

VERTISOLS IN THE COLLECTION OF
THE INTERNATIONAL SOIL MUSEUM AND
SOME SUGGESTIONS ON CLASSIFICATION

HANS VAN BAREN, WIM G. SOMBROEK AND ABRAHAM KAPLAN

Presented by W.G. Sombroek at the Fifth
International Soil Classification Workshop,
Khartoum, Sudan, November 1982



INTERNATIONAL SOIL REFERENCE AND INFORMATION CENTRE

ISRIC	
S 12	
	2
Wageningen	The Netherlands

VERTISOLS IN THE COLLECTION OF THE INTERNATIONAL SOIL
MUSEUM AND SOME SUGGESTIONS ON CLASSIFICATION

Hans van Baren¹, Wim G. Sombroek¹ and Abraham Kaplan²

ABSTRACT

This contribution contains descriptions and analytical data of Vertisols belonging to the collection of the International Soil Museum (ISM) at Wageningen, the Netherlands. It also gives some suggestions and discussion points on their classification in Soil Taxonomy and FAO-Unesco Soil Map of the World legend.

1. MATERIALS AND METHODS

Over the years, ISM collected nearly 20 Vertisol profiles and about 10 soils with vertic properties. Of these, 17 Vertisols have been analyzed with standard methods (see Appendix 3). The description of site and soil and the analytical data are given in Appendix 1. The following soils are comprised in this contribution:

Country and soil code	FAO-Unesco legend	USDA Soil Taxonomy
Australia	AUS4 Chromic Vertisol	Udorthentic Chromustert, fine, mixed (?) thermic
	AUS5 Chromic Vertisol	Typic Chromoxerert, very fine, mixed, thermic
	AUS6 Pellic Vertisol	Typic Pelludert, fine, montmorillonitic, thermic
Botswana	RB2 Pellic Vertisol	Typic Pellustert, fine, montmorillonitic/mixed, hyperthermic

¹International Soil Museum, Wageningen, the Netherlands

²Facultad de Agronomia, Universidad de la República, Montevideo, Uruguay

Country and soil code	FAO-Unesco legend	USDA Soil Taxonomy
Greece	GR1 Pellic Vertisol	Typic Pelloxerert, very fine, montmorillonitic, mesic
	GR6 Chromic Vertisol	Entic Chromoxerert, fine, montmorillonitic, mesic
India	IND8 Chromic Vertisol	Typic Chromustert, fine, montmorillonitic, hyperthermic
	IND10 Pellic Vertisol	Typic Pellustert, fine, montmorillonitic, hyperthermic
Italy	I13 Chromic Vertisol	Aquic Chromoxerert, very fine, mixed, mesic
Namibia	SWA9 Pellic Vertisol	Typic Pellustert, fine, mixed, hyperthermic
South Africa	ZA8 Pellic Vertisol	Udic Pellustert, fine, montmorillonitic, thermic
	ZA9 Chromic Vertisol	Typic (udic?) Chromustert, very fine, montmorillonitic, thermic
Spain	E3 Chromic Vertisol	Typic Chromoxerert, fine, montmorillonitic, thermic
	E12 Chromic Vertisol	Typic Chromoxerert, fine, montmorillonitic, thermic
	E18 Chromic Vertisol	Typic Chromoxerert, fine, montmorillonitic, thermic
Thailand	T2 Pellic Vertisol	Udic Pellustert, fine, montmorillonitic, isohyperthermic
Turkey	TR14 Pellic Vertisol	Typic Pelloxerert, fine, montmorillonitic, mesic

In addition to the above, ISM will receive soon a set of two Vertisol profiles, that is characteristic for many of the gently undulating low uplands of Uruguay. These are covered with clay loam sediments of aeolic origin, locally called 'lodolitas'. These low uplands have a microrelief of gilgai in a wavy pattern ("ondas"), forming a feather or finger print-like pattern on aerial photographs. The horizontal distance between the tops of the waves varies from 4 to 8 meters and there is a striking difference in soil development on the waves and in-between them. In the first case the very dark grey to black A1 (A11 to A15) extends to about 100 cm depth, in the second case it is only about 20-30 cm thick. In both cases the A1 is underlain by a thin ACck grading

into a Cck (Kaplan and Ponce de León, 1981; see Appendix 2).

Rather than characterizing the mapping unit concerned by two taxonomic soil units, i.e. typic Pelludert and Rendoll (?), the Uruguayan soil scientists prefer to consider it as one (poly)pedon, called deep phase and shallow phase of a *ruptic* Vertisol. ("ruptic" for horizontally discontinuous, cf. Altamirano et al., 1976). In contrast, the Vertisols without "double-profile" are called *haplic* Vertisols.

In some of the Uruguayan Vertisols - notably the deep phase of the ruptic ones - there is evidence of clay translocation, which is confirmed by micro-morphology. An A-Bt-C(ck) horizon sequence is found, hence a local classification of *luvic* (ruptic) Vertisols is applied.

2. DISCUSSION

The relatively small number of profiles did not allow to make general statements on the classification of Vertisols. Some specific points for discussion, partly based on the observations and data of the ISM soil monolith collection are, however, included in this contribution:

1. It may be useful to give a special name and code to the subsurface horizon of Vertisols (and vertic subgroups of other soils). Such a horizon would have a well-developed prismatic structure, pronounced slickensides, a minimum percentage of clay and montmorillonitic or at least mixed clay mineralogy.

For one, such a denomination would avoid the awkward multiple subdivisions of the Al c.q. the AC horizons found in many Vertisol profile descriptions. One may then speak of a "*vertic horizon*", with the coding P (for Pelosol - Kubiëna/Mückenhausen) or V (for Verton - FitzPatrick).

A denomination as Bv or (B)v would seem to be less appropriate because it concerns not a horizon of "weathering" (v for Verwitterung - Kubiëna/Mückenhausen), but one of structural development.

2. The classification of Vertisols on account of the presence of gilgai, intersecting slickensides, and wedge-shaped or parallelepiped structural

aggregates needs a quantitative definition of these phenomena. Specifically, minimal requirements should be established to distinguish Vertisols proper from soils of Vertic subgroups.

3. The present subdivision of the Vertisols at Suborder level into *Torrverts*, *Xerverts*, *Usterts* and *Uderts* - with definitions mainly related to a different duration of cracking over the year, rather than to the soil moisture regime within the peds - is very management-oriented and at times awkward once irrigation is practised. The influence of different climatic environments on soil characteristics might be better defined on the depth of occurrence of free carbonates (see separate paper Sombroek), where necessary complemented with a clay mineralogical criterion (Vertisols in some of the old, filled-in river valleys ("dambos"), of the Eastern-African peneplains have relatively low CEC-clay values, i.e. below 40 meq/100 g).
4. On the other hand, there may be a case for distinguishing Aquerts, notably for Vertisols in riverplains with a shallow phreatic level in the dry season. It is doubtful whether the distinction can be made on colour criteria alone (although such soils tend to have dark grey rather than very dark greyish brown subsoil horizons). Quantifying the depth and oscillation of the groundwater level may in such cases be a better proposition (cf. the "watertable classes" used in the Dutch soil survey; see Van Heesen, 1970).
5. As mentioned repeatedly in ICOMVERT circular letters, the present definitions of *Chromic* and *Pellic* does not result in a satisfactory subdivision between the Vertisols in position of free external drainage (those on sloping terrains) and the Vertisols in a position of imperfect drainage (those on flat terrains).

The erstwhile differentiation between "lithomorphic" versus "topomorphic" Vertisols (D'Hoore et al.) was straightforward and useful for mapping purposes, and an effort may be made to re-introduce them.

6. There are quite a few Vertisol-like soils that have very thin (≤ 10 cm) topsoils of a massive and hard nature, over strongly cracking subsurface and

subsoil horizons that conform all criteria for Vertisols (abundance of slickensides, montmorillonitic clay minerals, little or no clay skins). They occur e.g. in parts of Kenya (Mara plains) and in Uruguay and have been called "minimal Planosols" at one time. They would probably fall under the "*mazic*" Vertisols of early approximations of Soil Taxonomy. Rather than "bury" such soils in the multitude of taxa of the Alfisols, one may want to bring to the fore the relationship with the Vertisols that have a crumby surface structure by broadening the definition of Vertisols. "*Mazic*" and "*Grumic*" could then be major subdivisions.

7. There may be a case to distinguish *luvic* Vertisols for the profiles with some degree of argilluviation, and *ruptic* Vertisols for the double-profile situations as reported by the Uruguayan soil scientists.

3. REFERENCES

- Altamirano, A. et al. 1976. Carta de reconocimiento de suelos del Uruguay. Tome I, Clasificación de Suelos. Ministerio de Agricultura y Pesca, Dirección de Suelos y Fertilizantes, Montevideo, Uruguay.
- D'Hoore, J.L. 1964. Soil Map of Africa scale 1:5,000,000. Explanatory monograph. CTCA Publication No. 93, Lagos.
- Kaplan, A. and J. Ponce de León 1981. Caracterización de un vertisol de la unidad "La Carolina" I. Propiedades Físicas. Tesis, Facultad de Agronomía, Universidad de la República, Montevideo, Uruguay.
- Van Heesen, H.C. 1970. Presentation of the seasonal fluctuation of the water-table on soil maps. Geoderma, Vol. 4, No. 3, pp. 257-279.

Appendix 1. DESCRIPTIONS OF SITES AND PROFILES, ANALYTICAL DATA.

Profile AUS 4

Classification

FAO-Unesco: Chromic Vertisol, fine textured

USDA: Udorthentic Chromustert, fine, mixed(?), thermic

Local: Grey Clay; Ug 5.24

(Handbook of Australian Soils, profile 10 D)

Location

Australia, Queensland, Chinchilla District.

Bottom of a depression with a mellen-hole gilgai complex. Slope less than 1%.

Elevation: 305 m. Drainage: poorly drained.

Parent material/Substratum

Clays overlying and probably derived from siltstone of Jurassic.

Walloon Coal measures.

Vegetation and Land use

Native vegetation brigalow forest of *Acacia harpophylla* with *Casuarina cristata*, some *Geijera parviflora* and *Melaleuca lanceolata*. Now cleared for sparse grazing of volunteer herbage. Fodder crops and improved pastures for dairying and cattle fattening as well as grain production (wheat and sorghum) in nearby areas.

Particle size distribution (μm in weight %)

Depth cm	Horizon	> 2 mm	Particle size distribution (μm in weight %)								pH		Org. matter			'Free' Fe_2O_3 %	
			Coarse Sand		Fine Sand		Silt		Clay < 2	H_2O	CaCl_2	CaCO_3 %	C %	N %	C/N		
			2000	1000	500	250	100	50									20
1	0-10	A															
2	10-20	Au1		3			28		6	63	6.6	5.5		2.9	0.13	22	
3	20-30	Au1		3			29		17	51	7.0	6.1		0.09			
4	30-45	Au2		3			30		17	50	7.6	6.7		1.4	0.07	20	
5	45-60	Au2		3			29		17	51	7.2	6.5		1.2	0.06	20	
5	60-90	Au3		3			31		14	52	5.6	5.1		0.9	0.04	22	
7	120-150	Au4		7			26		14	53	5.6	5.1		0.04			
3	150-180	Au4		2			29		15	54	6.0	5.6		0.03			
				2			29		15	54	6.3	6.0					

Depth cm	Exchangeable cations								CEC Soil Clay %	BS %	EC (mS/cm)	Water soluble salts							
	Ca	Mg	K	Na	Sum	Exch. acid.	Soil	Clay				Ca	Mg	K	Na	CO_3	HCO_3	Cl	SO_4
	meq/100 g											meq/100 g							
1		6.6	1.4	1.4				26		100									
2		9.4	0.9	4.5				25		100									
3		9.4	0.8	5.6				24		100									
4		7.8	0.7	6.1				22		100									
5		7.3	0.6	5.6				22		100									
7		12	1.0	8.8				23		100									

Depth cm	Elemental composition of the total soil (weight %)											Ign. loss	Molar ratios			
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	P_2O_5			$\frac{\text{SiO}_2}{\text{Al}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{Fe}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{R}_2\text{O}_3}$	$\frac{\text{Al}_2\text{O}_3}{\text{Fe}_2\text{O}_3}$
1	78.7	13.5	3.9	0.5	0.6	0.6	0.3	1.10	0.08	0.05		6.7				
2	80.0	13.3	4.0	0.2	0.7	0.5	0.7	1.09	0.15	0.04		5.2				

Depth cm	Elemental composition of the clay fraction (weight %)											Ign. loss	Molar ratios			
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	P_2O_5			$\frac{\text{SiO}_2}{\text{Al}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{Fe}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{R}_2\text{O}_3}$	$\frac{\text{Al}_2\text{O}_3}{\text{Fe}_2\text{O}_3}$

Clay mineralogy										
Kaol	Mi/Ill	Verm	Chlor	Smec	Mix	Quar	Feld	Gibb	Goeth	Hem

Sand mineralogy	Bulk density (kg/dm^3)	Soil moisture		
		pF 2.0	pF 2.5	pF 4.2
		(weight %)		

Profile AUS 4

Profile description

Horizon / Depth / Description

- A 0-10 cm. Very dark grey (10YR 3/1) moist and dark grey (10YR 4/1) dry, few (dark) grey moist mottles, clay; weak medium plate breaking to moderate coarse to fine angular blocky; very plastic, very sticky; firm moist, hard dry; very few small soft black nodules; gradual smooth boundary.
- Au1 10-29 cm. Dark greyish brown (10YR 4/1.5) moist and greyish brown (10YR 5/1.5) dry, very dark grey in cracks, clay; moderate very coarse angular blocky, breaking to fine angular blocky and crumb; very plastic, very sticky, firm moist, hard dry; very few small soft black nodules; gradual smooth boundary.
- Au2 29-60 cm. Grey (10YR 5/1) moist and light brownish grey (10YR 6/1.5) dry with dark greyish brown moist along cracks and few light grey mottles, clay; strong coarse angular blocky breaking to fine angular blocky; very plastic, very sticky, very firm moist, very hard dry; diffuse smooth boundary.
- Au3 60-120 cm. Grey (10YR 5/1) moist and light brownish grey (10YR 6/1.5) dry with dark yellowish brown moist mottles, clay; moderate very coarse angular blocky breaking to medium angular blocky; very plastic, very sticky, firm moist, very hard dry; diffuse smooth boundary.
- Au4 120-170 cm. Greyish brown (10YR 5/1.5) moist and light grey (10YR 6/1) dry, clay; moderate very coarse parallelepiped breaking to fine; firm moist, very hard dry.

N.B.:

- very few quartz sand and gravel and small black nodules in the whole solum
- deep cracks develop in the dry season

Profile AUS 5

Classification

FAO-Unesco: Chromic Vertisol, fine textured

USDA: Typic Chromoxerert, very fine, mixed, thermic

Local: Grey Clay; Ug 5.4

(Handbook Australian Soils, profile 10 I)

Location and Site

Australia, New South Wales, Riverina

Flat, far-floodplain of a prior stream. Slope less than 1%.

Elevation: 95 m. Drainage: poorly drained.

Parent material/Substratum

Quaternary alluvium.

Vegetation and Land use

Native vegetation shrubland of *Atriplex vesicaria*, *Kochia aphylla*, *Nitraria schoberi*. The sample site is a travelling-stock reserve.

Nearby sheep grazing and irrigated improved pastures.

Profile AUS 5

Profile description

Horizon / Depth / Description

A	0-3 cm. Very dark greyish brown (10YR 3/2) dry, with few light grey mottles, clay; surface skin is platy, then weak coarse angular blocky; hard dry; abrupt smooth boundary.
Au1	3-20 cm. Very dark greyish brown (10YR 3/2) dry, clay; moderate medium angular blocky; very hard dry; gradual smooth boundary.
Au2	20-40 cm. Very dark greyish brown (10YR 3/2) dry, clay; moderate medium angular blocky; very hard dry; slickensides; gradual smooth boundary.
Au3	40-90 cm. Dark greyish brown (10YR 3.5/2) moist, clay; moderate medium angular blocky; extremely firm moist, intersecting slickensides and efflorescence of salt both increasing with depth; gradual smooth boundary.
ACg	90-120 cm. Dark greyish brown (10YR 4/2) moist with common brown (7.5YR 5/4) mottles, clay; moderate medium angular blocky; extremely firm moist; few gypsum crystals; soft red nodules; manganiferous staining on surfaces of cracks, increasing with depth; gradual smooth boundary.
Cg	120-180 cm. Greyish brown (2.5Y 5/2) and brown (7.5YR 5/4) moist, clay; moderate coarse angular blocky; extremely firm moist; some gypsum crystals.

