AGROPEDOLOGY, 4:1994

Characterisation and Classification of Vertisols Derived from Different Parent Materials

I.Y.L.N. MURTHY *, T.G. SASTRY**, S.C. DATTA, G. NARAYANASAMY AND R.K. RATTAN

Division of Soil Science and Agricultural Chemistry, Indian Agricultural Research Institute, New Delhi - 110 012.

Abstract : *Vertisols developed on basaltic parent material showed higher clay content, CEC, WHC and lower pH and EC. Irrespective of parentage, all the pedons are calcareous. Steep reduction in organic carbon was noticed in the basalt and granitic- granodiorite parent material soils. Basalt, Granitic- granodiorite and Limestone parentage soils are placed under 'Calcic Chromusterts' while Grey shale and Granodiorite parentage soils are classified as 'Typic Chromustert' and 'Calcic Pellustert' respectively.* (**Key words**: *parent material, Vertisols, physico-chemical properties, pedon, taxonomic classification).*

Parent matrerial is one of the important factor responsible for variation in soil properties. A genetic profile is a product of physical, chemical and biological processes acting upon a given parent material. The degree of profile development conditioned with the climate gives rise to different diagnostic features to the soil. Based on there diagnostic features, the soils are being grouped into different classes in order to understand the similarity of behaviour for better land use planning. In the present investigation, soil variability as related to parent material and on different physical, physico-chemical properties of soil is discussed.

MATERIAL AND METHODS

Soil samples were collected horizonwise from five pedons, one each from village Suhagpur Dhana (Betul district, Madhya Pradesh), Panjari Farm, Central Institute for Cotton Research, Nagpur (Nagpur district, Maharashtra), Baklavanvalli, Makthal and Undevalli (Mahaboobnagar district, Andhra Pradesh). The pedons were described as below as per standard procedures (Soil Survey Manual 1970). Air dried soil samples (< 2 mm) were analysed for mechanical composition, pH, EC, CEC, WHC, organic carbon and $CaCO_3$.

* *Central Institute for Cotton Research, Regional Station, Coimbator - 641 003;* ** *Deceased.*

PEDON 1

Location	:	Suhagpur Dhana village
Climate	:	Semiarid
Vegetation	:	*Parthenium* sp., *Datura sp.*, *Acacia sp.* and short grasses
Geology	:	Grey shale
Permeability:		Slow
Drainage	:	Poorly drained
Land use	:	Cowpea, soybean, mungbean and wheat. (Irrigated).
Profile description	:	

Ap	0-14 cm	Grayish brown (10 YR 5/2) when dry, clay, medium moderate subanglar blocky; hard, firm, sticky and plastic manay roots; when wet glazed appearance, clear and smooth boundary.
A	14-40 cm	Greyish brown (10 YR 5/2) when dry, clay, medium moderate subangular blocky; hard, firm, sticky and platic; slickensides, few roots; clear and smooth boundary.
AC	40-70 cm	Greyish brown (10 YR 5/2) when dry, clay, coarse moderate subangular blocky; hard, firm, very sticky and very plastic, slight effervescence, slickensides, clear and smooth boundary.
C	70-100 + cm	Greyish brown (10 YR 5/2) when dry, clay, coarse medium subangular blocky, hard, firm, very sticky and plastic, effervescence, hexagonal cracks present upto 100 cm depth.

PEDON 2

Location	:	Panjari Farm, CICR, Nagpur
Climate	:	Subhumid
Vegetation	:	Cotton, wheat, sorghum, subabul, neem, *Acacia sp.* tamarind, Parthenium, etc.
Geology	:	Basalt
Permeability	:	Slow
Drainage	:	Moderately well
Land use	:	Cotton, wheat, jowar, and green manuring crops. (rainfed).

Profile description :

Ap 0-14 cm	Dark brown (10 YR 4/3) when dry, clay, fine granular, hard, firm, sticky and plastic, slight effervescence, many roots, gradual and smooth boundary.
A 14-30 cm	Black (10YR 5/2) when dry, clay, medium moderate subangular blocky, hard, firm, sticky and plastic, slight effervescence, slickensides, many roots, diffuse smooth boundary.
AB 30-46 cm	Black (10 YR 5/2) when dry, clay, coarse medium angular blocky; hard, firm, sticky and plastic, slight effervescence, slickensides, diffuse smooth boundary
AC 46-60 cm	Black (10 YR 5/2) when dry; clay; coarse angular blocky; hard, firm, very sticky and plastic, slight effervescence, few roots, slickensides, diffuse smooth boundary.
C 60-100 + cm	Black (10 YR 4/2) when dry, clay, coarse medium angular blocky, hard, firm, very sticky and very plastic, slight effervescence, diffuse wavy boundary.

