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Characterization of some soils of Singarayakonda Mandal in Prakasam District of Andhra Pradesh

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Abstract
Seven representative pedons from Singarayakonda, Pakala, Pataiahgaripalem, Kalikivaya, Binginepalle, Old Singarayakonda and Modaguntapadu of Singarayakonda mandal in Prakasam district of Andhra Pradesh were selected and studied. Clay mineralogy from X-ray diffraction analysis revealed that smectite, kaolinite were the dominant minerals present in clay fraction. Black soils (pedons 2, 3 and 4) were dominated by smectite but red soils (pedons 1, 6 and 7) were dominated by kaolinite mineral followed by smectite, illite, feldspar and plagioclase feldspars. In sandy soils, kaolinite, illite and quartz were the minerals present. Based on morphology, physical, physico-chemical and climatological data of the study area, pedon 1 and 6 were classified under Alfisols, pedon 2 and 4 under Vertisols, pedon 3 and 7 under Inceptisols and pedon 5 under Entisols.

Keywords: Pedons, smectite, kaolinite, Alfisols, Vertisols, Inceptisols, Entisols and X-ray diffraction analysis

Introduction
The systematic study of soil characteristics is the pre-requisite for complete exploitation of soil types by appropriate management practices. The clay mineralogical data is necessary for predicting of physico-chemical behaviour of soils and for the management of sustainable agriculture. Soil health is also very much dependent on the nature and quality of minerals present in clay fractions. According to many researchers understanding of soil genesis and classification is a pre-requisite for sound land use planning and land management (Soil Survey Staff, 1994). Systematic study of soils is important for better scientific utilization for agricultural production.

Some work has been carried out on the study of genesis, morphology and classification of soils in Andhra Pradesh (Rao *et al*, 1995). There is however, a lot of scope left for conducting systematic studies in these soils. The present study is on the soils of Singarayakonda mandal in Prakasam district of Andhra Pradesh which has both red and black soils. The soils of the mandal has got agricultural importance as these soils are under food, vegetable and commercial crops cultivation. Keeping in mind the agricultural potential of the soils of Singarayakonda and the lack of systematic studies of these soils the present investigation has been taken up to characterize and classify these soils.

Materials and Methods
Clay fraction from soil samples of second horizon of each pedon was separated by following the procedure outlined by Jackson (1976) [2]. Seven pedons were classified up to family level according to Keys to Soil Taxonomy (Soil Survey Staff, 1998) [9].

Twenty grams of soil were taken from second horizon of the each profile into a 1000 ml beaker to which 200 ml of sodium acetate (pH 5.0) was added. The suspension was digested for 30 minutes on a water bath with intermittent stirring to destroy the carbonates. The clean supernatant liquid was siphoned out. The suspension was then treated with 5ml of 30 per cent H_2O_2 and allowed for overnight digestion. This was heated for 2 to 4 hours on water bath by adding more of H_2O_2 until the suspension was evaporated to a thin paste. 100 ml of sodium acetate (pH 7.0) was added to the beaker and the contents were stirred. 40 ml of 0.3M sodium citrate solution was then added to the contents of beaker, 5 ml of 1M sodium bicarbonate solution was later added to the contents of beaker and heated on water bath. When the temperature of the contents in the beaker reached 70-80° C, one gram of solid sodium dithionite was added and stirred well until the contents turned to ash colour. To this, 10 ml of saturated NaCl solution was added to promote de-flocculation. The supernatant liquid was siphoned out after settling. The beaker was fitted with distilled water. This process was repeated till the contents of the beaker remained in dispersed state.

The suspension was stirred with an electrical stirrer and the contents were transferred to a tall form beakers and made up to a 1000 ml. The contents were allowed to settle for a specific time. The top layer was siphoned upto 10 cm depth into a bottle and stored as sodium clay suspension after adding suitable quantity of NaCl.

1. A. Preparation of Ca-Saturated Clay

Suitable quantity of sodium clay suspension was transferred to a centrifuge tube. 30ml of IN $CaCl_2$ solution was added and centrifuged for 5 minutes at the rate of 500 rpm. This treatment was repeated twice and the Ca-saturated clay was washed with methanol for removing excess calcium. This clay was later transferred into a bottle using required quantity of distilled water to make 2 per cent clay suspension.

