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Identification of Clay Minerals with Different Parent Soils of Renigunta Mandal in Chittoor District, Andhra Pradesh

S. Selvaraj* and M.V.S. Naidu
Department of Soil Science and Agricultural Chemistry,
S.V. Agricultural College (ANGRAU), Tirupati, 517 502, Andhra Pradesh

The work was carried out with different parent materials to identify various clay materials in Reniguntal mandal of Chittoor district, Andhra Pradesh. The soils had pH 6.2 to 8.96, clay 3.74 to 46.58 % and CEC 2.16 to 43.63 cmol (p_+) kg_{-1}. In general, surface horizon had relatively higher organic carbon and decreased with depth. Soils were low in available nitrogen and phosphorus, low to medium in available potassium and high in available sulphur. Seven representative pedons were selected after surveying the areas for the study of clay minerals. The mineralogical and chemical characteristics of soils developed from granite-gneiss and calcareous murrum and alluvium parent materials. The clay film invariably exhibited the characteristic peaks of illite and kaolinite. Semi-quantitative estimates of clay fractions based on relative areas under corresponding peaks indicated that all the pedons dominated by illite and kaolinite followed by Feldspars. Quartz is present in traces. However, use and management of these soils for agricultural production require an understanding of their clay mineralogy.

Key words: Clay mineralogy, parent materials, illite, kaolinite, quartz, feldspars

Soil is very dynamic, ever-changing and evolving and continued response of the soil to its environment that determines its state of productivity. Soil is the most important basic natural resource which determines the ultimate sustainability of any agricultural system. Clay is an important soil constituent that controls its properties and also influences its management and productivity (Davies *et al.,* 1972). Clay with cementing agents contributes structural stability that helps in resisting the destructive effects of rain and wind. Moreover, clays have a large specific area that is mostly negatively charged and these sites retain nutrients like K_+ and NH_{4+} ions and also adsorb many toxic elements. The mineralogy of soil clays is the results of several factors interacting with the parent material. In certain combination of circumstances soil forming processes exhibit their effects on the clay mineralogy *viz.,* Oxisols, Vertisols and Andisols (Newman, 1984).

Knowledge of clay minerals in soils is thus critical to our understanding and use of the soil. However, there is no information available on clay mineralogy of soils of Renigunta mandal of Chittoor district. Hence, the present study was carried out to identify the clay minerals in those soils for their sustainable management.

Materials and Methods

Study area

The study area is located between 13_0 32' and 13_0 53' North latitude and 79_0 29' and 79_0 50' East longitude. The area is semi-arid with mean annual precipitation of 1286.02 mm and mean annual air temperature of 27.98 $_0$C. The soils of the study area are formed from granite-gneiss and calcareous murrum parent materials.The area under investigation has natural vegetation of *Azadirachta indica, Lantana camara* , *Cynodon dactylon*, *Cyprus rotundus*, *Parthenium hysterophorus* and *Lucas aspera.*

Seven representative pedons (P_1 to P_7) of Renigunta mandal in Chittoor district of Andhra Pradesh were selected after surveying the area. The horizon- wise soil samples were collected for analysis of chemical parameters whereas the samples collected from control section (25-100 cm) of the pedons were analysed for clay minerals.

The chemical parameters were determined by following standard procedures. The clay fractions were separated by sedimentation technique (Jackson, 1979). The clay samples were saturated with Ca and K. The Ca saturated samples were solvated with ethylene glycol (EG) and the K-saturated samples were heated to 105, 300 and 550 $_0$C. The X-ray diffraction analysis was carried out on Philips diffractometer using CuKQ radiation with Ni filter. All the specimens were scanned at a speed of 2_0 2è per minute. The semi-quantitative estimation of clay minerals was made based on peak intensities (Gjems, 1967).

*Corresponding author email: selvaraj147@gmail.com

Results and Discussion

The general features of the study area have been reported in Table 1. Pedons 1, 2 and 3 occurring on gentle slopes (3-8%) and pedons 5 and 6 developed from plains (0- 1%) were originated from granite-gneiss. Pedon 4 and 7 lying on plains were originated from calcareous murrum and alluvium parent materials, respectively. The drainage varied from well drained to moderately well drained. Most of the area was under agricultural field crops (Table 1).