No	Depth cm	Horizon	Particle size distribution (μm in weight %)								pH		CaCO ₃ %	Org. matter			'Free' Fe ₂ O ₃ %
			> 2 mm	Coarse Sand			Fine Sand		Silt	Clay	H ₂ O	CaCl ₂		C %	N %	C/N	
				2000	1000	500	250	100	50	20							
1	0-3	A		11		42		18	29	5.6	4.9		2.5	0.13	20		
2	3-10	Au1		6		24		10	60	6.2	5.6		1.9	0.10	19		
3	10-20	Au1		4		17		9	70	6.7	6.3		1.4	0.08	18		
4	20-30	Au2		4		18		9	69	6.9	6.6		1.1	0.07	16		
5	30-60	Au3		4		19		9	68	7.0	6.7		0.9	0.06	15		
6	60-90	Au3		3		18		11	68	6.9	6.7		0.5	0.03	17		
7	90-120	ACg		2		16		18	64	6.9	6.9		0.3	0.02	15		
8	150-180	Cg		5		23		15	57	7.1	7.0		0.2	0.02	10		

No.	Exchangeable cations			CEC			EC (mS/cm)	Water soluble salts										
	Ca	Mg	K	Na	Sum	Exch. acid.		Soil	Clay	BS %	Ca	Mg	K	Na	CO ₃	HCO ₃	Cl	SO ₄
1	4.5	4.6	0.8	0.8	10.7		10	100										
2	7.5	11	1.0	3.2	22.7		23	99										
3	7.5	11	0.9	5.8	25.2		27	93										
4	7.7	12	0.9	7.6	28.2		28	100										
5	6.4	12	0.8	6.8	26.0		25	100										
6	5.0	11	0.6	4.9	21.5		26	83										
7																		
8																		

No.	Elemental composition of the total soil (weight %)											Ign. loss	Molar ratios			
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	K ₂ O	Na ₂ O	TiO ₂	MnO	P ₂ O ₅			SiO ₂ /Al ₂ O ₃	SiO ₂ /Fe ₂ O ₃	SiO ₂ /R ₂ O ₃	Al ₂ O ₃ /Fe ₂ O ₃
	1	82.7	8.7	2.9	0.3	0.4	1.7	0.7	0.8	0.08	0.09		5.3			
2	69.1	18.4	6.6	0.4	1.2	2.2	0.8	0.9	0.08	0.06	7.0					
3																
4																
5	69.7	17.7	6.2	0.4	1.5	2.2	1.1	0.9	0.08	0.05	6.2					
6																
7																
8																

No.	Elemental composition of the clay fraction (weight %)											Ign. loss	Molar ratios			
	SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	K ₂ O	Na ₂ O	TiO ₂	MnO	P ₂ O ₅			SiO ₂ /Al ₂ O ₃	SiO ₂ /Fe ₂ O ₃	SiO ₂ /R ₂ O ₃	Al ₂ O ₃ /Fe ₂ O ₃
	1															
2																
3																
4																
5																
6																
7																
8																

No.	Clay mineralogy											
	Kaol	Mi/Ill	Verm	Chlor	Smec	Mix	Quar	Feld	Gibb	Goeth	Hem	
1												
2												
3												
4												
5												
6												
7												
8												

No.	Sand mineralogy			Bulk density (kg/dm ³)	Soil moisture		
					pF 2.0	pF 2.5	pF 4.2
1							
2							
3							
4							
5							
6							
7							
8							

Profile AUS 6

Classification

FAO-Unesco: Pellic Vertisol

USDA: Typic Pelludert, fine, montmorillonitic, thermic

Local: Black tarth, Ug 5.16

(Handbook Australian Soils, profile 11 A)

Location and Site

Australia, Queensland, Darling Downs.

Lower midslope of a long pediment slope (2°). Sampled on a shelf of linear gilgai.

Elevation: 396 m. Drainage: very poorly drained.

Parent material/Substratum

Colluvium from a Tertiary basalt cap over Jurassic Walloon sediments (sandstones and shales).

Vegetation and Land use

Native vegetation open grassland with *Mentha saturejoides*, *Plantago varia*, *Swainsona galegifolia* and *Bassia* sp. Used for grazing of beef cattle. Nearby used for winter (chiefly wheat) and summer (mainly sorghum) grain crops.

Profile AUS 6

Profile description

Horizon / Depth / Description

A(p)	0-5 cm. Very dark greyish brown (10YR 2.5/1) moist and very dark grey (10YR 3/1) dry, with common fine grey mottles, clay; thin brittle crust over granular, grading to strong medium angular blocky; firm moist, hard to very hard dry; few grass and herb roots; few faunal channels; gradual smooth boundary.
Au1	5-50 cm. Black (10YR 2/1) moist, clay; strong very coarse angular blocky breaking to fine angular blocky with visible fine aggregation; firm to very firm moist; few black nodules; many grass and herb roots; few faunal channels; gradual smooth boundary.
Au2ck	50-78 cm. Very dark grey (10YR 2.5/1) moist with some dark grey-brown patches in vertical cracks, clay; moderate parallelepiped breaking to coarse angular blocky with visible fine aggregation; firm moist; few small soft carbonate in pockets and few carbonate nodules; few grass roots, few faunal channels; diffuse smooth boundary.
ACck	75-105 cm. Very dark grey (10YR 2.5/1) moist with common medium distinct dark greyish brown (10YR 4/2) moist mottles, increasing to many coarse mottles with depth, clay; moderate parallelepiped breaking to angular blocky with visible fine aggregation; firm moist; few soft carbonate in pockets and few carbonate nodules; few gypsum crystals; few grass roots.

N.B.:

- slickenside occur between 150 and 220 cm depth
- alkaline throughout the solum
- the area has a well-developed gilgai relief
- depths of sampling do not coincide fully with the ISM monolith

No.	Depth cm	Horizon	> 2 mm	Particle size distribution (μm in weight %)								pH		Org. matter			'Free' Fe_2O_3 %	
				Coarse Sand			Fine Sand		Silt		Clay < 2	H_2O	CaCl_2	CaCO_3 %	C %	N %		C/N
				2000	1000	500	250	100	50	20								
1	0-15	Ap	tr		7		32		20	41	6.6	5.4	-	7.2	0.28	26		
2	5-10	Au1	tr		7		29		19	45	6.7	5.3	-	4.9	0.18	27		
3	10-45	Au1	tr		4		23		17	55	7.6	6.4	0.1	4.2	0.13	31		
4	45-83	Au2ck	tr		4		19		17	60	7.7	7.2	0.9	2.9	0.07	41		
5	83-105	ACck	tr		5		20		16	59	7.7	7.3	4.1	1.5	0.03	50		
6	105-150		2		3		22		16	59	7.8	7.3	4.8					
7	150-175		14		4		19		16	61	7.8	7.3	5.7					
8																		

No.	Exchangeable cations								CEC Soil Clay	BS %	EC (mS/cm)	Water soluble salts					
	Ca	Mg	K	Na	Sum	Exch. acid.	Na	Mg				K	Na	CO_3	HCO_3	Cl	SO_4
	meq/100 g						meq/100 g										
1	25	11	1.7	1.1	38.8		41		95								
2	23	9.9	0.9	1.4	35.2		36		98								
3		15	0.5	5.4			48		100								
4		20	0.5	11			51		100								
5		17	0.5	9.2			39		100								
6		17	0.5	9.6			38		100								
7		16	0.4	10			38		100								
8																	

No.	Elemental composition of the total soil (weight %)										Ign. loss	Molar ratios			
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	P_2O_5		$\frac{\text{SiO}_2}{\text{Al}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{Fe}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{P}_2\text{O}_5}$	$\frac{\text{Al}_2\text{O}_3}{\text{Fe}_2\text{O}_3}$
	1														
2															
3	76.5	12.0	5.7	1.1	1.1	0.7	0.5	1.8	0.17	0.07	9.3				
4															
5															
6	69.7	12.9	5.7	5.5	1.6	0.7	0.8	1.8	0.13	0.08	7.2				
7															
8															

No.	Elemental composition of the clay fraction (weight %)										Ign. loss	Molar ratios			
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	P_2O_5		$\frac{\text{SiO}_2}{\text{Al}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{Fe}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{P}_2\text{O}_5}$	$\frac{\text{Al}_2\text{O}_3}{\text{Fe}_2\text{O}_3}$
	1														
2															
3															
4															
5															
6															
7															
8															

No.	Clay mineralogy										
	Kaol	Mi/Ill	Verm	Chlor	Smec	Mix	Quar	Feld	Gibb	Goeth	Hem
1											
2											
3											
4											
5											
6											
7											
8											

No.	Sand mineralogy	Bulk density (kg/dm^3)	Soil moisture		
			pF 2.0	pF 2.5	pF 4.2
1					
2					
3					
4					
5					
6					
7					
8					

Profile RB 2

Profile description

Horizon / Depth / Description

Ah	0-3 cm. Very dark grey (10YR 3/1) moist, clay; strong fine granular, overlain by a very thin brittle crust; sticky, plastic, friable moist, slightly hard dry; common fine and medium roots; abrupt wavy boundary.
Au1	3-33 cm. Very dark grey (10YR 3/1) moist and dry, clay; moderate coarse prismatic breaking into moderate medium angular blocky; sticky, plastic, firm moist, very hard dry; common fine and medium roots; very few fine pores; few wedge-shaped elements in the lower part of the horizon; cracks are 1 cm wide at 33 cm and occupy 10% of the volume; gradual smooth boundary.
Au2	33-67 cm. Very dark grey (10YR 3/1) moist and dry, clay; common very weak fine wedge-shaped structural elements and few slickensides; sticky, plastic, firm moist, very hard dry; few fine and very fine roots; few small hard carbonate nodules; cracks are 5 mm wide; gradual smooth boundary.
Au3	67-96 cm. Black (10YR 2/1) moist and dry, clay loam; weak coarse prismatic to massive; sticky, plastic, firm moist, hard dry; few very fine roots; common pressure faces and few intersecting slickensides; very few small and medium hard carbonate nodules; cracks are 5 mm wide; gradual smooth boundary.
AC	96-142 cm. Very dark grey (10YR 3/1) moist and dry, silty clay loam; massive; sticky, plastic, firm moist, hard dry; very few fine roots; common pressure faces and few intersecting slickensides; coarse fragments of calcium carbonate in lower part of the horizon; gradual smooth boundary.
2C	142-190 cm. Red (2.5YR 4/6) and very dark grey (2.5YR 3/0) moist, weathered calcrete of very gravelly coarse sandy loam texture; common coarse and very coarse subangular fragments of calcrete of pinkish white colour (7.5YR 8/2) moist; the red material is non to slightly calcareous; very hard calcrete at 190 cm.

N.B.:

- the whole profile shows an admixture with sand grains and gravel up to 1 cm, of quartz and carbonate nature
- cracks reach to a great depth in the dry season
- the profile is formed in a region with melon-hole gilgai

Profile RB 2

Classification

FAO-Unesco: Pellic Vertisol, fine textured
USDA: Typic Pellustert, fine, montmorillonitic/mixed, hyperthermic
Local: Manale series

Location and Site

Botswana, 6 km SE of Shoshong
Upper part of gentle slope with gilgai relief. Slope: 5%
Elevation: 1131 m. Drainage: poorly drained.

Parent material/Substratum

Dolerite

Vegetation and Land use

Acacia mixed woodland with *A. grandicornuta*, *A. karroo*, *A. tenuispina* and
Dichrostachys ceneria. Good grass cover.
Occasional grazing.

Particle size distribution (μm in weight %)

Depth cm	Horizon	> 2 mm	Sand						Silt		Clay	pH		Org. matter			'Free' Fe ₂ O ₃ %
			2000	1000	500	250	100	50	50	20	H ₂ O	KCl	CaCO ₃	C	N	C/N	
			1000	500	250	100	50	20	2	< 2	%	%	%	%	%	%	
0-3	Ah	2	9	3	7	7	9	13	52	8.2	6.5	0.91	0.83	0.12	7		
3-33	Au1	1	8	3	5	5	13	27	39	8.7	6.7	0.45	0.78	0.10	8		
33-67	Au2	1	10	3	5	6	7	13	56	8.8	6.8	0.64	0.44				
67-96	Au3	1	7	3	5	5	16	31	33	8.6	6.8	0.82	0.74				
96-142	AC	1	5	2	4	5	18	36	30	8.5	6.7	0.62	0.65				
142-190	2C	69	42	12	6	4	5	12	19	8.6	7.0	1.13	0.07				

Exchangeable cations			CEC						EC (mS/cm)	Water soluble salts						
Ca	Mg	K	Na	Sum	Exch. acid.	Soil	Clay	BS %		Ca	Mg	K	Na	CO ₃	HCO ₃	Cl
			meq/100 g						meq/100 g							
10.6	2.0	0.2				52.3		100								
11.5	1.0	1.5				60.6		100								
11.5	1.0	3.7				58.2		100								
11.9	0.8	5.4				60.8		100								
13.3	1.0	5.6				77.6		100								
9.3	0.6	4.4				45.4		100								

Elemental composition of the total soil (weight %)											Molar ratios			
SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	K ₂ O	Na ₂ O	TiO ₂	MnO	P ₂ O ₅	Ign. loss	SiO ₂ /Al ₂ O ₃	SiO ₂ /Fe ₂ O ₃	SiO ₂ /R ₂ O ₃	Al ₂ O ₃ /Fe ₂ O ₃
85.8	8.6	2.0	0.24	0.51	3.43	1.64	0.47	0.07	13.1	17.0	112.2	14.79	6.6	
79.5	11.6	3.0	0.19	0.57	4.89	0.00	0.40	0.08	15.2	11.6	69.6	9.96	6.0	
78.0	12.0	3.8	0.28	1.07	4.12	1.46	0.58	0.12	15.1	11.0	55.0	9.18	5.0	
78.5	13.3	3.9	0.74	0.53	3.68	0.38	0.75	0.05	15.3	10.0	54.0	8.44	5.4	
83.7	9.6	2.8	0.29	0.15	3.66	2.28	0.47	0.04	15.9	14.9	80.5	12.58	5.4	
78.6	14.4	4.6	0.35	0.86	3.11	0.33	0.59	0.06	14.2	9.3	45.6	7.74	4.9	

Elemental composition of the clay fraction (weight %)											Molar ratios			
SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	K ₂ O	Na ₂ O	TiO ₂	MnO	P ₂ O ₅	Ign. loss	SiO ₂ /Al ₂ O ₃	SiO ₂ /Fe ₂ O ₃	SiO ₂ /R ₂ O ₃	Al ₂ O ₃ /Fe ₂ O ₃
56.4	23.4	12.2	2.96	2.75	1.01	0.00	0.80	0.48		4.1	12.3	3.07	3.0	
57.1	22.6	12.6	2.60	2.13	1.36	0.00	0.88	0.81		4.3	12.0	3.17	2.8	
57.9	21.4	12.2	2.43	4.11	1.00	0.00	0.68	0.36		4.6	12.9	3.37	2.8	

Clay mineralogy											
Kaol	Mi/III	Verm	Chlor	Smec	Mix	Quar	Feld	Gibb	Goeth	Hem	
+	+			++		XX					
+	+			++		XX					
+	+			++		XX					
+	+			++		XX					
+	+			++		X					
+	+			++		X					

Sand mineralogy	Bulk density (kg/dm ³)	Soil moisture		
		pF 2.0	pF 2.5	pF 4.2
		(weight %)		

Profile GR 1

Classification

FAO-Unesco: Pellic Vertisol, fine textured
USDA: Typic Pelloxerert, very fine, montmorillonitic, mesic
Local: Grumusol

Location and Site

Greece, Prov. of Thrace, approx. 45 km NW of Orestiás.
Lacustrine (?) plain, flat to nearly flat. Slope 0.5%.
Elevation: 60 m. Drainage: poorly drained.