2. B. Preparation of K-Saturated Clay

The procedure used to prepare Ca-saturated clay was followed to prepare K-saturated clay also by using IN KG solution.

3. C. Preparation of K and Ca Saturated Clay Slides

The slides of Ca and K saturated clay were prepared by spreading 1ml of 2 per cent clay suspension Ca and K saturated clays were mounted separately on clear microscopic slides and allowing them to dry at room temperature.

The parallel oriented clay slides prepared were of the following treatments:

1. K-saturated clay at room temperature.
2. K-saturated clay heated to 110 °C.
3. K-saturated clay heated to 300 °C.
4. K-saturated clay heated to 550 °C.
5. Ca-saturated clay at room temperature.
6. Ca-saturated and glycerol solvated clay at room temperature.

X-ray Diffraction Analysis

The X-ray diffraction analysis was carried out on Philips X-ray diffractometer PW 1140 with the following scanning details.

Current : 20 MA 40 KV
Scanning speed: 2°20/minute
Radiation: Cu Ku

Ca^{+i} and Ca-EG scanning from 4° 20 to 30° 20
$K^{+'}$ 25 °C, K110 °C, K 550" C from 4° 20 to 15° 20
K 300 ^{0}C from 4^0 20 to 30° 20

Results and Discussion

Seven representative pedons from Singarayakonda, Pakala, Pataiahgaripalem, Kalikivaya, Binginepalle, Old Singarayakonda and Modaguntapadu of Singarayakonda mandal in Prakasam district of Andhra Pradesh were selected and studied. The details of the pedons of soil profiles were given in table 1. The X-ray diffraction of the clay fraction from the second horizon of each pedon was analysed. The d-spacing of different clay minerals observed in X-ray diffraction patterns were presented in table 2 and relative proportions of the clay minerals were indicated in Table 3.

Mineralogical studies by X-ray diffraction of soil clays were obtained with the following treatments:

1. Ca-saturated at room temperature.
2. Ca-saturated at ethylene glycerol solvated.
3. K-saturated at room temperature.
4. K. saturated and heated to 110 °C.
5. K-saturated and heated to 300 °C.
6. K-saturated and heated to 550 °C.

Table 1: Details of the pedons of soil profiles of Singarayakonda Manda

Pedon No	Location	Horizon	Horizon thickness
1	**Singarayakonda**	**Ap**	**0.00 - 0.09**
		Ap2	0.09 - 0.25
		Bt,	0.25 - 0.42
		Bt_2	0.42 - 0.69
		C	0.69-1.18
2	**Pakala**	**Ap**	**0.00 - 0.06**
		B	0.06 - 0.39
		Bssi	0.39 - 0.65
		Bss_2	0.65 - 0.92
		Bss_3	0.92-1.24
		AC	Below 1.24
3	**Potaiahgaripalem**	**Ap**	**0.00 - 0.08**
		B,	0.08 - 0.32
		B_2	0.32 - 0.64
		Bwi	0.64 - 0.77
		Bw_2	0.77 -1.08
		C	Below 1.08
4	**Kalikivayi**	**Ap**	**0.00 - 0.11**
		Bwi	0.11 - 0.24
		Bw2	0.24 - 0.52
		Bss,	0.52 - 0.87
		BSS2	0.87-1.32
		AC	Below 1.32
5	**Binganipalli**	**Ap**	**0.00 - 0.09**
		AB	0.09 - 0.34
		c	0.34 - 0.69
		c_2	0.69 - 0.94
		c_3	0.94-1.36
		Ca	Below 1.36
6	**Old Singarayakonda**	***Ap***	**0.00 - 0.16**

		B	0.16 - 0.54
		Bt,	0.54 - 0.78
		Bt2	0.78 -1.02
		Bt3	1.02-1.27
		C	Below 1.27
7	**Moolaguntapadu**	***AP***	**0.00 - 0.11**
		Bwi	0.11 - 0.35
		BW2	0.35 - 0.72
		Bt,	0.72-1.12
		C	Below 1.12

Table 2: d Spacing (A^o) of X-RAY Diffractograms in clay fraction (< 2 micron fractions)