Table 1. Salient soil site characters of the study area in different villages (Pedon 1 to 7)

Features (Location)	Pedon 1 (Balaepalli*)	Pedon 2 (Mamandur*)	Pedon 3 (Karakampadi*)	Pedon 4 (Veddalacheruvu*)	Pedon 5 (Kothapalem*)	Pedon 6 (Suraprakasam*)	Pedon 7 (Thandlam*)
Physiology	Upland	Upland	Upland	Plain land	Plain land	Plain land	Plain land
Slope (%)	3-8	3-8	3-8	0-1	0-1	0-1	0-1
Elevation (msl)	118 m	118 m	118 m	118 m	118 m	118 m	118 m
Drainage	Well drained	Well drained	Well drained	Moderately well drained	Well drained	Well drained	Moderately well drained
Parent material	Alluvium	Stones mixed with soil	Granite-gneiss	Calcareous murrum	Gnanite – gneiss	Gnanite – gneiss	Alluvium
Erosion	Moderate	Moderate	Moderate				
Land use	Agricultural field crops						

Chemical Composition

The data on chemical composition (Table 2) show that the soils are slightly acidic (pH = 6.2) to strongly alkaline (pH = 8.96) and have very low to medium content of soluble salts. The cation exchange capacity of the soils ranges from 2.16 to 43.63 cmol (p_+) kg_{-1} which is related to the variation in content and nature of organic and inorganic colloids in soils. The base saturation on the