Parent material/Substratum

Probably Tertiary calcareous lacustrine (?) deposits.

Vegetation and Land use

Arable land, cereals.

Profile GR 1

Profile description

Horizon / Depth / Description

Ap	0-25 cm. Black (10YR 2/1) moist, dark grey (10YR 4/1) dry, clay; moderate coarse prismatic, breaking to strong fine angular blocky, in the upper 10 cm pockets with medium crumb; sticky, very plastic, very firm moist, very hard dry; common very fine and fine roots; common very fine pores; non calcareous; diffuse, smooth boundary.
Au1	25-83 cm. Black (10YR 2/1) moist, dark grey (10YR 4/1) dry, clay; moderate coarse prismatic, breaking to strong medium angular blocky; sticky, very plastic, very firm moist, very hard dry; few very fine and roots; common very fine pores; non calcareous; diffuse, smooth boundary.
Au2	83-113 cm. Very dark grey (10YR 3/1) moist, very dark grey (10YR 3/1) dry, clay; weak coarse prismatic, breaking to strong medium angular blocky; sticky, very plastic, very firm moist, very hard dry; few very fine and fine roots; common very fine pores; non calcareous; diffuse, wavy boundary.
C	133-147 cm. Dark brown (10YR 3/3) moist; grey (10YR 5/1) dry, clay; massive; sticky, plastic, firm moist, very hard dry; few very fine and fine roots; common very fine and fine pores; non calcareous to slightly calcareous; diffuse, wavy boundary.
2C	147-190 cm. Dark greyish brown (10YR 4/2) moist, greyish brown (10YR 5/2) dry, silt loam; massive; sticky, plastic, firm moist, hard dry; very few very fine and fine roots; few very fine and fine pores; strongly calcareous.

N.B.:

- Pronounced slickensides occur throughout the solum, intersecting in the AC horizon
- In the C horizon horizontal and vertical root channels filled with material from the overlying horizons
- Cracks of 2 cm wide occur to a depth of 83 cm

No.	Depth (cm)	Horizon	> 2 mm	Particle size distribution (μm in weight %)									pH		Org. matter			'Free' Fe_2O_3 %
				Sand			Silt			Clay < 2	H_2O	KCl	CaCO_3 %	C %	N %	C/N		
				2000	1000	500	250	100	50								20	
1	0-25	Ap	tr	tr	tr	1	3	4	10	19	63	7.6	6.8	0.2	1.3	0.10	13	
2	25-82	Au1	tr	tr	tr	1	3	4	10	19	63	8.3	7.0	0.5	1.0	0.07	15	
3	82-113	Au2	tr	tr	tr	1	3	4	9	20	63	8.3	7.1	3.2	0.8	0.05	16	
4	113-147	C	1	tr	tr	1	5	7	13	25	49	8.2	7.2	3.3	0.4	0.04	10	
5	147-160	2C	1	tr	tr	1	5	7	14	28	45	8.0	7.2	3.5	0.3	0.03	10	
6																		
7																		
8																		

No.	Exchangeable cations					CEC			EC 2.5 (mS/cm)	Water soluble salts							
	Ca	Mg	K	Na	Sum	Soil	Clay	BS %		Ca	Mg	K	Na	CO_3	HCO_3	Cl	SO_4
	meq/100 g					Exch. acid.				meq/100 g							
1		8.6	0.9	1.1			52.6	100	0.42								
2		11.9	0.7	2.4			55.2	100	0.46								
3		11.8	0.5	4.9			49.0	100	0.66								
4		8.3	0.5	5.4			37.8	100	1.39								
5		7.3	0.6	5.9			34.7	100	1.50								
6																	
7																	
8																	

No.	Elemental composition of the total soil (weight %)										Ign. loss	Molar ratios			
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	P_2O_5		$\frac{\text{SiO}_2}{\text{Al}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{Fe}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{R}_2\text{O}_3}$	$\frac{\text{Al}_2\text{O}_3}{\text{Fe}_2\text{O}_3}$
	1	61.5	17.4	5.7	2.1	1.9	2.0		0.8	0.1		tr	8.2	6.0	28.9
2	59.1	16.9	5.7	3.9	2.1	2.1		0.8	0.1	tr	9.1	5.9	27.7	4.9	4.7
3	58.3	16.8	5.8	4.2	2.4	2.5		0.7	0.1	0.1	7.8	5.9	26.5	4.8	4.5
4	58.6	17.3	6.1	3.6	2.4	2.8		0.7	0.1	0.1	7.0	5.8	25.3	4.7	4.4
5															
6															
7															
8															

No.	Elemental composition of the clay fraction (weight %)										Ign. loss	Molar ratios			
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	P_2O_5		$\frac{\text{SiO}_2}{\text{Al}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{Fe}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{R}_2\text{O}_3}$	$\frac{\text{Al}_2\text{O}_3}{\text{Fe}_2\text{O}_3}$
	1	54.7	23.2	8.6	0.5	2.4	2.0		0.7	0.1		0.1	8.2	4.0	16.9
2	54.8	23.2	8.6	0.5	2.5	1.9		0.7	0.1	0.1	8.0	4.0	17.0	3.2	4.2
3	57.1	22.1	8.1	0.4	2.5	2.0		0.8	0.1	0.1	7.5	4.4	18.7	3.6	4.3
4	54.1	21.7	9.2	0.1	2.9	0.8		0.2	2.2	0.5	7.6	4.2	15.6	3.3	3.7
5	55.0	21.0	9.0	0.1	3.0	0.8		0.1	2.5	0.5	7.0	4.4	16.2	3.5	3.7
6															
7															
8															

No.	Clay mineralogy											
	Kaol	Mi/Ill	Verm	Chlor	Smec	Mix	Quar	Feld	Gibb	Goeth	Hem	Pyroph.
1	+	0/+	-		+++		x	tr				tr
2	+	0/+	-		+++		x	tr				tr
3	+	0/+	tr		+++		x	tr				tr
4	+	0/+	tr		+++		x	tr				tr
5	+	0/+	tr		+++		x	tr				tr
6												
7												
8												

No.	Sand mineralogy			Bulk density (kg/dm ³)	Soil moisture		
					pF 2.0	pF 2.5	pF 4.2
1							
2							
3							
4							
5							
6							
7							
8							

Profile GR 6

Classification

FAO-Unesco: Chromic Vertisol, fine textured
USDA: Entic Chromoxerert, fine, montmorillonitic, mesic
Local: Grumusol

Location and Site

Greece, Prefecture of Larissa, 1.5 km S of Larissa.
Old lake basin floor (?) in nearly level plain in flat landscape.
Slope 1%. Altitude: 75 m. Drainage: somewhat poorly drained.

Parent material/Substratum

Unconsolidated calcareous deposits of Pleistocene age.

Vegetation and Land use

Arable land, small grain.

Profile GR 6

Profile description

Horizon / Depth / Description

Ap	0-21 cm. Dark brown (10YR 3.5/3) moist, clay; moderate fine sub-angular; very sticky, very plastic, firm moist, very hard dry; many very fine and fine roots; common very fine pores; non calcareous; clear smooth boundary.
A	21-52 cm. Dark brown (10YR 4/3) moist, clay; weak fine angular blocky; very sticky, very plastic, firm moist, very hard dry; many very fine and fine roots; common very fine pores; non calcareous; clear wavy boundary.
AcK	52-65 cm. Dark brown (7.5YR 4/4) moist, clay; weak fine angular blocky; very sticky, very plastic, firm moist, very hard dry; many very fine and fine roots; common very fine pores; few large and small, soft, spherical and irregular, white carbonate nodules; common slickensides; calcareous, gradual wavy boundary.
ACck1	65-104 cm. Strong brown (7.5YR 5/6) moist, silty clay; weak fine angular blocky; sticky, plastic, friable moist; common very fine roots; many very fine pores; frequent small and large, soft, spherical and irregular, white, carbonate nodules; very few slickensides; strongly calcareous; clear wavy boundary.
ACck2	104-135 cm. Strong brown (7.5YR 5/6) moist, silty clay loam; massive; sticky, plastic, friable moist; no roots; many very fine pores; few large, soft, irregular, white carbonate nodules; strongly calcareous; clear smooth boundary.
Cck	135-150 cm. Strong brown (7.5YR 5/6) moist, clay; massive; very sticky, very plastic; no roots; many very fine pores; frequent small and large, soft, spherical and irregular, white, carbonate nodules, strongly calcareous.

No	Depth cm	Horizon	Particle size distribution (μm in weight %)										pH		Org. matter			'Free' Fe_2O_3 %
			>2 mm	Sand				Silt		Clay <2	H_2O	KCl	CaCO_3 %	C %	N %	C/N		
				2000	1000	500	250	100	50								50	
1	0-21	Ap	0	tr	tr	1	3	16	33	46	7.6	6.5	0	0.95	0.08	12	1.00	
2	21-52	A	tr	tr	tr	1	3	14	21	60	7.9	7.0	0.3	0.76	0.07	11	1.08	
3	52-73	Ack	tr	tr	tr	1	2	15	28	53	8.3	7.6	11.6	0.43	0.04	11	0.88	
4	73-104	ACck1	tr	tr	tr	1	2	13	33	50	8.5	7.6	19.8	0.22	0.03	7	0.66	
5	104-135	ACck2	1	1	1	2	3	15	32	45	8.6	7.8	20.6	0.19	0.02	9	0.69	
6	135-150	Cck	1	2	2	2	2	11	21	59	8.7	7.7	21.4	0.09	0.02	5	0.74	
7																		
8																		

No	Exchangeable cations			CEC					EC 5 (mS/cm)	Water soluble salts								
	Ca	Mg	K	Na	Sum	Exch. acid.	Soil	Clay		BS %	Ca	Mg	K	Na	CO_3	HCO_3	Cl	SO_4
				meq/100 g						meq/100 g								
1		11.7	1.5	0.5			42.2		100	0.08								
2		11.4	1.1	0.4			41.7		100	0.16								
3		10.5	0.9	0.3			38.1		100	0.16								
4		12.4	0.7	0.3			33.2		100	0.18								
5		16.0	0.8	0.5			33.5		100	0.26								
6		19.3	0.8	0.6			32.9		100	0.27								
7																		
8																		

No	Elemental composition of the total soil (weight %)											Ign. loss	Molar ratios					
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	P_2O_5			$\frac{\text{SiO}_2}{\text{Al}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{Fe}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{R}_2\text{O}_3}$	$\frac{\text{Al}_2\text{O}_3}{\text{Fe}_2\text{O}_3}$		
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		

No	Elemental composition of the clay fraction (weight %)											Ign. loss	Molar ratios					
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	P_2O_5			$\frac{\text{SiO}_2}{\text{Al}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{Fe}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{R}_2\text{O}_3}$	$\frac{\text{Al}_2\text{O}_3}{\text{Fe}_2\text{O}_3}$		
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		

No	Clay mineralogy										
	Kaol	Mi/Ill	Verm	Chlor	Smec	Mix	Quar	Feld	Gibb	Goeth	Hem
1											
2											
3											
4											
5											
6											
7											
8											

No	Sand mineralogy	Bulk density (kg/dm ³)	Soil moisture		
			pF 2.0	pF 2.5	pF 4.2
			(weight %)		
1					
2					
3					
4					
5					
6					
7					
8					

Profile IND 8

Profile description

Horizon / Depth / Description

Au1	0-17/25 cm. Very dark grey (10YR 3.5/1) dry, clay loam; weak coarse prismatic breaking to weak medium subangular blocky; sticky, plastic, firm moist, dry hard; small irregular calcium carbonate nodules; many fine roots; slightly calcareous; clear irregular boundary.
Au2	17/25-40/44 cm. Very dark greyish brown (10YR 3/2) moist, clay loam to clay; weak coarse prismatic breaking into weak medium subangular blocky; sticky, plastic, firm moist, hard dry; broken cutans along ped faces, probably pressure faces; small irregular calcium carbonate nodules; common fine and very fine roots; slightly calcareous; clear wavy boundary.
Au3	40/44-65 cm. Very dark greyish brown (10YR 3/2) moist, many coarse greyish brown (10YR 5/2) mottles, clay; weak coarse prismatic breaking into moderate coarse subangular blocky; sticky, plastic, firm moist, hard dry; prominent intersecting slickensides; calcium carbonate nodules absent; few very fine roots; clear smooth boundary.
AC	65-110 cm. Very dark greyish brown (10YR 3/2) moist, many pale brown (10YR 6/3) mottles, increasing with depth, clay; strong very coarse subangular blocky; very sticky, very plastic, firm moist, hard dry; some pressure faces; calcium carbonate nodules absent; very few very fine roots.

N.B.:

- Cracks of 1-2 cm wide appear up to a depth of 65 cm in the dry season
- Few concretions of manganese and iron oxides appear in the profile below 17 cm depth

Profile IND 8

Classification

FAO-Unesco: Chromic Vertisol, fine textured

USDA: Typic Chromustert, fine, montmorillonitic, hyperthermic

Local: Deep Black Clay

Location and Site

India, Maharashtra State, Nagpur District, Mundha village.

Mid slope. Slope 1-3%.

Elevation: 200 m. Drainage: moderately well drained.

Parent material/Substratum

Calcareous material on basalt (?)

Vegetation and Land use

Originally *Acacia arabica* and *Butea frondosa*; now fallow.

Particle size distribution (μm in weight %)

Depth cm	Horizon	>2 mm	Particle size distribution (μm in weight %)							Clay <2	pH		CaCO ₃ %	Org matter			'Free' Fe ₂ O ₃ %
			Sand			Silt			H ₂ O		KCl	C		N	C/N		
			2000	1000	500	250	100	50	20					%	%	%	
0-17	Au1		tr	tr	1	1	1	13	48	36	7.8	6.4	4.3	0.37	0.04	9	1.64
17-44	Au2		tr	tr	1	1	1	8	47	42	7.9	6.5	3.7	0.24	0.03	8	1.72
44-71	Au3		2	3	1	1	1	11	42	39	8.0	6.7	21.3	0.17	0.02	8	1.48
71-120	AC		4	5	1	12	1	8	38	31	8.1	6.8	27.8	0.17	0.02	8	1.34

Exchangeable cations			CEC					EC 2.5 (mS/cm)	Water soluble salts								
Ca	Mg	K	Na	Sum	Exch. acid.	Soil	Clay		BS	Ca	Mg	K	Na	CO ₃	HCO ₃	Cl	SO ₄
			meq/100 g					%	meq/100 g								
8.4	0.7		0.3			57.4		100									
11.9	0.5		0.3			57.4		100									
15.0	0.4		0.3			53.9		100									
18.6	0.4		0.3			52.2		100									

Elemental composition of the total soil (weight %)											Ign. loss	Molar ratios			
SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	K ₂ O	Na ₂ O	TiO ₂	MnO	P ₂ O ₅			SiO ₂ Al ₂ O ₃	SiO ₂ Fe ₂ O ₃	SiO ₂ R ₂ O ₈	Al ₂ O ₃ Fe ₂ O ₃

Elemental composition of the clay fraction (weight %)											Ign. loss	Molar ratios			
SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	K ₂ O	Na ₂ O	TiO ₂	MnO	P ₂ O ₅			SiO ₂ Al ₂ O ₃	SiO ₂ Fe ₂ O ₃	SiO ₂ R ₂ O ₃	Al ₂ O ₃ Fe ₂ O ₃

Clay mineralogy										
Kaol	Mi/III	Verm	Chlor	Smec	Mix	Quar	Feld	Gibb	Goeth	Hem

Sand mineralogy	Bulk density (kg/dm ³)	Soil moisture		
		pF	pF	pF
		2.0	2.5	4.2
		(weight %)		

Profile IND 10

Classification

FAO-Unesco: Pellic Vertisol, fine textured
USDA: Typic Pellustert, fine, montmorillonitic, hyperthermic
Local: Saongi series, Medium Black Soil

Location and Site

India, Maharashtra State, Nagpur District, Saongi village.
Midslope. Slope 1-3%.
Elevation: 300 m. Drainage: moderately well drained.

Parent material/Substratum

Basalt of the Deccan trap.

Vegetation and Land use

Originally miscellaneous bushes and grasses. Present land use: Dolichos, cotton and paddy.