Pedon	Calcium saturated		Potassium saturated				Clay mineral
	Glycerol Solvated	Room temperature	Room temperature	110^{0}C	300^{0}C	550^{0}C	
Pedon 1	10.04	10.04	9.61	9.61	10.04	10.04	Illite
	-	-	-	-	4.92	-	
	3.32	3.32	-	-	3.32	-	
	7.13	7.13	7.13	-	7.13	-	Kaolinite
	3.59	3.59	-	-	3.59	-	
Pedon 2	18.41	14.9	13.81	13.81	13.81	10.04	Smectite
	10.04	10.04	10.04	10.04	10.04	10.04	Illite
	4.92	4.92	4.92	-	4.92	-	
	3.32	3.32	-	-	3.32	-	
	7.13	7.13	7.13	7.13	7.13	-	Kaolinite
	3.53	3.53	-		3.53	-	
Pedon 3	18.41	15.78	13.81	13.81	13.81	10.04	Smectite
	10.04	10.04	10.04	10.04	10.04	10.04	Illite
	4.92	4.92	4.92	-	4.92	-	
	3.32	3.32	-	-	3.32	-	
	7.13	7.13	7.13	7.13	7.13	-	Kaolinite
	-	3.53	-	-	3.53	-	
Pedon 4	18.41	15.78	13.81	13.81	13.81	10.04	Smectite
	-	10.04	-	10.04	10.04	10.04	Illite
	-	4.92	-	-	4.92	-	
	3.37	3.32	-	-	3.32	-	
	7.13	7.13	7.13	7.13	7.13	-	Kaolinite
	-	-	-	-	3.56	-	
	3.14	3.14	-	-	-	-	Feldspars, Plagioclase, Feldspar
	3.05	-	-	-	-	-	
	6.91	-	-	-	-	-	
Pedon 5	10.04	10.04	10.04	10.04	10.04	10.04	Illite
	4.92	4.92	-	-	4.92	-	
	3.37	3.37	-	-	3.37	-	
	7.13	7.13	7.13	7.13	7.13	-	Kaolinite
	3.59	3.59	-	-	-	-	
	4.27	4.23	-	-	4.27	-	Quartz
Pedon 6	15.23	15.23	-	-	15.23	10.04	Smectite
	10.04	10.04	10.04	10.04	10.04	-	Illite
	4.92	4.92	-	-	4.92	-	
	3.32	3.32	-	-	3.32	-	
	7.13	7.13	7.13	7.13	7.13	-	Kaolinite
	3.59	3.59	-	-	3.59	-	
Pedon 7	10.04	10.04	10.04	10.04	10.04	10.04	Illite
	-	4.92	-	-	4.92	-	
	3.32	3.32	-	-	3.32		
	7.13	7.13	7.13	7.13	7.13	-	Kaolinite
	3.59	3.59	-	-	3.59	-	
	3.05	3.05	-	-	3.14	-	Feldspars

Table 3: Relative proportion of clay minerals (from x-ray diffractograms)

Pedon	Location		Clay	Mineral in Per cent		
		Smectite	Illite	Kaolinite	Quartz	Feldspar
1	Singarayakonda	—	20.23	79.76	—	—
2	Pakala	52.94	32.94	14.11	—	—
3	Potaiahgaripalem	67.24	26.72	14.65	—	—
4	Kalikavaya	67.54	14.56	7.94	—	9.93
5	Binginipalli	—	50.00	23.52	26.47	—
6	Old Singarayakonda	17.20	21.50	61.29	—	—
7	Moolaguntapadu	—	18.91	74.32	—	6.75

Pedon.1

X-ray diffractograms at different treatments were presented in Fig. 1. Kaolinite was identified by the presence of the following peaks at different d-spacing. Strong peaks were registered at 7.13 A° d-spacing in all the treatments except in K-550 °C treatment. Second order peaks were observed at 3.59 A^0 at d-spacing in Ca-saturated ethylene glycerol solvated treatment. Illite peaks were observed at 10.04 A° d-spacing following peaks in all treatments. Peaks were observed at 10.04 A° d-spacing in all the treatments. Higher order peaks were observed at 4.92 A° in different treatments.