Table 2. Chemical composition of Renigunta soils

Pedon no. & horizon	Depth (m)	pH (1:2.5)	EC (dSm_{-1})	CEC {cmol (p_+) kg_{-1}}	SiO_2 (%)	Fe_2O_3 (%)	Al_2O_3 (%)	P_2O_5 (%)	K_2O (%)	Na_2O (%)	CaO (%)	MgO (%)	LOI (%)
Pedon 1.Fine loamy, illitic, iso hyperthermic,Typic Haplustalfs (Upland)													
Ap	0.00-0.20	7.80	0.17	20.2	82.98	4.23	8.27	0.06	0.76	0.11	2.37	1.30	6.50
A1	0.20- 0.48	7.33	0.15	19.2	84.20	4.97	6.98	0.08	0.66	0.09	1.98	0.48	5.30
E	0.48-0.71	7.00	0.06	22.8	83.80	5.84	6.41	0.09	0.93	0.10	1.30	0.53	4.86
Bt1	0.71-0.96	7.46	0.12	22.3	81.90	5.88	7.37	0.45	0.02	0.09	2.98	0.89	2.12
Bt2	0.96-1.18	7.87	0.21	20.1	83.90	4.76	5.74	0.08	0.51	0.08	2.26	1.96	7.27
C	1.18-1.60	7.27	0.22	25.1	82.00	4.54	6.46	0.10	0.64	0.09	2.40	1.90	8.29
Pedon 2 . Fine-loamy, silicious, iso-hyperthermic,Typic Ustifluvents (Upland)													
Ap	0.00-0.23	6.49	0.11	16.7	78.70	6.11	9.24	0.20	0.43	0.08	3.78	1.28	10.18
A1	0.23-0.47	6.86	0.07	19.9	87.00	4.54	5.41	0.11	0.79	0.09	1.54	0.90	7.17
A2	0.47-0.67	6.73	0.05	19.9	81.40	5.51	6.94	0.13	1.30	0.12	2.40	1.70	7.65
A3	0.67-0.88	6.16	0.20	12.6	79.50	4.83	7.92	0.09	1.28	0.10	3.66	2.13	4.69
A4	0.88-1.07	7.01	0.11	13.1	80.80	5.14	6.31	0.05	1.17	0.11	3.54	2.02	4.76
A5	1.07-1.50	7.17	0.08	13.3	79.10	5.35	8.80	0.09	0.94	0.10	3.40	2.16	4.06
C	1.50	Stones mixed with soil											
Pedon 3. Fine loamy, silicious, iso-hyperthermic,Typic Ustorthents (Upland)													
Ap	0.00-0.16	6.79	0.06	21.54	86.90	3.96	5.79	0.13	0.47	0.07	1.96	0.96	5.92
A1	0.16-0.33	6.68	0.08	23.91	85.90	4.78	4.37	0.08	0.95	0.08	2.68	1.03	5.14
A2	0.33-0.58	6.67	0.09	25.27	86.40	4.58	5.17	0.05	0.46	0.08	1.82	0.85	4.93
C	0.58	Stones mixed with soil											
Pedon 4. Fine, illitic, iso-hyperthermic,Typic Haplustepts (Plain)													
Ap	0.00-0.17	7.22	0.16	43.63	85.70	3.91	5.74	0.07	0.28	0.09	2.68	0.96	6.71
A1	0.17-0.32	7.76	0.10	37.37	86.10	4.26	6.24	0.09	0.40	0.09	2.10	1.02	6.23
Bw1	0.32-0.54	8.56	0.18	34.71	82.90	5.71	7.74	0.08	0.15	0.09	1.26	1.16	4.78
Bw2	0.54-0.75	8.49	0.16	33.71	83.81	5.55	7.60	0.06	0.62	0.10	1.12	0.86	4.13
Bw3	0.75-0.94	8.46	0.21	39.74	81.70	4.88	7.87	0.07	0.97	0.13	2.82	0.97	4.87
Bw4	0.94-1.18	8.33	0.16	39.64	86.00	5.01	4.44	0.11	0.54	0.09	2.24	1.17	5.71
Bw5	1.18-1.40	8.94	0.14	32.51	83.20	4.98	7.77	0.10	0.77	0.07	2.38	1.68	4.61
C	1.40 Weathered gneiss mixed with soil												
Pedon 5. Fine, illitic, iso-hyperthermic, Typic Haplustepts (Plain)													
Ap	0.00-0.23	7.43	0.37	13.82	82.80	3.76	9.69	0.11	0.05	0.08	2.26	1.02	4.12
A1	0.23-0.43	7.80	0.20	11.34	80.22	3.01	10.29	0.08	0.54	0.07	2.12	1.97	4.81
Bw1	0.43-0.69	7.36	0.34	10.04	79.80	4.04	10.51	0.13	0.46	0.25	2.98	1.60	5.01
Bw2	0.69-0-89	6.41	0.28	32.18	83.10	4.15	9.00	0.11	0.38	0.21	1.84	0.47	5.52
Bw3	0.89-1.10	6.23	0.40	37.80	84.00	4.75	7.70	0.27	0.67	0.33	1.98	0.24	4.61
Bw4	1.10-1.30	6.20	0.68	19.22	83.50	4.81	6.14	0.05	0.26	0.07	2.70	1.37	4.12
Pedon 6. Fine, illitic, iso-hyperthermic, Typic Haplustepts (Plain)													
Ap	0.00-0.29	7.82	0.37	21.06	86.20	1.76	10.24	0.08	0.24	0.09	1.12	0.76	5.01
A1	0.29-0.57	8.48	0.14	20.52	84.50	2.01	11.14	0.09	0.28	0.12	1.54	0.19	4.63
Bw1	0.57-0.86	8.16	0.10	20.09	78.90	4.85	11.65	0.07	0.34	0.10	2.82	0.99	5.81
Bw2	0.86-1.09	8.96	0.20	35.00	79.50	4.93	9.32	0.05	0.29	0.09	3.68	1.72	4.43
B3	1.09-1.33	8.43	0.33	28.94	82.50	2.71	12.04	0.04	0.27	0.14	1.96	1.09	4.78
Bw4	1.33-1.70	8.22	0.03	31.64	80.10	3.56	11.44	0.11	0.26	0.19	2.10	1.92	5.64
C	1.70 Weathered gneiss mixed with lime												
Pedon 7. Coarse-loamy, siliceous, iso-hyperthermic, Typic Ustipsamments (Plain)													
Ap	0.00-0.28	8.69	0.11	23.22	83.50	3.06	9.09	0.12	0.33	0.12	2.26	1.98	4.01
A1	0.28-0.55	8.68	0.07	18.47	90.30	2.47	5.68	0.09	0.24	0.09	0.84	0.22	2.71
A2	0.55-0.87	8.28	0.05	15.62	91.10	2.41	5.09	0.08	0.12	0.08	0.70	0.19	2.63
A3	0.87-1.00	8.30	0.05	21.71	91.50	3.02	3.73	0.07	0.11	0.09	1.12	0.76	1.05
A4	1.00-1.26	7.85	0.03	5.83	89.30	2.45	4.02	0.06	0.16	0.10	2.54	0.86	2.69
C1	1.26-1.53	7.87	0.03	6.91	87.15	3.06	6.39	0.05	0.62	0.16	1.68	0.73	3.56
C2	1.53-2.00	8.66	0.01	2.16	88.40	4.10	5.40	0.04	0.17	0.09	1.82	0.88	2.01

exchange complex ranges from 70.01 to 96.09 %. Higher values of loss on ignition (LOI) may be due to the presence of expanding type of minerals. The values of SiO_2 and Al_2O_3 indicate the occurrence of appreciate amount of 2:1 type of clay minerals. The Fe_2O_3 content of clays to these soils suggests the presence of iron- bearing amorphous minerals. Values of MgO and CaO indicate the presence of minerals rich in magnesium and calcium. The K_2O content in all pedons indicates the presence of K-bearing clay minerals (Raina *et al*., 2006). Relatively higher values of P_2O_5 in the soil might be due to the occurrence of P-bearing minerals such as calcium apatite and also due to use of higher doses of phosphatic fertilizers (Table 2).