Profile IND 10

Profile description

Horizon / Depth / Description

Ap	0-15 cm. Very dark greyish brown (10YR 3/2), dry, clay; strong coarse subangular blocky; sticky, plastic, firm moist, very hard dry; few irregular calcium carbonate nodules; common roots; cracks up to 1 cm wide; calcareous; gradual smooth boundary.
Au1	15-35 cm. Very dark grey (10YR 3/1) moist, clay; moderate coarse prismatic breaking into coarse subangular blocky; sticky, plastic, firm moist, hard dry; few irregular calcium carbonate nodules; common roots; cracks up to 2-4 mm wide; calcareous; gradual smooth boundary.
Au2	35-58 cm. Very dark grey (10YR 3/1) moist, clay; weak medium prismatic breaking into moderate medium angular blocky; sticky, plastic, firm moist, hard dry; few irregular calcium carbonate nodules, common roots; common intersecting slickensides, cracks 2-3 mm wide; calcareous; clear smooth boundary.
ACck	58-72 cm. Very dark greyish brown (10YR 3/2) and light brownish grey (10YR 6/2) moist, loam; moderate medium angular blocky; slightly sticky, slightly plastic, friable moist, slightly hard dry; common irregular calcium carbonate nodules of 2-20 mm and soft carbonate; strongly calcareous; clear smooth boundary.
CA	72-115 cm. Pale brown (10YR 6/3) moist, weathered basaltic (?) material; strongly calcareous.

Profile I 13

Classification

FAO-Unesco: Chromic Vertisol, fine textured
USDA: Aquic Chromoxerert, very fine, mixed, mesic
Local: Vertisuolo

Location and Site

Italy, Frosinone Province, 1.5 km S of Falvaterra.
Concave slope in karst basin.
Slope: 10%. Elevation: approx. 300 m. Drainage: imperfectly drained.

Parent material/Substratum

Pleistocene colluvial deposits, covered with Holocene colluvial deposits,
both derived from limestone with some admixture of volcanic material in
the recent colluvial deposits.

Vegetation and Land use

At present grasses for cattle; formerly used for wheat.

Profile I 13

Horizon / Depth / Description

- Ap1 0-5 cm. Dark reddish brown (5YR 3/3) moist, clay; weak coarse sub-angular blocky, falling apart into moderate fine and medium sub-angular blocky; sticky, plastic, firm moist; many very fine to coarse discontinuous and continuous random inped and exped tubular pores; few small soft spherical black iron-manganese nodules; few pottery fragments; common animal burrows (worms, ants, etc.) and chambers; many medium and common fine roots; clear, smooth boundary.
- Ap2 5-20 cm. Dark reddish brown (5YR 3/3) moist, clay; weak coarse sub-angular blocky, falling apart into moderate fine subangular blocky; sticky, plastic, friable to firm moist; few pressure cutans along animal channels and patchy thin clay-iron cutans on pedfaces and root channels; many very fine to coarse discontinuous and continuous random inped and exped tubular pores; few small soft spherical black iron-manganese nodules; few pottery and charcoal fragments; common animal burrows (milliped, worms, ants, etc.), birth chambers, storage chambers, etc.; many fine and common medium roots; clear, smooth boundary.
- Bt1 20-38 cm. Dark reddish brown (5YR 3/4) moist, clay; weak fine and medium prismatic, falling apart into moderate fine and medium sub-angular blocky; sticky, plastic, friable moist; broken thin to moderately thick clay-iron cutans on pedfaces and along pores; many fine discontinuous random inped tubular pores and common very coarse discontinuous horizontal tubular and vesicular (bio-)pores; few small soft spherical black iron-manganese nodules; few pottery fragments and charcoal; many animal burrows and insect nests of millipodes, ants, etc.; many fine and few medium roots; clear, smooth boundary.
- Bt2 38-50 cm. Dark reddish brown (5YR 3/4) moist, clay; few medium and coarse prominent clear dark brown (7.5YR 4/4) and dusky red (10R 3/4) mottles; weak medium prismatic, falling apart into moderate fine and medium subangular blocky; sticky, plastic, friable moist; broken moderately thick iron-clay cutans on pedfaces and in pores; many very fine and fine discontinuous random inped tubular pores and few coarse discontinuous horizontal exped tubular and vesicular (bio-)pores; few small soft spherical black iron-manganese nodules; few pottery and charcoal fragments; few animal burrows; birth- and storage chambers of millipodes, ants and other insects; common fine and few medium roots; abrupt, wavy boundary.
- 2Bg1 50-67 cm. Reddish brown (5YR 4/4) moist, clay; common coarse prominent clear light gray (5Y 7/2) and reddish yellow (7.5YR 6/6) and common medium to coarse faint diffuse weak red (10R 4/4) mottles; strong medium to coarse prismatic; sticky, plastic, firm to very firm moist; patchy moderately thick clay-iron-humus cutans on some vertical pedfaces and in pores, patchy moderately thick clay-cutans on some pedfaces, patchy thin iron-manganese cutans and common medium intersecting slickensides; common very fine and fine discontinuous random inped tubular pores and few coarse to very coarse discontinuous horizontal exped tubular and vesicular (bio-) pores; few fine and very few medium roots; gradual, smooth boundary.

No	Depth cm	Horizon	Particle size distribution (μm in weight %)										pH		Org. matter			'Free' Fe_2O_3 %
			> 2 mm	Sand				Silt		Clay < 2	H_2O	KCl	CaCO_3 %	C %	N %	C/N		
				2000 1000	1000 500	500 250	250 100	100 50	50 20								20 2	
1	0- 5	Ap1	tr	tr	1	2	2	8	18	69	6.3	5.1				2.60		
2	20- 38	Bt1	tr	tr	1	2	1	8	20	68	6.5	5.1				0.87		
3	38- 50	Bt2	tr	tr	1	2	1	9	17	70	6.5	5.0				0.84		
4	67- 90	2Bg2	0	0	0	tr	tr	3	3	94	6.2	4.8				0.26		
5	140-165	2Bg4	0	0	0	0	0	1	2	97	4.9	3.6				0.12		
6																		
7																		
8																		

No.	Exchangeable cations			CEC					EC 2.5 (mS/cm)	Water soluble salts							
	Ca	Mg	K	Na	Sum	Exch. acid.	Soil	Clay		BS %	Ca	Mg	K	Na	CO_3 meq/100 g	HCO_3	Cl
1	7.5	1.4	1.4	0.0	10.3			34.7	30	0.16							
2	6.6	1.1	0.5	0.0	8.2			29.0	28	0.09							
3	6.8	1.1	0.4	0.1	8.4			31.0	27	0.07							
4	10.2	2.3	0.6	0.5	13.6			39.0	35	0.06							
5	6.4	1.8	0.4	0.3	8.9			36.8	24	0.05							
6																	
7																	
8																	

No.	Elemental composition of the total soil (weight %)											Ign. loss	Molar ratios			
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	P_2O_5			$\frac{\text{SiO}_2}{\text{Al}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{Fe}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{R}_2\text{O}_3}$	$\frac{\text{Al}_2\text{O}_3}{\text{Fe}_2\text{O}_3}$
	1															
2																
3																
4																
5																
6																
7																
8																

No.	Elemental composition of the clay fraction (weight %)											Ign. loss	Molar ratios			
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	P_2O_5			$\frac{\text{SiO}_2}{\text{Al}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{Fe}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{R}_2\text{O}_3}$	$\frac{\text{Al}_2\text{O}_3}{\text{Fe}_2\text{O}_3}$
	1															
2																
3																
4																
5																
6																
7																
8																

No	Clay mineralogy										
	Kaol	Mi/Ill	Verm	Chlor	Smec	Mix	Quar	Feld	Gibb	Goeth	Hem
1											
2											
3											
4											
5											
6											
7											
8											

No	Sand mineralogy			Bulk density (kg/dm^3)	Soil moisture		
					pF 2.0	pF 2.5	pF 4.2
1							
2							
3							
4							
5							
6							
7							
8							

- 2Bg2 67-113 cm. Reddish brown (5YR 4/4) clay; many coarse prominent sharp light gray (5YR 7/2) and yellow (10YR 7/6) and common medium distinct diffuse weak red (10R 4/4) mottles; strong coarse to very coarse (sub)angular blocky, peds locally wedge-shaped; sticky and plastic when wet, firm to very firm when moist; patchy moderately thick clay-iron cutans on some pedfaces and in pores and many large intersecting slickensides; few very fine and fine discontinuous random inped tubular pores; few fine roots; gradual, smooth boundary.
- 2Bg3 113-140 cm. Reddish brown (5YR 4/4) moist, clay; many medium distinct clear grayish brown (2.5Y 5/2) and brownish yellow (10YR 6/6) mottles; strong coarse angular blocky, wedge-shaped; sticky, plastic, firm to very firm moist; patchy moderately thick clay-iron cutans in pores, patchy thin iron-manganese cutans on some pedfaces and many medium intersecting slickensides; few very fine and fine discontinuous random inped tubular pores; few very fine and fine roots; abrupt, smooth boundary.
- 2Bg4 140-165 cm. Dark reddish brown (2.5YR 3/4) clay; common coarse prominent diffuse light gray (5Y 7/2) and few fine distinct clear reddish yellow (7.5YR 6/6) mottles; strong fine to medium angular blocky, peds locally wedge-shaped; sticky, plastic, firm moist; many small intersecting slickensides; few fine discontinuous random inped tubular pores; few very fine roots; clear, wavy boundary.
- 3B(t) 165-200+ cm. Dark reddish brown (5YR 3/3) moist, clay; few medium prominent sharp red (2.5YR 5/8) mottles inside the peds; moderate fine to medium angular blocky; sticky, plastic, firm moist; patchy thin clay-iron cutans mainly on vertical pedfaces, broken to continuous thin iron-manganese cutans on all pedfaces and few small intersecting slickensides; very few fine discontinuous random inped tubular pores; very few medium roots.

B.B.:

- some gilgai microrelief
- description according to Dr. O.C. Spaargaren, collector of the monolith

Profile SWA 9

Classification

FAO-Unesco: Pellic Vertisol, fine textured

USDA: Typic Pellustert, fine, mixed, hyperthermic

Local: -----

Location and Site

Namibia, 30 km E of Tsumeb. Farm Smithfield, lot 541.

Bottom of flat closed basin, surrounded by undulating landscape.

Slope nil. Elevation: approx. 1300 m. Drainage: imperfectly drained.

Parent material/Substratum

Basin clay.

Vegetation and Land use

Fallow, after cereals.

Profile SWA 9

Profile description

Horizon / Depth / Description

Ap 0-20 cm. Dark grey (2.5Y 4/1) moist, grey (2.5Y 4.5/1) dry, clay; strong very fine and fine granular, in the lower part weak coarse subangular blocky; very sticky, very plastic, friable moist; hard dry; few small soft irregular white calcium carbonate nodules; few fine roots; calcareous throughout; abrupt, wavy boundary.

Au1 20-40 cm. Very dark grey (2.5Y 3.5/1) moist, grey (2.5Y 4.5/1) dry, clay; weak coarse prismatic breaking to weak medium subangular blocky; very sticky, very plastic, friable moist, hard dry; few very fine discontinuous random inped pores; few small, soft irregular white calcium carbonate nodules; very few fine roots; strongly calcareous; gradual smooth boundary.

Au2 40-80 cm. Very dark grey (2.5Y 3.5/1) moist, grey (2.5Y 4.5/1) dry, clay; moderate coarse prismatic, breaking to medium angular blocky; very sticky, very plastic, firm moist, very hard dry; few very fine discontinuous random inped pores; few oblique slickensides, number increasing with depth; few small soft irregular white calcium carbonate nodules; very few fine roots; strongly calcareous; gradual smooth boundary.

Au3 80-120 cm. Very dark grey (2.5Y 3.5/1) moist, grey (2.5Y 4.5/1) dry, clay; weak coarse prismatic breaking to strong medium to fine angular blocky; very sticky, very plastic, firm moist, very hard dry; few inped very fine discontinuous random pores; very prominent and abundant slickensides resulting in wedge-shaped elements; few soft small irregular white calcium carbonate nodules; strongly calcareous.

N.B.:

- Wide cracks extend to depths below 50 cm and have a spacing of 30-50 cm

Depth cm	Horizon	> 2 mm	Particle size distribution (μm in weight %)								pH		Org. matter			'Free' Fe_2O_3 %		
			Sand				Silt		Clay < 2	H_2O	KCl	CaCO_3 %	%					
			2000 1000	1000 500	500 250	250 100	100 50	50 20					C	N	C/N			
1	0-20	Ap	5	2	1	2	31	10	2	22	30	8.3	7.0	8.1	1.02	0.05	20	0.43
2	20-40	Au1	7	2	1	1	27	9	22	24	34	8.5	7.0	7.4	0.72	0.03	24	0.40
3	40-60	Au2	2	2	2	1	25	8	3	25	34	8.5	7.1	7.2	0.67	0.03	22	0.43
4	60-80	Au2	3	2	2	2	24	8	3	24	35	8.6	7.1	8.0	0.67	0.03	22	0.43
5	80-100	Au3	3	1	1	1	24	9	3	23	38	8.7	7.1	5.8	0.62	0.03	21	0.40
5	100-120	Au3	3	2	1	1	22	8	6	28	32	8.7	7.2	9.9	0.56	0.03	19	0.43

Depth cm	Exchangeable cations						CEC Soil Clay %	BS %	EC 2.5 (mS/cm)	Water soluble salts							
	Ca	Mg	K	Na	Sum	Exch. acid.				Ca	Mg	K	Na	CO_3	HCO_3	Cl	SO_4
	meq/100 g									meq/100 g							
1		8.8	0.4	0.4			29.2	100	0.22								
2		12.5	0.3	0.2			33.5	100	0.24								
3		15.2	0.3	0.2			37.0	100	0.24								
4		16.7	0.3	0.2			35.1	100	0.27								
5		18.7	0.3	0.5			38.3	100	0.30								
5		20.6	0.3	0.7			37.7	100	0.32								

Depth cm	Elemental composition of the total soil (weight %)											Ign. loss	Molar ratios			
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	P_2O_5			$\frac{\text{SiO}_2}{\text{Al}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{Fe}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{R}_2\text{O}_3}$	$\frac{\text{Al}_2\text{O}_3}{\text{Fe}_2\text{O}_3}$
	1															
2																
3																
4																
5																

Depth cm	Elemental composition of the clay fraction (weight %)											Ign. loss	Molar ratios			
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	P_2O_5			$\frac{\text{SiO}_2}{\text{Al}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{Fe}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{R}_2\text{O}_3}$	$\frac{\text{Al}_2\text{O}_3}{\text{Fe}_2\text{O}_3}$
	1															
2																
3																
4																
5																

Clay mineralogy											
1	Kaol	Mi/III	Verm	Chlor	Smec	Mix	Quar	Feld	Gibb	Goeth	Hem

Sand mineralogy										
1										

Depth cm	Bulk density (kg/dm^3)	Soil moisture		
		pF 2.0	pF 2.5	pF 4.2
1				
2				
3				
4				
5				

Profile ZA 8

Profile description

Horizon / Depth / Description

Au1	0-30 cm. Black (2.5Y 2/1) moist and black (10YR 2/2) dry, clay; moderate fine subangular blocky, somewhat compact; very sticky, very plastic, friable to firm moist, very hard dry, clear smooth boundary.
Au2	30-55 cm. Colours as Ah, clay; moderate fine subangular blocky; very sticky, very plastic, firm moist, very hard dry, diffuse smooth boundary.
Ag	55-80 cm. Very dark grey (2.5Y 3.5/1 to 5Y 3.5/1) moist, common fine distinct yellowish brown (10YR 5/4) mottles, clay; moderate fine subangular blocky; very sticky, very plastic, friable moist, very hard dry; many slickensides, few continuous intersecting slickensides.
ACg	80-110 cm. Olive grey (5YR 4/2) moist, many light olive brown (2.5Y 5/3) and few dark greenish grey (5GY 4/1) mottles, clay; moderate fine subangular blocky; very sticky, very plastic, friable moist, very hard dry; many continuous intersecting slickensides.