PEDON 3

Location	:	Baklavanvalli, 5 km from Mahaboobnagar on way to Deverakadra.
Climate	:	Semiarid
Vegetation	:	*Acacia sp.*, Parthenium,
Geology	:	Granite-granodiorite
Permeability	:	Slow
Drainage	:	Poorly drained
Land use	:	Pearl millet, jowar

Profile description :

Ap 0-10 cm	Black (10 YR 5/2) when dry; clay; medium moderate subangular blocky; hard firm, sticky and plastic; slight effervescence; many small roots; medium moderate angular blocky; cracks upto 18 cm depth, clear and smooth boundary.
A 10-40 cm	Light black (10 YR 4/2) when dry, clay, medium moderate angular blocky, hard, firm, sticky and plastic, slight effervescence, few fine roots, cracks upto 18 cm depth, slickensides' clear and smooth boundary.

Ac 40-60 cm	Very light black (10 YR 5/2) when dry, gravelly clay, medium modeate angular blocky, slightly hard, firm, sticky and plastic, slight effervescence, slickensides, abrupt boundary.
C 60-80 + cm	Very light black (10 YR 5/2) when dry, clay loam, medium moderate subangular blocky, slight effervescence, weathered granodiorite material.

PEDON 4

Location	:	Makthal; 1.5 kilometers away from Makthal bus stand.
Climate	:	Semiarid.
Vegetation	:	*Acacia sp., Datura sp.* shrubs and small grasses.
Geology	:	Granodiorite
Permeability	:	Slow to moderate.
Land use	:	Paddy, jowar

Profile description :

Ap 0-14 cm	Black (10YR 4/3) when dry, clay loam, medium moderate subangular blocky, slightly hard, firm, sticky and plastic, slight effervescence, many roots, few medium pores, clear and smooth boundary.
A 14-36 cm	Black (10 YR 4/1) when moist, clay, coarse medium angular blocky, slightly hard, firm, sticky and plastic, slight effervescence, medium few roots, gravels, quartzite, 2 cm wide cracks, slickensides, clear and smooth boundary.
AC 36-50 cm	Black (10 YR 3/1) when moist, clay, coarse subangular blocky, hard, firm sticky and plastic, strong effervescence, few fine roots, quartzite gravels, 2 cm wide cracks, stress cutans present with sand deposition, artefacts present, gradual smooth boundary.
C 50-100 + cm	Black (10 YR 4/1) when moist, clay, medium angular blocky, slightly hard, firm, sticky and plastic, strong effervescence, few fine roots, 1 cm width crack, stress cutans with sand deposition, few pores, cracks upto 76 cm depth.

PEDON 5

Location	:	Undevalli 194 from Hyderabad on Hyderabad-Kurnool highway.
Climate	:	Semiarid.
Vegetation	:	Tree:*Acacia sp.* and small grasses
Geology	:	Limestone.

Permeability : Slow

Drainage : Poorly drained

Land use : Sorghum, pearl millet.

Profile description :

Ap 0-10 cm — Black (10 YR 4/2) when dry, and (10 YR 3/2) when moist, clay loam, medium moderate subangular blocky, slightly hard, firm, sticky and plastic, effervescence, medium few roots few fine pores, $CaC0_3$ concretions upto 3 mm size; coarse fragments, potteries present; cracks upto 10 cm, clear and smooth boundary.

A 10-28 cm — Black (10 YR 3/2) when moist, clay, medium moderate subangular blocky; slightly hard, firm, sticky and plastic, strong effervescence, fine few roots, no pores, $CaC0_3$ concretions upto 3 mm size, slickensides, clear and smooth boundary.

AC 28-62 cm — Black (10 YR 3/2) when moist, clay, medium moderate subangular blocky, slightly hard, firm, sticky and plastic, strong effervescence' few fine roots, patches of $CaC0_3$ concretions, slickensides, clear and smooth boundary.