X-ray Diffraction

The clay fraction of the pedon 1 contains illite, kaolinite and traces of feldspar (Fig.1). A high intensity peak 0.991 nm in Ca-saturated with ethylene glycol and 0.995 nm in ca-saturated samples indicated that the presence of illite.The

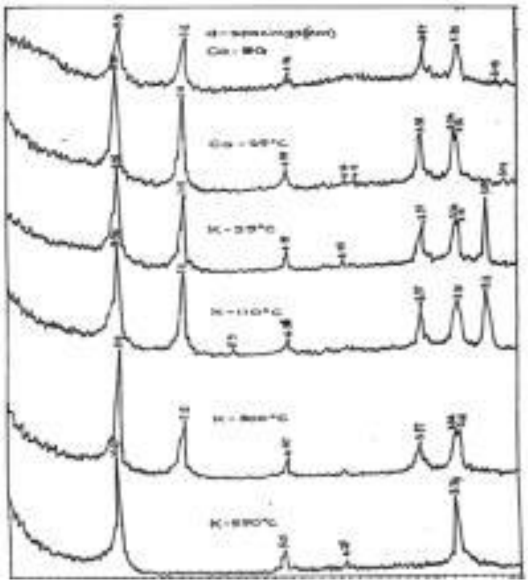

Fig. 1. Representative XRD diagram of fine loamy, illitic, iso hyperthermic,Typic Haplustalfs (<0.2 µm) of pedon 1.

small peak at 0.712 nm d-spacing in Ca-saturated with ethylene glycol and similar peaks are observed in Ca-25$_0$C, K-25$_0$C, K-110 $_0$C is indicative of kaolinite. Further, existence of small peaks at 0.309 nm in Ca-saturated with ethylene glycol and similar peaks also observed in Ca-25$_0$C and K-110 $_0$C treatment proved the presence of feldspars.

In the clay fraction of pedon 2, illite is dominant clay mineral followed by kaolinite (Fig. 2). The first order peak at 0.992 nm d-spacing observed in Ca-saturated with ethylene glycol and Ca-saturated at room temperature treatment in peak at 0.994 nm. Further, similar peaks also observed with K-25$_0$ C, K-110 $_0$C, K-300 $_0$C and K-550 $_0$C is indicative of illite. Diffraction peaks 0.714 nm with Ca-saturated ethylene glycol observed that presence of kaolinite.

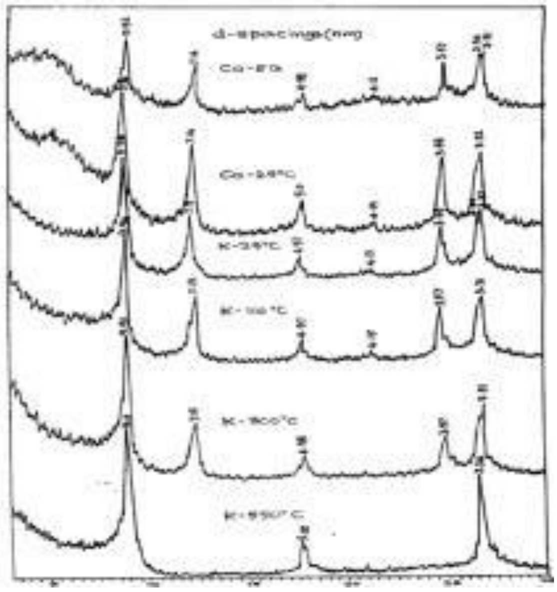

Fig. 2. Representative XRD diagram of Fine-loamy, silicious, iso-hyperthermic, Typic Ustifluvents (<0.2 µm) of pedon 2

Similarly other treatments like Ca-25$_0$C, K-25$_0$C, K-110$_0$C and K-300$_0$C also observed that the presence of kaolinite. The presence of feldspars was identified by a small peak at 0.331 and 0.332 nm d-spacing in Ca-saturated with ethylene glycol solved sample