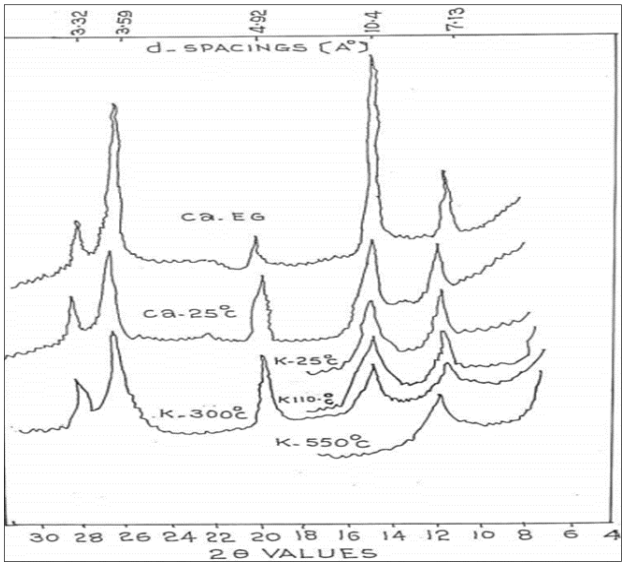

Fig 1: X-ray diffractograms of pedon-**1**

Pedon 2

Diffraction patterns of clay were presented in Fig. 2. The dominance of smectite is observed in this pedon. It is identified by the following reflections. A strong first order peak was noticed at 18.41 A^0 d-spacing in calcium ethylene glycerol solvation and at 14.91 A" in the Ca-saturated. These peaks were shifted to 13.81 A° in K-saturation at room temperatures of 110 °C and 300 °C respectively. Both these observations indicated that there is a clear dominance of smectite in clay fraction. Sharp peaks were observed at 10.04 A° in different treatments. Second order peak was registered at 4.92 A" d-spacing in Ca-saturated ethylene glycerol, Ca-room temperature, K-25 °C and K-300 °C. Third order reflections 3.32 A° d-spacing in Ca-saturated ethylene glycerol, Ca-saturated and K-300 °C treatments were observed. Kaolinite was observed in the clay sample by the following peaks: Peaks at 7.13 A^0 d-spacing in all the treatments except at K-550°C exhibited kaolinite presence. Reflections were observed at 3.53 A^0 with Ca-saturated ethylene glycerol, Ca-saturated and K-300 °C treatments.

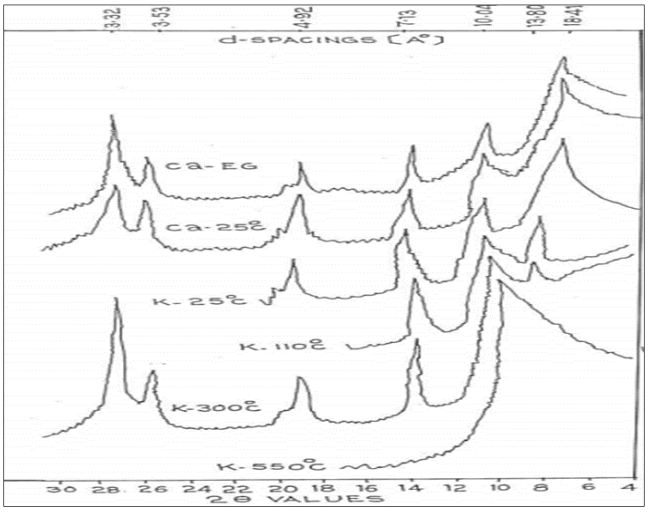

Fig 2: X-ray diffractograms of pedon-2

Pedon 3

X-ray diffractograms at different treatments were presented in Fig. 3. Smectite was identified by the following peaks under different treatments. A strong first order peak 15.78 A° in calcium saturated sample was visible which expanded to 18.41 A° on the calcium ethylene glycerol solution. These peaks were later shifted to 13.81 A° on K-25°C, K-110 °C and K-300 °C treatments. At K-550 °C it was visible at 10.04 A^0 d-spacing. Both these observations indicated the dominance of smectite in clay fraction. Mica was observed in

the clay sample by the following peaks. Sharp peaks were observed at 10.04 A° in different treatments. On heating they became sharp and conspicuous. First order peak was observed at 4.92 A^0 d-spacing with Ca-saturated ethylene glycerol solvated, Ca-saturated, K-25 °C and K-300 °C treatments. Kaolinite was observed in the clay sample by the presence of the following peaks: Strong peaks were registered at 3.53 A° d-spacing with Ca-saturated and K300 °C treatments.