C 62-102+ cm — Black (10 YR 3/2) when moist, clay, coarse moderate angular blocky, slightly hard, firm, sticky and plastic, strong effervescence, many $CaC0_3$ concretions.

RESULTS AND DISCUSSION

Mechanical composition reveals that clay content is minimum in Ap horizon of pedon 4 developed on granodiorite. Barring Ap horizon of pedon 4 and C horizon of pedon 3, rest of the samples fall in 'clayey' textural class (Table 1). There is an evidence of increase in clay content with depth in all the profiles.

Soils developed on trap or basalt parent material are found to be deep and clayey in texture. Uniformity within the profile in respect of texture is due to the pedoturbation- a major pedogenic process operating in Vertisols (Buol *et al.* 1980; Ahmed 1983) is inhibiting the horizonation (haploidization). Textural variation may be due to the position and location of the profile. Topography of the locality influences the texture of the soil; In case of slopy land, all the weathered products will be carried to the low lying areas. In the present investigation heavier texture encountered

Table 1. Mechanical composition (on soil basis) and physico-chemical properties of soils

Horizon with(cm) depth	Sand (%)	Silt (%)	Clay (%)	Texture	pH (1:2 5)	E.C (dSm^{-1})	CEC (cmol (+) kg-1)	OC (%)	Moisture 33kPa	$CaCO_3$ (%)
Pedon 1 (Grey shale)										
Ap (0-14)	12.2	34.3	47.3	C	7.25	0.10	42.0	0.76	33.1	6.5
A (14-40)	10.2	33.3	48.5	C	7.13	0.25	37.0	0.44	33.6	8.5
AC(40-70)	9.2	32.8	49.8	C	7.15	0.10	38.2	0.48	36.2	9.0
C (40-110 +)	9.1	32.1	32.1	C	7.15	0.25	38.2	0.43	36.4	9.5
Pedon 2 (Basalts)										
Ap(0-14)	2.0	25.4	59.1	C	7.22	0.25	49.5	0.67	40.1	15.5
A (14-30)	1.6	24.3	62.4	C	7.18	0.10	48.2	0.50	40.5	13.0
AB (30-46)	1.3	21.6	65.5	C	7.16	0.10	46.4	0.39	41.2	13.0
AC(46-60)	1.8	22.4	63.8	C	7.14	0.15	48.2	0.38	45.9	13.5
C (60-100 +)	1.1	22.2	63.6	C	7.21	0.25	46.3	0.24	45.3	15.0
Pedon 3 (Granite granodiorite)										
Ap (0-10)	43.2	7.1	40.6	C	7.9[illegible]	1.20	24.4	0.88	29.5	10.0
A (10-40)	34.2	12.0	43.4	C	8.41	1.20	29.4	0.39	40.1	11.5
AC (40-60)	25.0	4.9	38.6	C	8.80	1.10	53.9	0.17	54.3	46.0
C (60-80 +)	43.0	9.2	23.6	C	8.83	1.20	32.0	0.12	37.6	32.0
Pedon 4 (Granodiorite)										
Ap (0-14)	49.3	9.1	25.9	C	8.14	0.40	28.1	1.19	31.0	18.5
A (14-36)	25.8	10.1	42.0	C	8.07	0.75	29.0	0.81	33.0	28.0
AC (36-50)	21.7	9.6	43.3	C	8.01	0.90	30.3	0.74	36.0	26.5
C (50-100 +)	24.9	7.1	51.6	C	8.00	0.70	29.4	0.58	37.6	19.5
Pedon 5 (Lime stone)										
Ap (0-10)	8.0	13.5	62.0	C	7.60	0.20	42.0	0.55	33.0	19.5
A (10-28)	6.2	14.0	63.8	C	7.56	0.35	53.9	0.46	33.8	19.0
AC (28-62)	5.5	14.0	66.0	C	7.41	0.25	49.5	0.44	36.3	17.0
C (62-102 +)	4.0	13.8	68.0	C	7.29	0.30	54.5	0.41	35.9	16.5

* C = claycy; cl = clay loam

in soils derived from granitic parent material. This may be due to the modifying effects induced by dominance of topography.