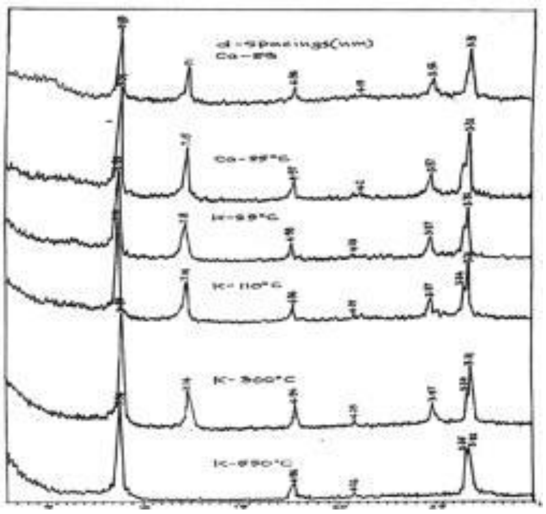

Fig. 3. Representative XRD diagram of fine loamy, silicious, iso-hyperthermic,Typic Ustorthents (<0.2 µm) of pedon 3

and K-saturated at room temperature treatments, respectively.

Ilite is the dominant clay mineral in pedon 3 showing that 0.985 and 0.994 nm d-spacing are observed in treatments of Ca-saturated with ethylene glycol and Ca-saturated with room temperature at 0.356 nm. The peaks at 1.00, 0.50 nm respectively and similar peaks also observed in K-25 $_0$C, K-110 $_0$C, K-300 $_0$C and K-550 $_0$C on the presence of illite mineral. The presence of kaolinite group of minerals in the clay fraction was detected by a small peaks at 0.710 nm followed by small peak and 0.33 nm d-spacing show the presence of

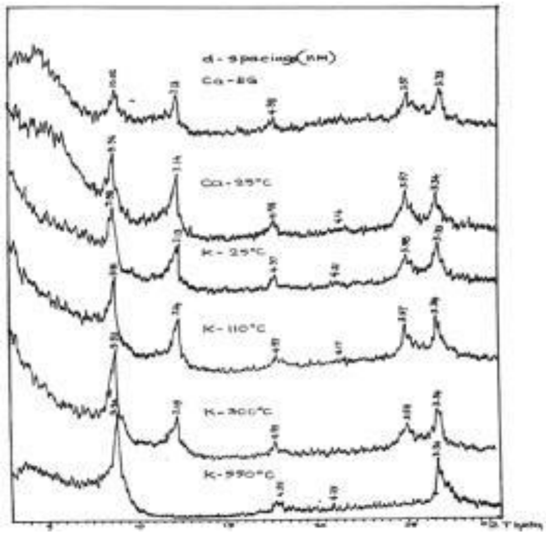

Fig. 4. Representative XRD diagram of fine, illitic, iso-hyperthermic,Typic Haplustepts (<0.2 µm) of pedon 4

feldspars.

The presence of abundance quantities of illite in pedon 4 was detected by the presence of a sharp peak at 0.99 nm followed by 0.33 nm in Ca-saturated sample showed a peak at 0.713 nm followed by sharp peak 0.357 nm in ethylene glycol treatment indicates the presence of kaolinite. The small peaks at 0.416, 0.421, 0.417 and 0.425 nm in four treatments indicate the presence of quartz (Fig.4).

Illite is the dominant mineral in pedon 5, showing relatively sharp peaks at 0.99 nm in calcium saturated sample at room temperature which expanded into 1.004 nm on ethylene glycol salvation (Fig.5). The presence of kaolinite minerals in the clay fraction was detected by a small peaks at 0.414, 0.416 and 0.412 nm d-spacing with K-saturated at room temperature, Ca-saturated at room

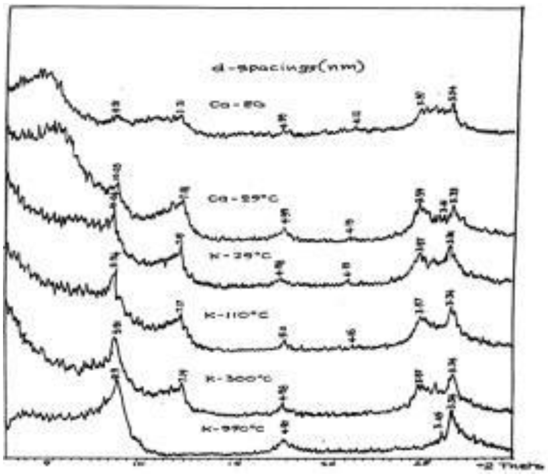

Fig. 5. Representative XRD diagram of fine, illitic, iso-hyperthermic, Typic Haplustepts (<0.2 µm) of pedon 5

temperature in all six treatments indicates the presence of quartz. X-ray diffraction analysis of clay fraction of pedon-6 (Fig.6) and 7 (Fig.7) showed peaks similar to that of pedon 1 indicating the dominance of Illite minerals.