Profile ZA 8

Classification

FAO-Unesco: Pellic Vertisol, fine, textured
USDA: Udic Pellustert, fine, montmorillonitic, thermic
Local: Rensburg Form

Location and Site

Rep. of South Africa, Natal, 20 km N of Pietermaritzburg.
Slope near bottom of narrow valley in undulating landscape.
Slope: 10%. Elevation: 700 m. Drainage: poorly drained.

Parent material/Substratum

Residue of weathering diorite

Vegetation and Land use

Thornbush with Acacia spp. and grasses.

Particle size distribution (μm in weight %)

Depth cm	Horizon	>2 mm	Sand							Silt	Clay	pH		CaCO ₃ %	Org. matter			'Free' Fe ₂ O ₃ %
			2000	1000	500	250	100	50	20	50	20	H ₂ O	KCl		C	N	C/N	
			1000	500	250	100	50	20	2	<2			%		%	%	%	
0-30	Au1		3	2	2	4	5	15	23	46	6.3	5.0		2.43	0.08	30	5.47	
30-55	Au2		3	2	3	7	6	11	17	51	6.7	5.4	-	1.43	0.06	24	3.38	
55-80	Ag		4	3	3	7	5	7	11	60	7.1	5.6	-	0.62	0.02	31	3.15	
80-100	ACg		2	2	4	11	6	7	10	58	7.0	5.6	-	0.52	0.03	17	1.66	
100-110	ACg		1	2	4	9	8	9	12	55	7.3	5.8	tr	0.48	0.03	16	2.23	

Exchangeable cations			CEC				BS %	EC 2.5 (mS/cm)	Water soluble salts							
Ca	Mg	K	Na	Sum	Exch. acid.	Soil			Clay	Ca	Mg	K	Na	CO ₃	HCO ₃	Cl
			meq/100 g						meq/100 g							
15.2	10.5	0.19	0.65	26.6		42.0	63	0.14								
19.3	21.5	0.14	0.85	41.8		51.2	82	0.22								
25.2	21.6	0.14	1.07	48.0		53.6	90	0.15								
21.8	22.7	0.14	0.87	45.5		53.1	86	0.16								
25.1	24.4	0.14	0.87	50.5		32.6	100	0.14								

Elemental composition of the total soil (weight %)

SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	K ₂ O	Na ₂ O	TiO ₂	MnO	P ₂ O ₅	Ign. loss	Molar ratios			
											SiO ₂ Al ₂ O ₃	SiO ₂ Fe ₂ O ₃	SiO ₂ R ₂ O ₃	Al ₂ O ₃ Fe ₂ O ₃
62.7	11.1	10.9	1.0	0.6	0.3		1.8	0.18	0.07	10.6	9.6	15.2	5.9	1.6
62.0	11.8	12.4	1.8	1.0	0.3		1.6	0.19	0.03	8.8	8.9	13.3	5.2	1.5
57.4	15.5	13.4	2.0	1.3	0.3		1.5	0.06	0.04	7.7	6.3	11.4	4.0	1.8
60.6	17.1	10.7	2.7	1.3	0.4		1.5	0.07	0.07	6.5	6.0	15.0	4.3	2.5
57.2	18.1	11.1	2.7	1.3	0.4		1.4	0.05	0.08	6.9	5.4	13.7	3.9	2.6

Elemental composition of the clay fraction (weight %)

SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	K ₂ O	Na ₂ O	TiO ₂	MnO	P ₂ O ₅	Ign. loss	Molar ratios			
											SiO ₂ Al ₂ O ₃	SiO ₂ Fe ₂ O ₃	SiO ₂ R ₂ O ₃	Al ₂ O ₃ Fe ₂ O ₃
49.2	21.1	13.7	0.3	0.7	0.2		1.4	0.14	0.13	10.9	4.0	9.6	2.8	2.4
54.8	18.1	14.3	0.5	1.0	0.1		1.3	0.14	0.09	9.9	5.2	10.2	3.4	2.0
59.3	17.2	12.4	1.0	1.2	0.2		1.4	0.05	0.08	7.3	5.8	12.7	4.0	2.2
57.1	18.7	12.3	1.2	1.3	0.2		1.4	0.06	0.09	7.4	5.2	12.3	3.7	2.4
51.3	20.5	14.4	0.2	1.5	0.1		1.1	0.06	0.06	10.8	4.3	9.5	2.9	2.2

Clay mineralogy

Kaol	Mi/III	Verm	Chlor	Smec	Mix	Quar	Feld	Gibb	Goeth	Hem
+				+++		x	-			
+				+++		x	-			
+				+++		x	x			
tr				+++		x	x			
tr				+++		tr	x			

Sand mineralogy

Bulk density (kg/dm ³)	Soil moisture		
	pF 2.0	pF 2.5	pF 4.2
(weight %)			

Profile ZA 9

Classification

FAO-Unesco: Chromic Vertisol, fine textured

USDA: Typic (Udic?) Chromustert, very fine, montmorillonitic, thermic

Local: Arcadia Form

Location and Site

Rep. of South Africa, Natal, 20 km N of Pietermaritzburg.

Midslope in rolling country. Irregular pattern of deep, 3 cm wide cracks in polygons of 30-40 cm diameter. Slope 6%. Altitude 700 m.

Drainage: imperfectly to moderately well drained.

Parent material/Substratum

Residue of weathering diorite.

Vegetation and Land use

Thornveld bush, Acacia spp.

Profile ZA 9

Profile description

Horizon / Depth / Description

- | | |
|-----|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ah1 | 0-15 cm. Very dark brown (10YR 2/2) moist and (7.5YR 2/2) dry, clay; strong fine subangular blocky; very sticky, very plastic, friable moist, very hard dry; non calcareous; clear, smooth boundary. |
| Ah2 | 15-35 cm. Same colours as Ah1, clay; moderate fine subangular blocky; very sticky, very plastic, friable moist, very hard dry; non calcareous; diffuse, smooth boundary. |
| Au1 | 35-100 cm. Black (10YR 1/1) moist, clay; weak very coarse prismatic, breaking to moderate and fine subangular blocky; very sticky, very plastic, friable moist, very hard dry, common small and few continuous slickensides; non calcareous; diffuse smooth boundary. |
| Au2 | 100-120 cm. Black (10YR 1/1) moist, clay; weak coarse prismatic, breaking to moderate and fine subangular blocky; very sticky, very plastic, friable moist, very hard dry; common continuous intersecting slickensides; non calcareous. |

Particle size distribution (μm in weight %)

No.	Depth cm	Horizon	Particle size distribution (μm in weight %)									pH		Org. matter			'Free' Fe_2O_3 %
			Sand			Silt		Clay <2	H_2O	KCl	CaCO_3 %	C %	N %	C/N			
			>2000 mm	1000 500	500 250	250 100	100 50								50 20	20 2	
1	0-20	Ah1	1	3	6	9	5	9	10	57	6.8	5.3	-	1.61	0.14	12	4.86
2	20-40	Ah2	tr	1	3	7	6	9	11	62	7.1	5.5	-	1.31	0.11	12	4.46
3	40-60	Au1	tr	1	4	8	5	10	12	60	7.4	5.9	tr	1.16	0.11	11	4.84
4	60-80	Au1	tr	tr	2	4	4	10	13	66	7.6	6.2	tr	1.40	0.10	14	4.84
5	80-100	Au1	tr	tr	1	3	3	9	14	72	7.8	6.3	tr	1.11	0.10	11	4.84
6	100-110	Au2	tr	tr	1	3	4	11	16	64	8.1	6.6	tr	1.29	0.09	14	4.50
7																	
8																	

No.	Exchangeable cations			CEC					EC 2.5 (mS/cm)	Water soluble salts								
	Ca	Mg	K	Na	Sum	Exch. acid.	Soil	Clay		BS %	Ca	Mg	K	Na	CO_3	HCO_3	Cl	SO_4
1	18.5	19.7	0.28	0.76	39.2		45.2		87	0.11								
2	24.8	20.9	0.20	1.24	47.2		49.4		95	0.12								
3	18.7	23.2	0.23	1.73	43.9		56.4		78	0.14								
4	22.3	24.6	0.27	2.24	49.4		55.5		89	0.26								
5	22.5	24.4	0.57	2.66	50.1		57.0		88	0.27								
6	22.2	29.0	0.33	3.06	54.6		55.3		99	0.35								
7																		
8																		

No.	Elemental composition of the total soil (weight %)										Ign. loss	Molar ratios			
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	P_2O_5		$\frac{\text{SiO}_2}{\text{Al}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{Fe}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{R}_2\text{O}_3}$	$\frac{\text{Al}_2\text{O}_3}{\text{Fe}_2\text{O}_3}$
	1	55.3	17.1	11.9	1.9	2.1	0.4		1.7	0.2		0.04	10.0	5.5	12.4
2	54.4	17.2	11.7	1.8	1.8	0.4		1.5	0.3	0.03	10.4	5.4	12.3	3.7	2.3
3	56.0	16.7	11.5	1.5	1.5	0.4		1.6	0.3	0.03	9.8	5.7	12.9	4.0	2.3
4	54.4	17.9	12.1	1.1	1.4	0.3		1.5	0.3	0.03	10.9	5.2	11.9	3.6	2.3
5	54.6	18.1	12.1	1.1	1.5	0.3		1.5	0.3	0.02	10.9	5.1	11.9	3.6	2.3
6	55.2	17.7	12.2	1.1	1.6	0.3		1.5	0.3	0.02	10.5	5.3	12.0	3.7	2.3
7															
8															

No.	Elemental composition of the clay fraction (weight %)										Ign. loss	Molar ratios			
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	P_2O_5		$\frac{\text{SiO}_2}{\text{Al}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{Fe}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{R}_2\text{O}_3}$	$\frac{\text{Al}_2\text{O}_3}{\text{Fe}_2\text{O}_3}$
	1	46.2	24.1	16.0	0.2	1.3	0.2		0.8	0.2		0.12	11.2	3.3	7.7
2	46.6	24.5	16.0	0.2	1.3	0.2		0.8	0.2	0.13	11.1	3.2	7.7	2.3	2.4
3	47.5	24.4	15.0	0.2	1.3	0.2		0.8	0.2	0.11	11.1	3.3	8.4	2.4	2.5
4	47.8	24.2	14.2	0.1	1.2	0.3		0.8	0.2	0.09	11.2	3.4	8.9	2.4	2.7
5	48.3	24.1	14.1	0.2	1.3	0.3		0.8	0.2	0.09	11.0	3.4	9.1	2.5	2.7
6	49.1	24.2	14.4	0.2	1.4	0.3		0.8	0.2	0.08	11.1	3.5	9.1	2.5	2.6
7															
8															

No.	Clay mineralogy										
	Kaol	Mi/Ill	Verm	Chlor	Smec	Mix	Quar	Feld	Gibb	Goeth	Hem
1	+				++	tr	tr				
2	+				++	tr	tr				
3	+				++	tr	tr				
4	+				++	tr	tr				
5	+				+++	tr	tr				
6	+				+++	tr	tr				
7											
8											

No.	Sand mineralogy			Bulk density (kg/dm^3)	Soil moisture		
					pF 2.0	pF 2.5	pF 4.2
1							
2							
3							
4							
5							
6							
7							
8							

Profile E 3

Profile description

Horizon / Depth / Description

Ap	0-10 cm. Dark reddish brown (5YR 3/6) moist and reddish brown (5YR 3.5/5) dry, clay; strong very fine and fine subangular blocky with some granular parts; very plastic, sticky, very friable moist, hard dry; very few small fragments of calcareous parent material; clear smooth boundary.
Au1	10-25 cm. Dark reddish brown (5YR 3/6) moist and reddish brown (5YR 3.5/5) dry, clay; weak thin platy, breaking to strong very fine angular blocky; sticky, very plastic, very friable moist; very few small fragments of calcareous parent material; some slickensides; gradual smooth boundary.
Au2	25-50 cm. Dark reddish brown (5YR 3/6) moist, clay; moderate coarse angular blocky, breaking to strong very fine angular blocky; sticky, very plastic, very friable moist, hard dry; very few small fragments of calcareous parent material; some slickensides and wedge-shaped elements; gradual smooth boundary.
Au3	50-70 cm. Dark reddish brown (5YR 3/6) moist, slightly gravelly clay; strong coarse angular blocky, breaking to strong very fine angular blocky; sticky, very plastic, very friable moist, hard dry; very few small fragments of calcareous parent material; many prominent slickensides and wedge-shaped elements; gradual wavy boundary.
Au4	70-90 cm. Dark reddish brown (5YR 3/6) moist, common medium prominent clear pale red (2.5YR 6/3) and few medium prominent clear dark red (2.5YR 3/6) mottles, clay; moderate coarse angular blocky, breaking to strong very fine angular blocky; sticky, plastic, very friable moist, hard dry; few fragments of calcareous parent material prominent slickensides and wedge-shaped elements: some cracks; clear wavy boundary.
CA	90-130+ cm. Dark reddish brown (5YR 3/6) moist, many fine and medium distinct sharp and clear pale red (2.5YR 6/3) and dark red (2.5YR 3/6) mottles, slightly gravelly clay; strong coarse angular blocky, breaking to strong medium and fine angular blocky; sticky, plastic, very friable moist, hard dry; fragments of calcareous parent material.

N.B.:

- Wide cracks up to a depth of 70 cm occur in the dry season

Profile E 3

Classification

FAO-Unesco: Chromic Vertisol, fine textured
USDA: Typic Chromoxerert, fine, montmorillonitic, thermic
Local: Vertisuelo topomorfo

Location and Site

Spain, Prov. of Badajoz, 4.5 km W of Torremegia.
Depression in slightly undulating landscape.
Elevation: 320 m. Drainage: moderately well drained.

Parent material/Substratum

Calcareous Miocene clay.

Vegetation and Land use

Olive trees and vine.

Particle size distribution (μm in weight %)

No.	Depth cm	Horizon	mm	Particle size distribution (μm in weight %)								pH		Org. matter			'Free' Fe_2O_3 %
				Sand				Silt		Clay <2	H_2O	KCl	CaCO_3 %	C %	N %	C/N	
				2000	1000	500	200	100	50								
1	0-10	Ap	1		6			14	13	14	53	7.8	6.3	3.5	0.46	0.06	8
2	10-25	Au1	1		7			14	12	15	53	8.0	6.2	3.3	0.38	0.04	10
3	25-50	Au2	1		6			14	12	14	53	8.1	6.4	3.3	0.32	0.04	8
4	50-70	Au3	3		5			14	14	15	52	8.3	6.9	5.4	0.26	0.03	9
5	70-90	Au4	1		5			15	13	16	51	8.3	7.0	7.8	0.23	0.02	12
6	90-110	CA	7		4			13	11	18	54	8.5	7.1	28.0	0.15	0.02	8
7	110-130	CA	1		3			16	14	19	47	8.5	7.2	9.7	0.03	0.02	

No.	Exchangeable cations			CEC				EC 2.5 (mS/cm)	Water soluble salts									
	Ca	Mg	K	Na	Sum	Exch. acid.	Soil		Clay	BS %	Ca	Mg	K	Na	CO_3	HCO_3	Cl	SO_4
1		8.2	1.0	0			44.4	100	0.28									
2		7.7	0.7	0			44.5	100	0.25									
3		8.6	0.5	0			44.5	100	0.28									
4		9.1	0.4	0			38.3	100	0.32									
5		9.2	0.4	0			34.9	100	0.33									
6		6.9	0.4	0			24.1	100	0.26									
7		8.3	0.4	0			26.9	100	0.26									

No.	Elemental composition of the total soil (weight %)											Molar ratios			
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	P_2O_5	Ign. loss	$\frac{\text{SiO}_2}{\text{Al}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{Fe}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{R}_2\text{O}_3}$	$\frac{\text{Al}_2\text{O}_3}{\text{Fe}_2\text{O}_3}$
	1	70.6	11.9	4.5	1.3	1.7	1.3		0.9	0.1	0	5.6	10.1	41.7	8.1
2	72.2	12.3	4.8	1.4	1.8	1.3		0.9	0.1	0	5.9	10.0	40.0	8.0	4.0
3	72.3	12.1	4.6	1.3	2.2	1.3		0.9	0.1	0	6.1	10.1	41.8	8.2	4.1
4	68.0	11.9	4.6	4.0	2.0	1.3		0.9	0.1	0.1	7.6	9.7	39.3	7.8	4.0
5	67.5	11.7	4.5	5.4	1.8	1.3		0.9	0.1	0.1	8.0	9.8	39.9	7.9	4.1
6	49.6	9.5	3.0	17.7	2.2	1.1		0.5	0.0	0.2	17.5	8.9	43.9	7.4	5.0
7	66.3	11.4	4.4	6.3	2.2	1.5		0.9	0.1	0.1	8.4	9.9	40.0	7.9	4.1

