) and dark grayish brown (2.5 Y 4/2) moist; clay; structureless; very firm moist; very few fine roots; parent rock strongly weathered; ploughing possible; no coherent and hard rock;

Laboratory data

Horizon	Depth cm	Sand	Texture (% weight) Silt	Clay	b.d. g/ml
(A)	0-2/5 no sample				
C	2-20	9	34	57	1.03

	Organic matter %C	%N	C/N	% O.M.	pH H_2O	P_2O_5 ppm
(A)	no sample					
C	0.19	0.07	-	0.3	5.8	13.9

	Exchangeable cations (me/100 g) Ca	Mg	K	Na	C.E.C.	% B.S.
(A)	no sample					
C	14.5	7.2	0.4	0.3	32.0	70

Eutric Regosol 65

Profile description

Ap 0-15 cm Very dark grayish brown (10 YR 3/2) moist; silt loam, strong fine granular and partly subangular blocky; firm moist; very frequent fine and few medium roots; gradual wavy boundary;

C1 15-30 cm Very dark grayish brown (10 YR 3/2) and dark yellowish brown (10 YR 4/6) moist; loam; medium fine granular; firm moist; frequent fine and very few medium roots; gradual weavy boundary;

C2 30 cm + Mixture of very dark grayish brown (10 YR 3/2), dark gray (2.5 Y 4/0) and dark grayish brown (2.5 Y 4/2) moist; clay; structureless; firm moist; very few fine roots; strongly weathered rock;

Laboratory data

Horizon	Depth cm	Texture (% weight) Sand	Silt	Clay	b.d. g/ml
Ap	0-15	25	51	24	0.97
C1	15-30	36	53	12	0.91
C2	30+	no sample			

	Organic matter %C	%N	C/N	% O.M.	pH H_2O	P_2O_5 ppm
Ap	0.3	-	-	0.6	5.9	9.1
C1	0	-	-	0	5.9	16.1
C2	no sample					

	Exchangeable cations (me/100 g) Ca	Mg	K	Na	C.E.C.	% B.S.
Ap	12.2	5.7	0.4	0.2	25.9	72
C1	13.5	6.3	0.2	0.2	28.6	71
C2	no sample					

Cambic Regosol 66
(Eutric Cambisol)

Profile description

Ap 0-15 cm Dark brown (10 YR 3/3) moist; loam; weak fine granular and fine subangular blocky; friable moist; common fine roots; gradual boundary;

A(B) 15-35 cm Dark brown (7.5 YR 3/2) moist; clay loam; common fine subangular blocky; firm moist; common fine roots; cambic properties; clear weavy boundary;

2C 35 cm + Dark yellowish brown (10 YR 4/4) moist; silt loam; structureless; firm moist; common fine roots; strongly weathered rock;

Laboratory data

Horizon	Depth cm	Texture (% weight) Sand	Silt	Clay	b.d. g/ml
Ap	0-15	26	51	23	0.97
A(B)	15-35	25	46	29	0.84
2C	35+	21	62	18	-

	Organic matter %C	%N	C/N	% O.M.	pH H_2O	P_2O_5 ppm
Ap	0.9	-	-	1.5	6.2	10.7
A(B)	1.0	-	-	1.7	5.6	8.8
2C	0.5	-	-	0.9	5.7	15.6

	Exchangeable cations (me/100 g) Ca	Mg	K	Na	C.E.C.	% B.S.
Ap	13.9	6.6	0.4	0.1	29.3	71
A(B)	13.3	6.4	0.3	0.1	32.6	62
2C	12.8	6.5	0.2	0.2	32.8	60

Our investigations clearly demonstrate that the dominant soil types in the more elevated areas of the RU are Andosols which represent an excellent soil for crop production. Any artificial activity, for example removal of the grass or bush vegetation for the sake of crop production, will start accelerated soil erosion. The mainly still undisturbed humic Andosols in the higher areas have, therefore, to be protected by conservation measures before they are used as arable land.

From this point of view, soil survey studies like the present one, can be of vital importance in helping to specify appropriate conservation measures which must quickly be taken if productivity is not to drop below starvation level.

5 Summary

This paper discusses soils and soil erosion in a research unit in the eastern Highlands of Ethiopia, especially in relation with agricultural use. Above approximately 3300 m humic Andosols are the original and typical soils. Below approximately 3400 m ochric Andosols occur in areas which are strongly influenced by soil erosion. These soils are especially distinguished by a lower content of organic matter in the topsoil and they are lighter in colour. In general the Andosols dominate above approximately 3300 m whilst at lower altitudes Regosols and Cambisols prevail.

Soil erosion is mainly caused by a high population and livestock pressure because more and more soils, formerly covered by natural vegetation, have to be used for basic food production. When the vegetation is undisturbed, Andosols usually exhibit low erodibility. However, as soon as they are used for agricultural purposes erosion starts. Our research has shown that approximately 11% of the soils in the research unit are strongly or extremely damaged; 8% are moderately damaged and 23% are slightly damaged. These figures clearly demonstrate that appropriate conservation measures have to be taken quickly if agricultural productivity is not to drop drastically in the immediate future.

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NOTES

1 Soil burning ("GUIE") is a general technique in the Highlands of the Shewa-Province to maintain soil fertility. It is mainly used in soils rich in clay and partly or completely water-logged (pseudovergleyt). In the Andit Tid RU soil burning is also applied intensively on Andosols. For further details see *J. Wehrmann* and *L. Wolde-Yohannes* (1965).

2 Defined as the maximum water content of medium and fine pores, e.g. absorbed with tensions of 0.1-15 bar. Calculation according to *S.C. Gupta* and *W.E. Larson* (1979) using texture, organic matter and bulk density.

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