Genesis of clay minerals

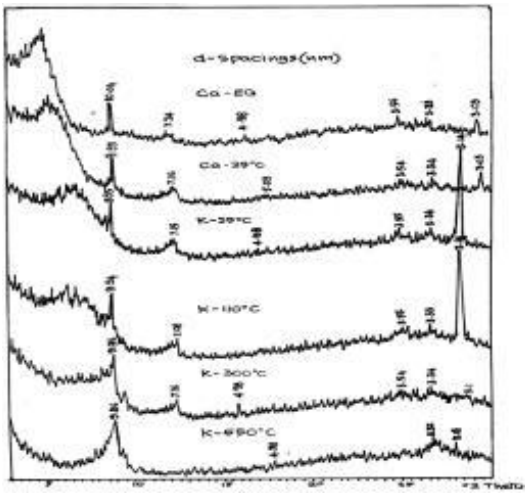

Fig. 6. Representative XRD diagram of Fine, illitic, iso-hyperthermic, Typic Haplustepts (<0.2 µm) of pedon 6

Illite was the dominant mineral in all the pedons than other minerals. The predominance of illite and kaolinite in clay fraction is responsible for low CEC and poor nutrient retention characteristics of these soils (Swarnam *et al*., 2004).

Kaolinite is the next dominant clay mineral in all pedons. Kaolinite minerals could be formed by

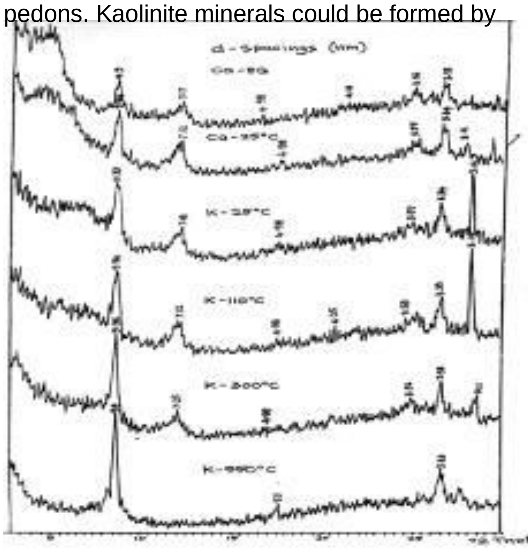

Fig. 7.Representative XRD diagram of coarse-loamy, siliceous, iso-hyperthermic, Typic Ustipsamments (<0.2 µm) of pedon 6

neosynthesis from the products of hydrolytic decomposition of feldspars and other products of hydrolytic decomposition of feldspars and other primary minerals (Murali *et al*., 1978; Rengasamy *et al*., 1978) and by conversion of smectite or vermiculite to kaolinite following hydroxyl interlayering in the expandable minerals of mixed layering between 2:1 and 1:1 layers (Pal et al., 1989: Bhattacharyya *et al*., 1993 and 2000).

Quartz was present in small quantities in these soils. The feldspars present in the clay might have been derived by alteration of minerals from the parent material under the prevailing conditions of the soil formation (Satyanarayana and Biswas, 1970).

Based on the outcome of the study, soil is a dynamic part of the earth's geomorphic cycle of surficial weathering, erosion, deposition and diagenesis. Thus minerals in the soil may be inherited from the parent rock and / or formed as a result of pedogenic process.

A thorough knowledge and appreciation of soil clay minerals in terms of their nature, properties and modification in the present and past environmental factors thus critical to our understanding and management. However, X-ray diffractograms revealed that all pedons of study area showed illite minerals and kaolinite minerals followed by quartz. Traces of feldspars were observed in pedons 1, 2 and 6. The information regarding relative proportion of various minerals is highly essential for effective management of soils to achieve sustainable production as well as sustainable management of the soils.

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