No.	Elemental composition of the clay fraction (weight %)											Molar ratios			
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	P_2O_5	Ign. loss	$\frac{\text{SiO}_2}{\text{Al}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{Fe}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{R}_2\text{O}_3}$	$\frac{\text{Al}_2\text{O}_3}{\text{Fe}_2\text{O}_3}$
	1	53.6	21.8	8.4	0.1	2.9	2.1		1.1	0.1	0.2	8.3	4.2	17.0	3.3
2	54.1	22.0	8.4	0.1	3.0	2.1		1.1	0.2	0.2	8.4	4.2	17.2	3.3	4.1
3	53.5	21.6	8.3	0.1	3.0	2.1		1.0	0.1	0.1	8.7	4.2	17.2	3.4	4.1
4	53.0	21.7	8.3	0.2	3.1	2.1		1.0	0.1	0.1	9.0	4.1	17.0	3.3	4.1
5	53.2	21.4	8.4	0.2	3.0	2.2		1.0	0.1	0.1	8.5	4.2	16.9	3.4	4.0
6	54.1	21.1	8.1	0.7	4.5	2.4		0.8	0.1	0.5	8.5	4.3	17.8	3.5	4.1
7	52.9	21.6	8.5	0.1	3.5	2.6		0.9	0.1	0.1	9.0	4.2	16.5	3.3	4.0

No.	Clay mineralogy										
	Kaol	Mi/Ill	Verm	Chlor	Smec	Mix	Quar	Feld	Gibb	Goeth	Hem
1	++	++			+++	-	x				
2	++	++			+++	-	x				
3	++	++			+++	tr	x				
4	++	++			+++	tr	x				
5	++	++			+++	tr	x				
6	++	++			+++	+	x				
7	++	++			+++	+	x				

No.	Sand mineralogy			Bulk density (kg/dm ³)	Soil moisture		
					pF 2.0	pF 2.5	pF 4.2
1							
2							
3							
4							
5							
6							
7							

Profile E 12

Classification

FAO-Unesco: Chromic Vertisol, fine textured
USDA: Typic Chromoxerert, fine, montmorillonitic, thermic
Local: Vertisuelo topomorfo

Location and Site

Spain, Prov. of Badajoz, 4 km NE of Merida.
Lower part of slope in gently undulating landscape. Slope 5%.
Elevation: 260 m. Drainage: moderately well drained.

Parent material/Substratum

Presumably Miocene clay, overlying greenish coloured hornblende schist.

Vegetation and Land use

Arable land, in most years used for wheat.

Profile E 12

Profile description

Horizon / Depth / Description

- | | |
|----|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Ap | 0-15 cm. Dark reddish brown (2.5YR 3/3) moist, clay; crumb and weak subangular blocky; very plastic, very sticky, very friable moist, hard dry; common fine and very fine pores; very few gravel up to 2 cm; clear smooth boundary. |
| A | 15-55 cm. Dark reddish brown (2.5YR 3/3) moist, clay; moderate fine angular blocky; very plastic, very sticky, very friable moist, hard dry; continuous slickensides and parallelepiped structural elements, increasing with depth, very few gravel up to 3 cm; gradual smooth boundary. |
| AC | 55-70 cm. Dark reddish brown (2.5YR 3/3) moist, common to many medium to coarse distinct yellowish and brown and some reddish mottles, increasing with depth; clay; moderate coarse to fine angular blocky; very plastic, very sticky, very friable moist, hard dry; continuous to broken slickensides, decreasing with depth; gradual wavy boundary. |
| C | 70-90+ cm. Reddish brown, reddish yellow and yellowish red clay, calcium carbonate nodules and fragments of weathered diorite. |

Particle size distribution (μm in weight %)

Depth cm	Horizon	>2 mm	Sand					Silt		Clay <2	pH		Org. matter			'Free' Fe ₂ O ₃ %	
			2000 1000	1000 500	500 200	200 100	100 50	50 20	20 2		H ₂ O	KCl	CaCO ₃ %	C %	N %		C/N
0-15	Ap	7		5			10		29	56	7.6	6.3	4.4	0.94	0.10	9	3.00
15-35	A	4		4			10		29	58	7.7	6.1	4.2	0.72	0.09	8	3.11
35-55	A	3		4			9		28	58	8.0	6.8	5.2	0.61	0.08	8	3.07
55-70	AC	7		4			8		28	60	8.1	6.9	50.6	0.54	0.05	11	1.61
70-90	C	2		3			5		14	78	8.5	7.1	20.0	0.38	0.05	8	2.63

Exchangeable cations					CEC			BS %	EC (mS/cm)	Water soluble salts						
Ca	Mg	K	Na	Sum	Exch. acid.	Soil	Clay			Ca	Mg	K	Na	CO ₃	HCO ₃	Cl
					meq/100 g			meq/100 g								
	7.5	0.9	0.1			67.0		100								
	7.0	0.5	0.1			67.5		100								
	7.7	0.5	0.1			68.5		100								
	8.4	0.4	0.1			59.3		100								
	6.8	0.4	0.1			43.4		100								

Elemental composition of the total soil (weight %)											Molar ratios			
SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	K ₂ O	Na ₂ O	TiO ₂	MnO	P ₂ O ₅	Ign. loss	SiO ₂ Al ₂ O ₃	SiO ₂ Fe ₂ O ₃	SiO ₂ R ₂ O ₃	Al ₂ O ₃ Fe ₂ O ₃
61.9	15.4	7.8	3.6	0.5	1.0		1.2	0.1	6.7	6.7	6.8	21.1	5.2	3.1
61.3	15.6	7.8	3.5	0.5	1.0		1.1	0.1	6.8	6.7	20.9	5.1	3.1	
60.2	15.7	7.8	4.4	0.5	1.0		1.1	0.1	6.8	6.5	20.5	4.9	3.2	
47.1	13.2	6.9	15.2	0.6	0.8		0.8	0.1	14.2	6.1	18.1	4.5	3.0	
24.3	8.6	5.2	30.9		0.4		0.3	0.3	28.0	4.8	12.4	3.5	2.6	

Elemental composition of the clay fraction (weight %)											Molar ratios			
SiO ₂	Al ₂ O ₃	Fe ₂ O ₃	CaO	MgO	K ₂ O	Na ₂ O	TiO ₂	MnO	P ₂ O ₅	Ign. loss	SiO ₂ Al ₂ O ₃	SiO ₂ Fe ₂ O ₃	SiO ₂ R ₂ O ₃	Al ₂ O ₃ Fe ₂ O ₃
51.8	22.1	11.5	0.6	2.0	1.2		1.0	0.1	0.3	7.9	4.0	12.0	3.0	3.0
51.7	22.0	11.1	0.6	2.1	1.2		1.0	0.1	0.3	7.9	4.0	12.4	3.0	3.1
51.3	22.5	11.2	0.6	2.4	1.2		1.0	0.1	0.2	8.0	3.9	12.2	2.9	3.1
51.6	21.6	12.1	2.0	2.4	1.0		0.9	0.1	0.8	8.0	4.1	11.3	3.0	2.8
52.0	22.0	11.5	0.6	2.0	1.2		1.0	0.1	0.2	8.8	4.0	12.0	3.0	3.0

Clay mineralogy										
Kaol	Mi/III	Verm	Chlor	Smec	Mix	Quar	Feld	Gibb	Goeth	Hem
+	+			+++	++	x				
+	tr			+++	++	x				
+	tr			+++	++	x				
tr	-			+++	++	tr				
+	tr			+++	++	x				

Sand mineralogy		Bulk density (kg/dm ³)	Soil moisture		
			pF 2.0	pF 2.5	pF 4.2
		(weight %)			

Profile E 18

Classification

FAO-Unesco: Chromic Vertisol, fine textured
USDA: Typic Chromoxerert, fine, montmorillonitic, thermic
Local: Vertisuelo topomorfo

Location and Site

Spain, Prov. of Badajoz, 6 km W of Torremegia.
Almost flat part in broad valley bottom in undulating landscape.
Slope: less than 2%.
Elevation: 292 m. Drainage: moderately well drained.

Parent material/Substratum

Miocene clay, colluvial material.

Vegetation and Land use

Vineyard with olive trees.

Profile E 18

Profile description

Horizon / Depth / Description

- Ap1 0-3 cm. Yellowish red (5YR 3/6) moist and dry, clay; moderate to strong medium crumbs; very sticky, very plastic, very friable moist, slightly hard dry; very few small gravels of calcareous and quartz nature; slightly calcareous; common fine and few medium roots; abrupt wavy boundary.
- Ap2 3-15 cm. Yellowish red (5YR 3/6) moist and dry, clay; massive to weak fine subangular blocky; very sticky, very plastic, very friable moist, slightly hard dry; very few very fine tubular pores; very few small gravels of calcareous and quartz nature; slightly calcareous; common fine and few medium roots; gradual smooth boundary.
- Au1 15-42 cm. Dark reddish brown (2.5YR 3/5) moist and reddish brown (2.5YR 3.5/5) dry clay; moderate fine blocky; very sticky, very plastic, firm moist, very hard dry; common intersecting slickensides; few very fine tubular pores; very few gravels of calcareous and quartz nature, less than in Ap; slightly calcareous; common fine and very few medium roots; gradual wavy boundary.
- Au2 42-52 cm. Dark reddish brown (2.5YR 3/5) moist and reddish brown (2.5YR 3.5/5) dry with many distinct coarse red mottles, clay; moderate fine blocky; very sticky, very plastic, firm moist, very hard dry; many intersecting slickensides; few very fine tubular pores; very few small gravels of calcareous and quartz nature, more than in B2; calcareous; few fine and few medium roots; clear wavy boundary.
- AC 52-66 cm. Red (2.5YR 4/7) moist and dry, with many medium distinct reddish yellow mottles, clay; strong fine blocky; sticky, very plastic, friable moist, hard dry; few very fine tubular pores; strongly calcareous; few medium roots; diffuse smooth boundary. (The overlying B3 material is tonguing into the BCca horizon.)
- 2C1ca 66-93 cm. Light red to red (2.5YR 5.5/6) moist clay; few fine faint red (2.5YR 4/6) and (10R 4/6) mottles which exhibit weak fine subangular blocky structure; very sticky, very plastic, extremely firm moist, hard dry; few very fine and fine tubular pores; strongly calcareous; few very fine roots; few large crotovinas of a diameter of 1-2 cm filled up with B3 material; soft powdery lime in pockets and elongated patches; gradual smooth boundary.
- 2C2ca 93-115 cm. Light red to red (2.5YR 5.5/6) moist, clay; dusky red (10R 3/4) clay occurs in nodules of 1-2.5 cm which exhibit a moderate to strong medium angular and subangular blocky structure set in a lime matrix; very sticky, very plastic, very firm moist; few very fine tubular pores; strongly calcareous; very few fine roots; dark ferromanganese cutans on the clay nodules; few slickensides which do not intersect; abrupt smooth boundary.

Profile E 18 (contd.)

Horizon / Depth / Description

2C3ca	115-200 cm. Dusky red (10R 3/4) moist, clay; red clay alternating with large (4 x 25 cm) pockets of gleyed clay of light grey (10YR 7/1) moist colour; pockets of soft lime up to 10 x 15 cm occur; hard CaCO ₃ pieces are also encountered; numerous slickensides intersecting at various angles are prominent; the cleavage faces are shining and coated with ferromanganese cutans and with white lime.
-------	-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

No	Depth cm	Horizon	Particle size distribution (μm in weight %)									pH		Org. matter			'Free' Fe_2O_3 %
			Sand				Silt		Clay	H_2O	KCl	CaCO_3 %	C %	N %	C/N		
			> 2000 mm	1000 500	500 250	250 100	100 50	50 20	20 2							< 2	
1	0-15	Ap	1	5	5	10	8	5	15	51	8.2	6.7	0.2	0.41	0.06	7	2.06
2	15-27	Au1	1	5	5	9	7	6	13	54	8.0	6.1	0.1	0.38	0.06	6	2.13
3	27-42	Au1	1	6	5	8	7	7	13	53	8.0	6.3	0.3	0.32	0.06	5	2.23
4	42-52	Au2	1	6	5	8	6	7	12	55	8.3	6.8	6.2	0.29	0.06	5	1.97
5	52-66	AC	2	6	6	8	7	8	38	25	8.4	6.9	30.0	0.25	0.05	5	1.44
6	66-82	C	1	7	6	12	11	10	10	43	8.7	7.2	56.6	0.16	0.02	8	0.94
7	82-102	C	2	6	5	11	10	9	10	47	8.7	7.2	50.8	0.06	0.02		0.99
8	102-118	C	2	6	6	17	16	9	7	37	8.7	7.4	69.8	0.03	0.02		0.70

No	Exchangeable cations			CEC			EC 2.5 (mS/cm)	Water soluble salts										
	Ca	Mg	K	Na	Sum	Exch. acid.		Soil	Clay	BS	Ca	Mg	K	Na	CO_3	HCO_3	Cl	SO_4
	meq/100 g			meq/100 g			%			meq/100 g								
1		6.9	0.9	-			46.3		100									
2		6.5	0.4	-			41.3		100									
3		6.7	0.3	-			43.8		100									
4		6.5	0.2	-			41.3		100									
5		5.5	0.2	-			31.7		100									
6		4.1	0.2	-			24.0		100									
7		4.7	0.2	-			24.5		100									
8		3.2	0.1	-			17.0		100									

No	Elemental composition of the total soil (weight %)											Ign. loss	Molar ratios					
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	P_2O_5			$\frac{\text{SiO}_2}{\text{Al}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{Fe}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{R}_2\text{O}_3}$	$\frac{\text{Al}_2\text{O}_3}{\text{Fe}_2\text{O}_3}$		
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		

No	Elemental composition of the clay fraction (weight %)											Ign. loss	Molar ratios					
	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	K_2O	Na_2O	TiO_2	MnO	P_2O_5			$\frac{\text{SiO}_2}{\text{Al}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{Fe}_2\text{O}_3}$	$\frac{\text{SiO}_2}{\text{R}_2\text{O}_3}$	$\frac{\text{Al}_2\text{O}_3}{\text{Fe}_2\text{O}_3}$		
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		

o	Clay mineralogy										
	Kaol	Mi/III	Verm	Chlor	Smec	Mix	Quar	Feld	Gibb	Goeth	Hem
1	+	tr	-		+++		0/x				
2	+	tr	-		++++		0/x				
3	+	-	-		++++		0/x				
4	+	-	-		+++		tr				
5	tr	-	-		++		tr				
6	tr	-	-		++		x				
7	tr	-	tr		++		x/xx				
8	tr	-	tr		++		x				

o	Sand mineralogy			Bulk density (kg/dm^3)	Soil moisture		
					pF 2.0	pF 2.5	pF 4.2
1							
2							
3							
4							
5							
6							
7							
8							

Profile T 2

Classification

FAO-Unesco: Pellic Vertisol, fine textured
USDA: Udic Pellustert, fine, montmorillonitic, isohyperthermic
Local: Grumusol, Lop Buri series

Location and Site

Thailand, Central Plain Region, Lop Buri Province, Muang Lop Buri District.
Slightly undulating low terrace with weak gilgai relief and few termite
hills. Slope less than 1%.
Elevation: 24 m. Drainage: somewhat poorly drained.

Parent material/Substratum

Calcareous marl.

Vegetation and Land use

Recently abandoned rice field, at present low grass vegetation.
Rice yield on similar soils nearby approx. 2000 kg/ha.