Moisture retained at 33 kPa pressure almost follows a similar trend as does the clay content (Table 1). Maximum moisture retention is observed in pedon 2 (derived from basalt). Subsurface horizon of pedon 3 (AC) exhibits maximum water retention at 33 kPa. All other pedons show comparable moisture retention capacity. The clay content and nature of clay depend on parent material. The water holding capacity depends upon the type of minerals present. Soil developed on trap (basalt) shows higher values of WHC than other soils developed on granitic or metamorphic parent material.

Pedon 2 and 4 exhibit strong alkalinity as indicated by pH data (Table 1). Development of sodicity in lower layers of pedon 3, is an indication of soil chemical degradation. Pedons 1 and 2 are almost neutral in reaction. With the exception of pedon 3, there is a tendency for the pH to fall gradually with increase in soil depth.

Cation exchange capacity does not show any regular trend with depth. It is highest in pedons 2 and 4 developed on basalt and limestone, respectively, followed by pedon 1. AC horizon of pedon 3 exhibits the highest cation exchange capacity. Data on soluble salts indicated EC much below the limit of 4 dSm^{-1} in all the pedons. However, on comparative basis, pedons 5 and 4 (limestone and granodiorite parent material, respectively) show a tendency towards salinization.

All pedons are calcareous in nature. Except for pedon 1, free calcium carbonate in all the pedons at all the depths exceeds 10 per cent (Table 1). Subsurface hgorizons of pedon 3 developed on granitic-granodiorite and pedon 4 derived from granodiorite indicate very high accumulation of free calcium carbonate. There was no consistent pattern in calcium carbonate content with depth, though its content is relatively high in lower horizons. All the pedons show decrease in organic carbon content with increase in soil depth. In terms of organic carbon content in Ap horizon, the pedons can be arranged in the order: pedon 4 (granodiorite) pedon 1 (grey shale) pedon 5 (limestone) pedon 2 (Basalt) pedon 3 (granitic-granodiorite). The reductions in organic carbon content

with depth in pedons 3 and 2 is more prominent.

The results of physico-chemical characteristics of the soils (pH, EC, CEC and organic carbon) are in consonance with the studies of Subbiah and Manickam (1987). $CaCO_3$ present in soils tends to enhance the soil pH as indicated from the significant correlation ($r = 0.76$) between the pH and $CaCO_3$. The organic carbon content in the pedons exhibits the same trend as reported for the soils of semiarid tropics by Roychowdhury *et al.* (1984). A significant positive correlation ($r = 0.76$) observed between clay content and CEC on one hand and lack of association of organic carbon with CEC on the other, indicates that the nature of clay (i.e. smectite) rather than organic carbon content is responsible for the higher CEC. $CaCO_3$ content in the soil developed on trap should be high but in this case it is medium, the reason being that under intense rainfall it has probably been leached out of profile. Correlation coefficients show the significant interdependence among pH, EC, CEC, and clay content. Soils derived from basaltic rocks have high clay content, CEC and WHC and lower pH and EC.

In the present study different parent materials viz. basalt, granitic-granodiorite, granodiorite, limestone, and shale are apt to influence the formation of smectitic type of clay mineral besides other minerals. Clay fractions obtained from different parent materials, do not indicate a very marked difference, however it is accepted that easily weatherable minerals of trap or basalt parent material give rise to smectitic clays. Granitic parent materials having biotite and muscovite in very small proportion, weather to yield montmorillonite and illite type of clays. It is the characteristics feature of the Vertisols to be dominated by smectite type of clay (Pal & Deshpande 1985). Ahmed (1983) reported that kaolinite was always present in Vertisols, irrespective of the origin, location or environmental conditions. It is however, to be admitted that weathering phenomenon and soil development, especially in the tropics are so closely related with parent materials, that a complete understanding of the processes involved can only be achieved by giving due consideration to the parent rock and its components, as well as to the mineral constituents found in the soil.

Soil classification : The diagnostic horizons and other characteristics were recognized for all the five pedons (Table 2) and arranged them suitably in taxonomic system (Soil Survey Staff 1975). The pedons have depth of more than one metre, with lithic or paralithic contact within 50 cm depth; clay content more than 30 per cent within 50 cm depth; cracks wider than one cm at 50 cm depth, wedge shaped soil structure in sub-surface horizons except few which had surface mulch; gilgai mic rorelief and slickensides development in all pedons. By this criteria the pedons are are placed under the order 'Vertisol'.