Profile T 2

Profile description

Horizon / Depth / Description

- Ahk 0-10 cm. Black (10YR 2/1) dry and moist, clay; strong fine and medium granular on surface, strong fine subangular blocky below; very sticky, very plastic, very hard dry; few very fine tubular and few very fine interstitial pores, few coarse sand grains; few fine and medium calcium carbonate nodules; many very fine and fine roots; clear, wavy boundary.
- Ahck 10-32 cm. Black (10YR 2/1) dry and moist, gravelly clay; strong fine subangular blocky; very sticky, very plastic, very hard dry; few pressure cutans; very few very fine tubular and very few very fine interstitial pores; few coarse sand grains; common fine and few medium calcium carbonate nodules; common roots; gradual smooth boundary.
- Ack 32-120 cm. Black (10YR 2/1) moist, gravelly clay; moderate fine angular blocky; very sticky, very plastic, very firm moist, very hard dry; few slickensides and pressure cutans; few very fine tubular and few very fine interstitial pores; few coarse sand grains; many fine and very fine and few medium calcium carbonate nodules; few roots; gradual smooth boundary.
- ACck 120-145 cm. Dark grey (10YR 4/1) moist, gravelly clay; moderate very fine angular blocky; very sticky, very plastic, very firm moist; very few very fine tubular and few very fine interstitial pores; few coarse sand grains; many fine and very fine and few medium calcium carbonate nodules; very few roots; gradual smooth boundary.
- CAck 145-170+ cm. Weathering marls. Greyish brown (10YR 5/2) moist, gravelly silt loam; moderate fine angular blocky; sticky, plastic, firm moist; very few pores; few coarse sand grains; many very fine, fine and medium and few coarse calcium carbonate nodules; common fine medium and coarse iron-manganese nodules; no roots.

Profile TR 14

Classification

FAO-Unesco: Pellic Vertisol, fine, textured
USDA: Typic Pelloxerert, fine, montmorillonitic, mesic
Local: Vertisol

Location and Site

Turkey, Thrace region, Tekirdag prov., Saray subprov.
Gentle slope in undulating peneplain. Slope + 5%.
Elevation: 131 m. Drainage: moderately well drained.

Parent material/Substratum

Fine-textured lacustrine deposits.

Vegetation and Land use

Grasses and legumes.

Profile TR 14

Profile description

Horizon / Depth / Description

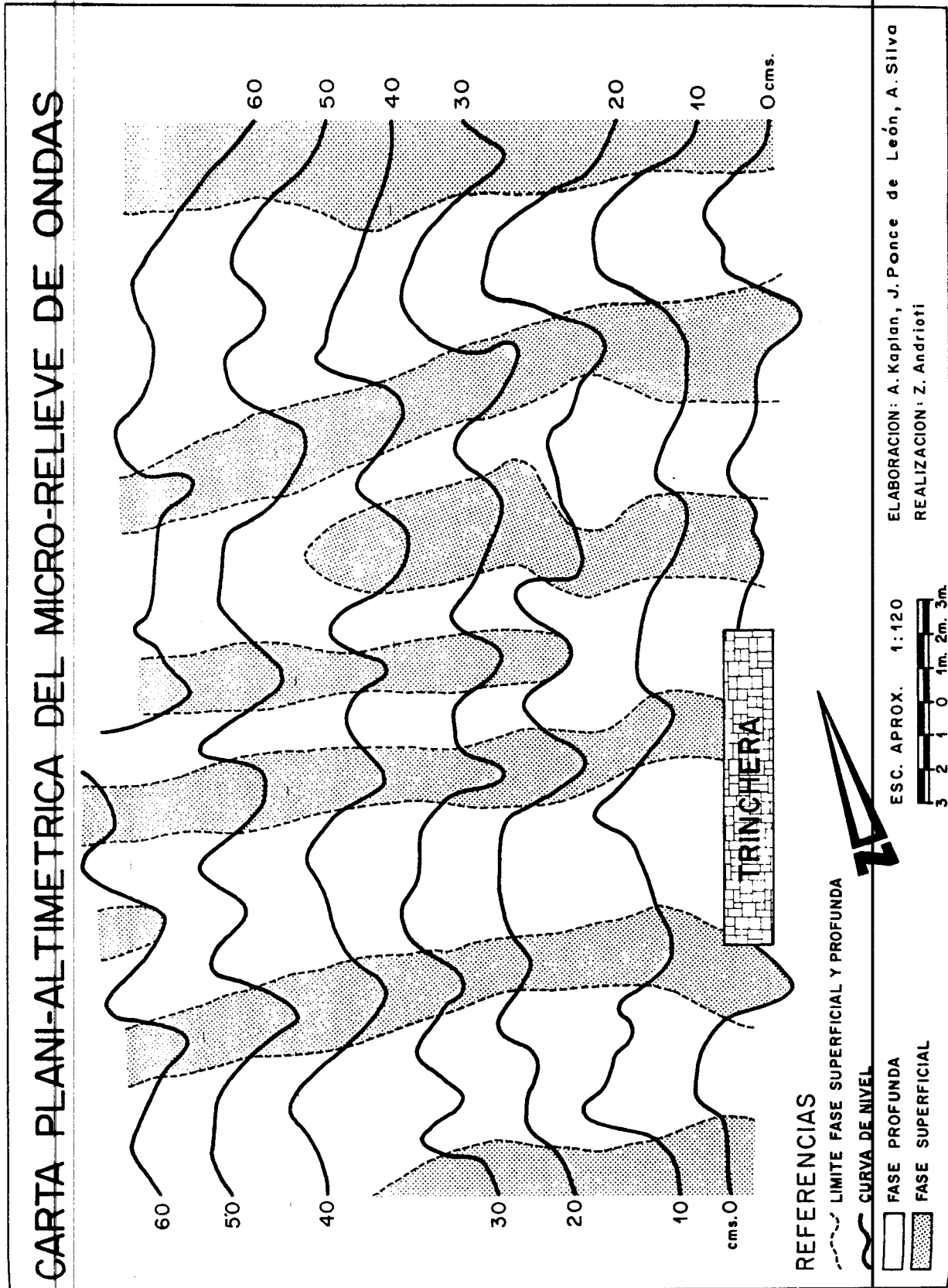
Ap	0-15 cm. Black (10YR 2/1) moist, very dark grey (10YR 3/1) dry, clay; weak coarse granular; very sticky, very plastic, firm moist, very hard dry; common roots; non calcareous; clear wavy boundary.
Au1	15-55 cm. Black (10YR 2/1) moist and dry, clay; weak prismatic, breaking to weak angular blocky; very sticky, very plastic, very firm moist, very hard dry; slickensides; common roots; calcareous; clear wavy boundary.
Au2	55-125 cm. Black (10YR 2/1) moist and dry, clay; weak prismatic, breaking to weak angular blocky; very sticky, very plastic, very firm moist, very hard dry; distinct slickensides, few roots; calcareous; clear wavy boundary.
AC	125-200 cm. Greyish brown (10YR 5/2) moist, light brownish grey (10YR 6/2) dry, clay; massive; very sticky, very plastic, very firm moist, very hard dry; slickensides; strongly calcareous.

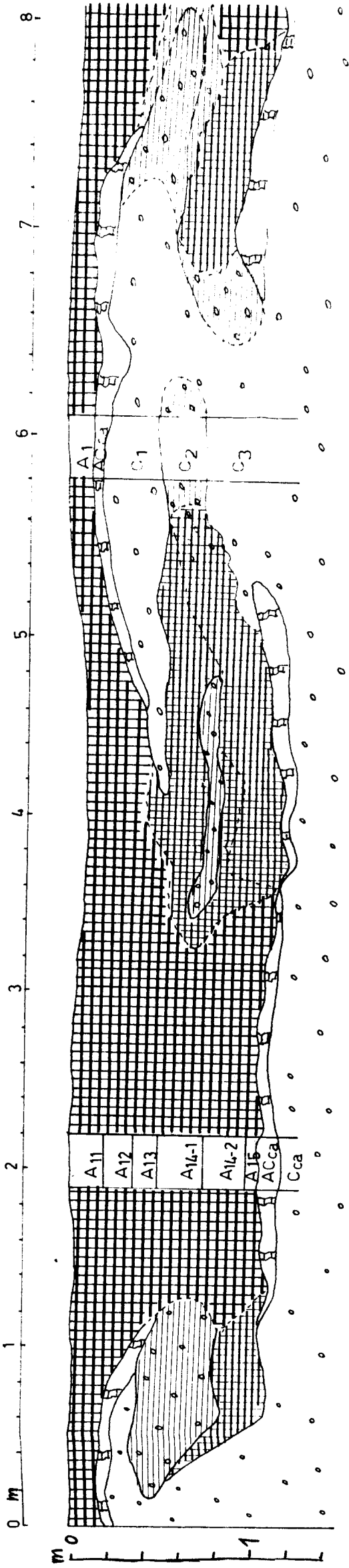
Appendix 2. DATA ON VERTISOL IN URUGUAY

(copied from Kaplan and Ponce de León, 1981)

FIGURA N° 12

143





■ solum negro (A₁)

▨ horizonte gris muy oscuro (A₁₄₋₁₅)

▧ horizonte agrisado (C_{2ca})

▩ horizonte ACca

▤ horizonte Cca pardo (C₁ y C₃)

Elaboración A. Kaplán y J. Ponce de León

Fig. 13 ESQUEMA DE LA MORFOLOGÍA DEL PERFIL DE LA TRINCHERA (Vertisol Rúptico)

Descripción del Perfil - Fase Profunda

Horizonte / Profundidad / Descripción

- A11 0-20 cm. Negro (10YR 2/1); arcillo limoso liviano; plástico y pegajoso; bloques subangulares finos y granular gruesa fuertes; transición gradual.
- A12 20-36 cm. Negro (10YR 2/1); arcilloso a arcillo limoso; muy plástico y pegajoso; granular media y gruesa, fuerte; películas de arcilla delgadas, en todas las caras de los agregados (caras de presión); transición gradual a difusa.
- A13 36-50 cm. Gris muy oscuro a negro (10YR 2.5/1); arcilloso; muy plástico y pegajoso; bloques subangulares medios que rompen en granular gruesa y media fuerte; películas de arcilla delgadas en todas las caras (caras de presión); transición gradual a clara.
- A14 50-100 cm. Gris muy oscuro a negro (10YR 2.5/1); arcilloso; muy plástico y pegajoso; bloques subangulares medios, moderados, que rompen en bloques finos y granular gruesa; películas de arcilla delgadas, comunes, gris muy oscuras (10YR 3/1) (caras de presión?); caras de deslizamiento medias y grandes, muy abundantes; transición gradual.
- A15 100(105)-106(112) cm. Gris muy oscuro (10YR 3/1); arcilloso; muy plástico y pegajoso; bloques subangulares medios, fuertes; caras de deslizamiento grandes, muy abundantes; transición clara y ondulante.
- ACca 106(112)-120 cm. Pardo (10YR 5/3) y pardo grisáceo oscuro (10YR 4/2); arcilloso a arcillo limoso; muy plástico y pegajoso, bloques subangulares medios, revestimientos (vetas) negros (10YR 2/1), abundantes; concreciones de CaCO_3 grandes y duras y fuerte reacción al HCl, transición clara e irregular.
- Cca 120+ cm. Pardo (7.5YR 5/3) y (7.5YR 5/2); arcilloso a arcillo limoso; muy plástico y pegajoso; caras de deslizamiento comunes; concreciones de CaCO_3 grandes, abundantes, friables; reacción al HCl muy fuerte.

Observaciones:

El horizonte A14 fue subdividido 50-75 y 75-100 cm a los efectos del muestro; el horizonte A15 presenta un espesor variable (hasta 25 cm o más) a lo largo de la fase profunda.

Analytical data Fase Profunda

DEPARTAMENTO : MOQUELTA PARAJE : MIRANDA GRANDE Vertisol Rústico Típico AcL
 SEGMENTO SECTOR PERFIL fase profunda

Nº Análisis	5747	5748	5749	5750	5751	5752	5753	5754		
Profundidad en cms.	0-20	20-35	35-50	50-75	75-100	100/106 106/112	106/112 112/120	120+		
Horizonte	A 11	A 12	A 13	A14-1	A14-2	A15	A-Coa	Coa		
Humedad 100 - 105° C	6.04	6.19	6.25	6.51	7.56	7.49	6.38	8.23		
Factor a seco	1.064	1.066	1.067	1.070	1.082	1.081	1.068	1.090		
pH	En H ₂ O	6.3	6.7	7.0	7.2	7.6	8.1	8.4	8.3	
	En KCl N	5.4	5.7	5.8	5.8	6.2	6.7	7.0	7.0	
P Bray Nº 1 ppm's	6	3	2	2	2	2	2	1		
DATOS REFERIDOS POR 100 grs. DE TIERRA SECA A 100 - 105° C										
Análisis mecánico internacional	ARENAS	Muy gruesa 2 - 1 mm %	1.1	2.7	3.1	3.0	3.0	2.5	1.8	1.4
		Gruesa 1 - 0.5 mm %	2.8	4.2	4.3	4.0	4.1	4.3	2.7	1.8
		Mediana 0.5 - 0.25 mm %	4.3	4.8	5.3	5.3	5.9	5.4	3.4	2.2
		Fina 0.25 - 0.10 mm %	4.3	4.8	5.3	5.4	5.6	5.0	3.2	2.2
		Muy fina 0.10 - 0.05 mm %	2.2	2.4	2.5	2.7	2.6	2.4	1.7	1.3
	Arena Total %	14.7	18.9	20.5	20.4	21.2	19.6	12.8	8.9	
	Limo %	43.6	37.3	32.3	32.2	32.8	33.6	37.5	37.2	
	Arcilla %	41.7	43.8	47.2	47.4	46.0	46.8	49.7	53.9	
	Textura*	AcL	Ac-AcL	Ac.	Ac.	Ac.	Ac.	Ac-AcL	Ac-AcL	
Materia orgánica %	9.19	3.57	2.28	1.79	1.74	1.36	0.45	0.15		
Carbono orgánico %	5.33	2.07	1.32	1.04	1.01	0.79	0.26	0.09		
Nitrógeno total %	0.46	0.21	0.16	0.13	0.12	0.11	0.04	0.04		
Relación C:N	11.6	9.9	8.3	8.0	8.4	7.2	6.5	2.3		
COMPLEJO DE INTERCAMBIO	me. / 100 g	Ca X	35.0	36.4	37.6	35.0	36.6	38.0	36.1	34.7
		Mg X	5.8	5.0	5.2	5.5	5.7	6.7	7.6	7.5
		K	0.9	0.6	0.6	0.6	0.5	0.6	0.7	0.9
		Na	0.4	0.6	0.8	0.9	1.0	1.2	1.3	1.4
		Bases totales	42.1	42.6	44.2	42.0	43.8	46.5	45.7	44.5
		Al								
	%	Acidez interc. pH 7.0								
		Capacidad Total pH 7.0 ^{XX}	45.2	43.1	44.2	42.0	43.8	46.5	45.7	44.5
		% de saturación pH 7.0 ^{XX}	92.9	98.8	100	100	100	100	100	100
		Acidez interc. pH 8.2								
		Capacidad Total pH 8.2 ^{XXX}	45.3	43.1	40.6	36.8	37.6	40.5	38.0	42.2
		% de saturación pH 8.2								
Rel. Ca/Mg	6.0	7.3	7.2	6.4	6.4	5.7	4.9	4.6		
C.I.C. Arcilla (xx)	64.5	82.1	84.0	81.0	87.6	93.5	90.1	82.0		
C.I.C. de la Arcilla (xxx)	64.5	82.1	76.3	70.1	74.2	80.7	74.6	77.7		
Ox. de Hierro libres (Fe ₂ O ₃) %										
Carbonatos (Ca CO ₃) %										
Cond. máximos cms 1/25° C										
Na de sales me. / 100 g										
K de sales me. / 100 g										
Cloruros (Cl) me. / 100 g										
Sulfatos (SO ₄) me. / 100 g										
Ca no intercambiable Ca con KCl					0.5	4.8	12.4	15.6		
(x) Ca y Mg extracción con KCl N 1.										
(xx) C.I.C. con AcNH ₄ a pH 7 y por encima por suma de bases a pH suelo										
(xxx) C.I.C. con AcNH ₄ a pH 7.										