The study area has semiarid and subhumid monsoonic climate i.e. distinct rainy and dry seasons with cracks remaining open for 90 cumulative days or more during the year and mean annual temperature of more than 22°C. Thus, these soils can be classified under the suborder Usterts. Among the pedons, pedon 4 had chroma less than 1.5 throughout the upper 30 cm depth. Hence it is placed under the great group Pelluststerts.

TABLE 2. Placement of pedons in Soil Taxonomy System

Pedon No.	Diagnostic horizon	Order	Suborder	Great group	Subgroup	Family
1	Vertic	Vertisol	Usterts	Chromusterts	Typi Chromusterts	Fine clayey smectitic, hyperthermic
2	Vertic	Vertisol	Usterts	Chromusterts	Calcic* Chromusterts	Very fine clayey, smectitic,hyperthermic
3	Vertic	Vertisol	Usterts	Chromusterts	Calcic* Chromusterts	Fine clayey, smectitic,hyperthermic
4	Vertic	Vertisol	Usterts	Pellusterts	Calcic* Pellusterts	Fine clayey, smectitic,hyperthermic
5	Vertic	Vertisol	Usterts	Chromusterts	Calcic* Chromusterts	Very fine clayey, smectitic,hyperthermic

* The subgroup has been newly introduced in 1986 by Sehsagiri Rao, The C horizon was having more than 15% of free $CaC0_3$ (absolute value of 23.75%). There was no subgroup having calcic horizon under Chromusterts. So 'Calcic' subgroup was introduced.

The other pedons 1, 2,3 and 5 have chroma of 1.5 or above in the upper 30 cm or more than half the depth of each pedon hence placed under the greatgroup Chromusterts.

At subgroup level only period of cracking and colour value were taken as criteria, irrespective of the calcium carbonate content. Free calcium carbonate content of C horizon is more than 15% in pedons 2, 3 and 5. Therefore they are placed Calcic Chromustert while pedon 4 is placed under Calcic Pellustert a new subgroup introduced by Seshagiri Rao (1986).

All the soils have predominantly smectitic clay minerals and high CEC values which are in favour of formation of smectite. These soils are placed under hyperthermic temperature regime depending on the difference between mean annual summer and winter temperatures by more than 5°C. Texturally, these soils are placed under fine and very fine depending upon the clay per cent of less than 60 or above.

ACKNOWLEDGEMENTS

Senior author is thankful to IARI, New Delhi for awarding the fellowship and all other facilities to conduct the above research work. He is also thankful to AISS&LUP for their help in the field studies and collection of soil samples.

REFERENCES

Ahmed, N. (1935) Vertisols in 'Pedogenesis and soil taxonomy II. The soil orders'. (Edgs. L.P. Wilding, N.E. Smeck and G.F. Hall). p. 91. Elsevier, Amsterdam.

Buol, S.W., Hole, F.D. & McCracken, R.S. (1980) Soil genesis and classification. Oxford and IBH Publishing Co.

Jackson, M.L. (1967) *Soil Chemical Anaysis.* Prentice Hall of India, New Delhi.

Jenny, H. (1941) Factors of soil formation. McGraw-Hill, New York.

Pal, D.K. & Deshpande, S.B. (1985) Characteristics and genesis of minerals in some benchmark vertisols of India. *Pedologie* XXXCII, 259.

Roychowdhury, C., Sharma, J.P., Challa, O. & Gaikawad, S.T. (1984) Environs and their impact on soil catena under different climatic conditions. Seminar on Soil Resources and Productivity Management, Indian Society of Soil Science Golden Jubilee and 49th Annual Convention, Dec. 7-10, New Delhi, p. 121.

Seshagiri Rao, M. (1986) Genesis and transofrmation of minerals in associated Ustalfs and Usterts of Telengana region of Andhra Pradesh. *Ph.D. Thesis*, IARI, New Delhi.

Soil Survey Manual (1970) All India Soil and Land Use Survey Organisation, IARI, New Delhi.

Soil Survey Staff (1975) Soil Taxonomy, U.S. Dept. Agric. Handbook 436, U.S. Govt. Printing Office, Washington, D.C.

Subbiah, G.V. & Manickam, T.S. (1987) Classification of black soils in dryland area of Andhra Pradesh. *Andhra agric. J.*, **34.**