ANÁLISIS DE TIERRAS Y FERTILIZANTES

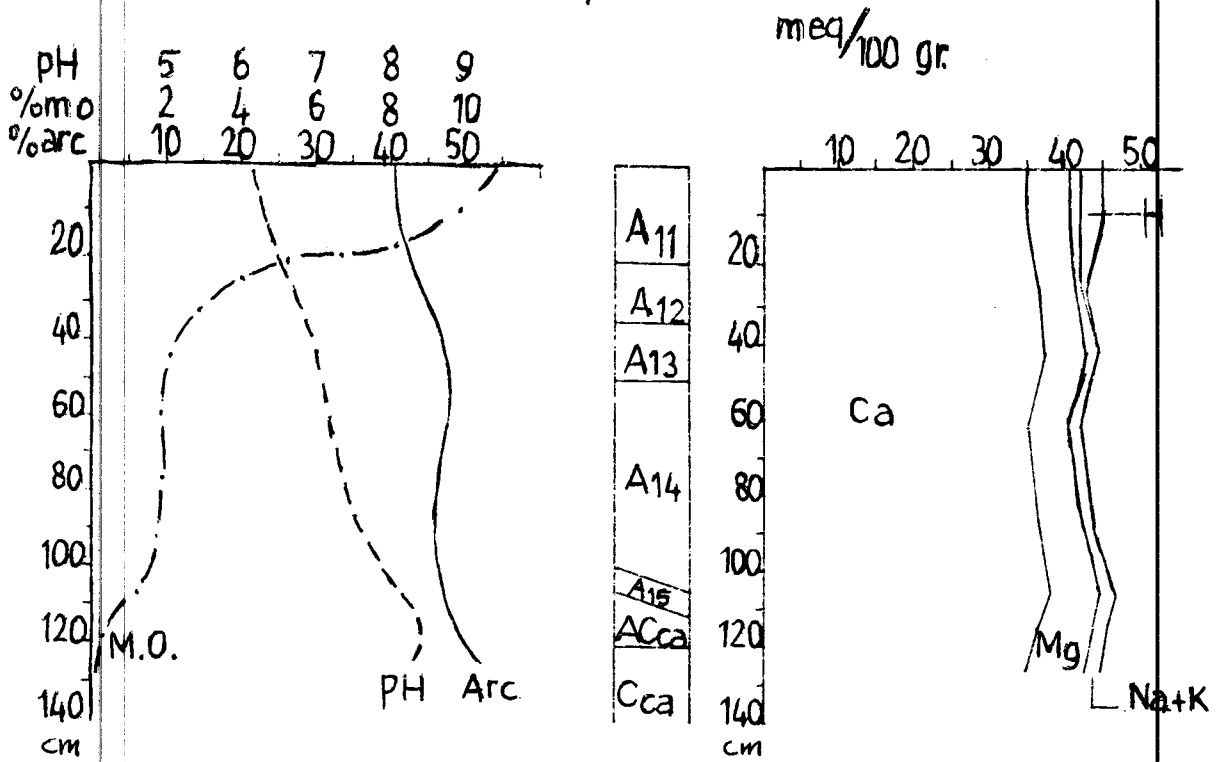
Descripción del Perfil - Fase Superficial

Horizonte / Profundidad / Descripción

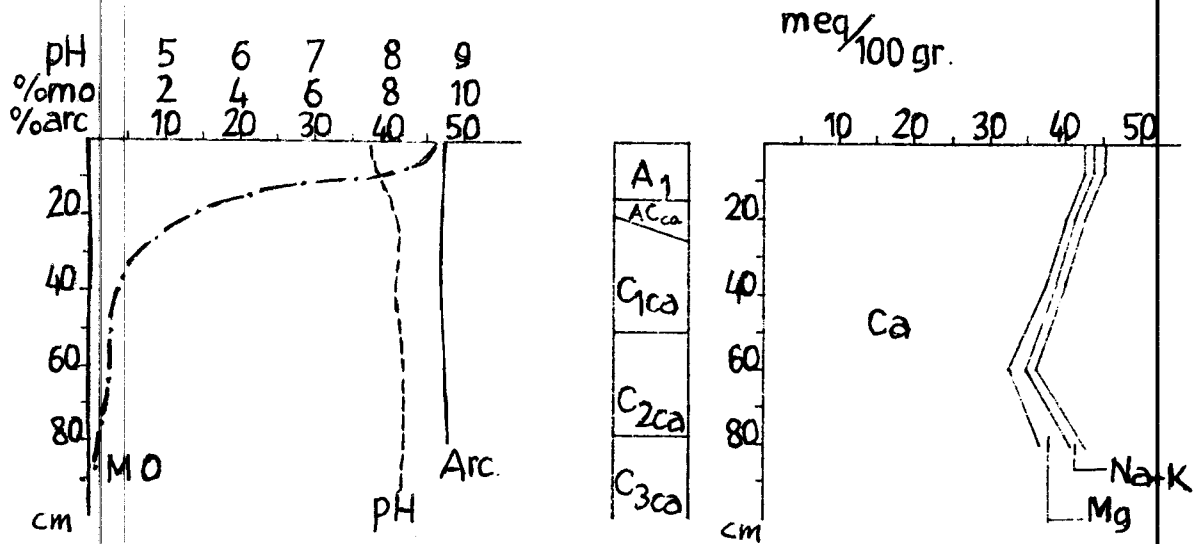
A1	0-15 cm. Negro (10YR 2/1); arcilloso a arcillo limoso; muy plástico y pegajoso; bloques subangulares finos y granular gruesa, fuertes; transición gradual.
ACca	15-20(25) cm. Pardo (10YR 5/3) y gris muy oscuro (10YR 3/1); arcilloso a arcillo limoso; muy plástico y pegajoso; bloques subangulares finos y granular gruesa, fuertes; concreciones de CaCO ₃ medianas, comunes friables y duras; reacción al HCl fuerte; transición gradual e irregular.
C1ca	20(25)-51 cm. Pardo (10YR 5/3) y (7.5YR 5/2); arcilloso e arcillo limoso; muy plástico y pegajoso; bloques subangulares finos y medios, moderados; caras de deslizamiento comunes; algunos nódulos negros 0.5 a 1 cm; concreciones de CaCO ₃ grandes, abundantes, friables; reacción al HCl muy fuerte; transición clara.
C2ca	51-78 cm. Gris oscuro (10YR 4/1), arcilloso; muy plástico y pegajoso, caras de deslizamiento abundantes; revestimientos (vetas) de color prado (10YR 5/3) comunes; concreciones de CaCO ₃ muy grandes, abundantes, friables; reacción al HCl muy fuerte; transición gradual.
C3ca	78+ cm. Pardo (10YR 5/3) y (7.5YR 5/2) con moteado pardo grisáceo (2.5Y 5/2) mediano, poco, tenue; arcilloso con algunas gravillas y gravas; plástico y pegajoso; caras de deslizamiento abundantes; algunas vetas negras; concreciones de Fe Mn pequeñas, pocas, duras y de CaCO ₃ muy grandes, abundantes y friables; reacción al HCl muy fuerte.

Graphs of analytical data, Fase Profunda and Fase Superficial

Representación gráfica de los datos de caracterización
Fase Profunda



Fase Superficial



Analytical data Fase Superficial

DEPARTAMENTO : TENDILIA		PARAJE : Carandi Grande					Vertisol Rúptico Típico AcL			
SEGMENTO		SECTOR			PERFIL <u>fase superficial</u>					
Nº Análisis	5755	5756	5757	5758	5759					
Profundidad en cms.	0-15	15-20/20-25	20/25-51	51-78	78+					
Horizonte	A	A-Cca	C ₁ ca	C ₂ ca	C ₃ ca					
Humedad 100 - 105°C	6.69	7.47	6.26	6.91	6.66					
Factor a seco	1.072	1.091	1.067	1.074	1.071					
pH	En H ₂ O	7.8	6.1	6.1	8.2	8.2				
	En KCl:N	6.9	7.0	6.9	7.0	7.0				
P Bray Nº 1 ppm.s	6	2	2	4	2					
DATOS REFERIDOS POR 100 grs. DE TIERRA SECA A 100 - 105°C										
Análisis mecánico internacional	ARENAS	Muy gruesa 2 - 1 mm %	3.4	3.5	3.4	3.9	3.8			
		Gruesa 1 - 0.5 mm %	3.4	3.4	3.2	4.7	3.3			
		Mediana 0.5 - 0.25 mm %	3.9	3.4	3.0	4.3	3.1			
		Fina 0.25 - 0.10 mm %	3.2	2.8	2.8	3.8	2.9			
		Muy fina 0.10 - 0.05 mm %	0.9	0.4	1.4	1.5	1.5			
	Análisis mecánico internacional		Arena Total %	14.8	13.5	13.8	18.2	14.6		
	Limo %	38.1	39.6	39.2	34.7	37.8				
	Arcilla %	47.1	46.9	47.0	47.1	47.6				
	Textura*	Ac-AcL	Ac-AcL	Ac-AcL	Ac.	Ac.				
Materia orgánica %	8.43	2.55	0.97	0.74	0.35					
Carbono orgánico %	4.89	1.48	0.56	0.43	0.20					
Nitrógeno total %	0.42	0.16	0.08	0.05	0.05					
Relación C/N	11.6	9.3	7.0	8.6	4.0					
COMPLEJO DE INTERCAMBIO me / 100 g	Ca con KCl/N pH ^{SUE} ₁₀	42.8	40.1	37.4	32.9	36.9				
		Mg " " "	1.2	1.3	1.5	2.1	3.9			
			K	1.0	0.9	0.8	0.6	0.7		
	Na	0.5		0.5	0.5	0.7	0.6			
		Bases totales	45.5	42.8	40.2	36.3	42.1			
	Al									
		Acidez interc. pH 7.0								
	Capacidad Total pH 7.0 ^x		45.5	42.8	40.2	36.3	42.1			
		% de saturación pH 7.0	100	100	100	100	100			
	Acidez interc. pH 8.2									
		Capacidad Total pH 8.2 ^{xx}	45.7	39.8	36.8	32.0	38.6			
% de saturación pH 8.2										
	Rel. Ca/Mg		35.7	30.8	24.9	15.7	9.5			
CIC Arcilla (x)		60.8	80.4	61.4	73.9	87.0				
C.I.C. de la Arcilla (xx)		61.2	74.0	74.2	64.8	79.6				
Ox. de Hierro libres (Fe ₂ O ₃) %										
Carbonatos (Ca CO ₃) %										
Cond. mmhos/cm 1/25°C										
Na de sales me / 100 g										
K de sales me / 100 g										
Cloruro (Cl) me / 100 g										
Sulfato (SO ₄) me / 100 g										
Ca con Ac. NH ₄ manos	18.5	18.5	16.9	17.0	17.1					
Ca con HCl/N										

(x) por suma de bases a pH suelo.

(xx) por Acetato de NH₄ a pH7.

Appendix 3. ANALYTICAL METHODS

The methods of the physical, chemical, and mineralogical analysis are given below.

This list is by no means final as methods may be changed or superseded by others and analyses of other characteristics may be added.

- *Particle size distribution*

Cementing materials are removed by mild acid (pH 5) buffer of NaOAc/HOAc and H₂O₂ (formerly, HCl was used instead of buffer). If carbonates are present, H₂O₂ is added only after cessation of effervescence and subsequent decantation and centrifuge washing (to avoid formation of Ca-oxalate). Dispersion with sodium pyrophosphate and shaking overnight. Particles larger than 50 µm are separated by sieving; smaller particles by pipette method. Of late: buffer treatment is omitted when carbonates are absent.

- *pH*

With pH-meter in 1:2.5 suspension with water and 1 N KCl solution. The extract is monitored for soluble salts with conductivity meter.

- *CaCO₃*

Scheibler's or Van Wesemael's methods: measurement of CO₂ after addition of HCl. Of late: rapid titration method. HCl is added to the sample, after reaction the unused acid is titrated with NaOH.

- *Organic matter*

Organic carbon: Walkley-Black. Oxidation with potassium dichromate and sulphuric acid. Residual dichromate is titrated against ferrous sulphate.

Nitrogen: Micro-Kjeldahl. The sample is digested with sulphuric acid. After addition of excess sodium hydroxide, ammonia is distilled, absorbed in boric acid and titrated with potassium biiodate or HCl.

- *Free iron oxides*

Reduction of iron with Na-dithionite in Na-citrate NaHCO₃ buffer solution. Determination of iron colorimetrically or by AAS.

- *Exchangeable cations and cation exchange capacity (CEC)*

Percolation of the sample with ammonium acetate (pH 7 or 8.2), determination of calcium and magnesium by AAS, sodium and potassium flamephotometrically.

The sample is then saturated with Na, in turn replaced by NH_4 after which Na is determined flamephotometrically for the CEC. The CEC of clay is derived from the CEC of total soil, in case of appreciable organic matter content such a calculation will be in serious error and is then omitted.

(Ca as exchangeable cation is not determined whenever free CaCO_3 is present.)

- *Electrical conductivity*

Specific conductivity of 1:2.5 extract ($\text{EC}_{2.5}$).

- *Water soluble salts*

Determination of ions in saturation extract or in 1:5 extract. Carbonate and bicarbonate by titration, chloride by titration, sulphate by turbidity of suspended barium sulphate, nitrate as ammonia by distillation and subsequent titration or colorimetrically, sodium and potassium flamephotometrically, calcium and magnesium by AAS. Of late: anions by Dionex analyzer (except carbonates).

- *Elemental composition*

By X-ray fluorescence analysis. Sodium flamephotometrically after digestion of sample in $\text{HF}/\text{H}_2\text{SO}_4$.

For clay analysis, the fine earth is pretreated as described for particle size analysis, except that dispersion is done with NaOH instead of pyrophosphate. Clay is separated by siphoning procedure. Part of the clay suspension is kept in plastic bottles for mineral analysis (item 22), part is flocculated with Ba, centrifuge-washed and freeze-dried for chemical analysis (item 21).

- As 20; sample is Ba-saturated clay as indicated above.

- *Clay mineralogy*

With X-ray diffractometer using the porous plate technique. When necessary, Guinier X-ray photographs for non-phyllsilicates. Thermal analysis (DTA and TG), selective dissolution analysis (SDA) and other techniques in

special cases (complicated samples; abundant amorphous material). The relative abundance of the mineral in the clay fraction is indicated by the number of ++ for clay minerals and xx for other minerals.

Kaol = kaolinite; Mi/ill = mica/illite; Verm = vermiculite;

Chlor = chlorite; Smec = smectite; Mix = mixed layer; Gibb = gibbsite;

Quar = quartz; Feld = feldspars; Goeth = goethite; Hem = hematite.

- *Sand mineralogy*

Fractions obtained with particle size analysis are deferrated by Na-dithionite treatment. Silt fraction analysed by X-ray diffraction (Guinier photos), sand fraction divided in light and heavy subfraction (bromoform), weighed and analysed microscopically.

- *Bulk density*

Estimated from dry weight of undisturbed core samples after determination of moisture characteristics.

- *Soil moisture characteristics*

By pressure plate extraction of undisturbed core samples (low tension range) and of disturbed soil material (high tension range). From the obtained pF-curve the available moisture (between pF 2.0 and pF 4.2) is derived. Of late: low tension also on silt/kaolin bath.

Other, non-routine analyses:

- *Extractable acidity*

Replacement from soil with TEA (triethanolamine) buffer and barium chloride. Back titration of buffer with HCl.

- *Exchangeable acidity (H + Al)*

Replacement from soil with 1 N KCl. Acidity determined by titration with NaOH (phenolphthalein as indicator) by AAS. Exchangeable aluminium by AAS in this extract.

- ~~pH~~-NaF

Mix 1 gram of soil in 50 ml 1 N NaF solution. pH measured after 2 minutes with pH-meter.

- "Free" Fe and Al in 3 extracts

This procedure supersedes the free iron oxides analysis given above. Extraction with Na-dithionite, NH₄-oxalate and Na-pyrophosphate. Fe and Al measured by AAS. In oxalate extract Si is also measured by AAS.

- Gypsum

Precipitation with acetone from 1:5 extract. Measurement by conductivity of re-dissolved precipitate.

- Coefficient of linear extensibility (COLE)

Calculated from difference in bulk density of a SARAN-coated clod when dry and when moist.

- ~~Water~~-dispersable clay

Determining clay content by pipette method after shaking the soil with water overnight without applying any pretreatment.