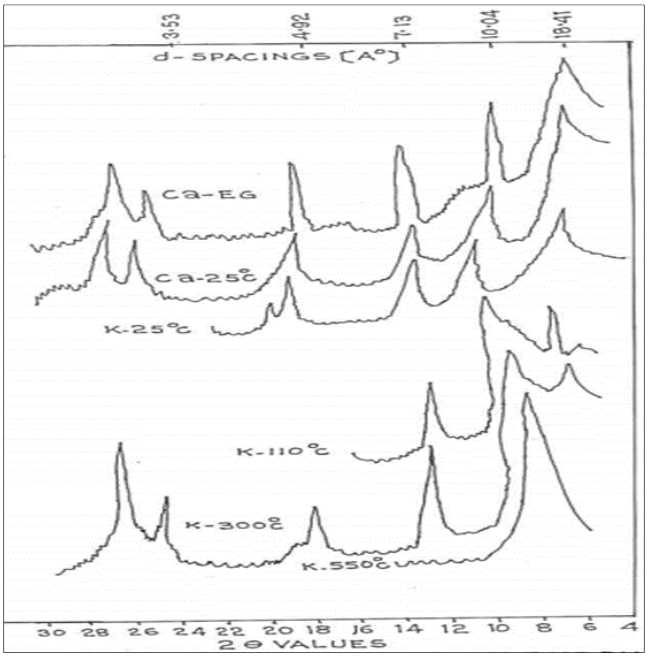

Fig 3: X-ray diffractograms of pedon-3

Pedon 4

The X-ray diffract grams for pedon 4 were presented in Fig. 4. Presence of smectite was observed by the following peaks: Higher reflection with a basal spacing of 15.78 in Ca-saturated at room temperature was seen which shifted to 18.41 A^0 after the addition of ethylene glycerol solvation. It was later converted to 13.81 A° d-spacing on K-saturation at 25 °C, 110 °C and 300 °C. In K-550 °C it appeared at 10.04 A" d-spacing. Presence of illite was observed by the following reflections: Sharp peaks were observed at 10.04 A° in Ca-saturated, K-110 °C, K-300 °C and K-550 °C Small, well defined peaks were observed at 4.92 A° and 3.32 A° when treated with Ca-saturated and ethylene glycerol and K-300 °C Small peaks at 7.13 A° and 3.56 A° d-spacing in Ca-saturated and ethylene glycerol solvated, K-25°C, K-110 °C and 300 °C treatments were identified by the presence of kaolinite. Small peaks at 3.14 A^0, 3.05 A^0, 6.91 A° respectively were noticed in Ca-saturated glycerol solvated, Ca-room temperature by which feldspars and plagio class feldspar were identified.

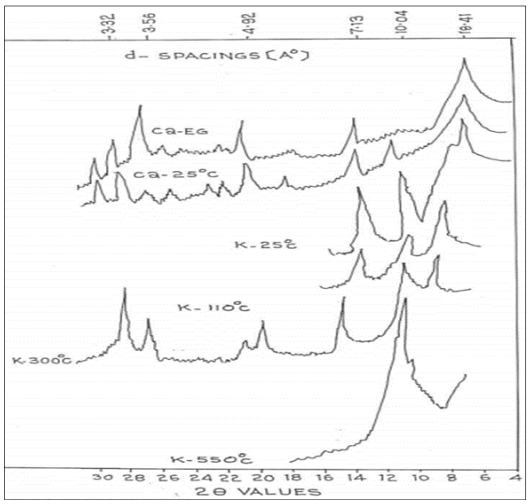

Fig 4: X-ray diffractograms of pedon-4

Pedon 5

X-ray diffractograms at different treatments were presented in Fig. 5. Presence of quartz was observed by sharp peak at 4.27 A^0 and 4.23 A° d-spacing in Ca-saturated ethylene glycerol and calcium at room temperature treatments. Sharp large peaks at 10.04 A°, 4.92 A° and 3.37 A° d-spacing on Ca-ethylene glycerol solvated, Ca-room temperature, K-25 °C, K-110 °C, K-300 °C and K-550 °C treatments indicated the

presence of Illite. Strong peaks were seen at 7.13 A° and 3.59 A° d-spacing in Ca-saturated ethylene glycerol, when Ca-room temperatures were heated up to 300 °C. These peaks however disappeared in K-550 °C treatments indicating the presence of kaolinite.

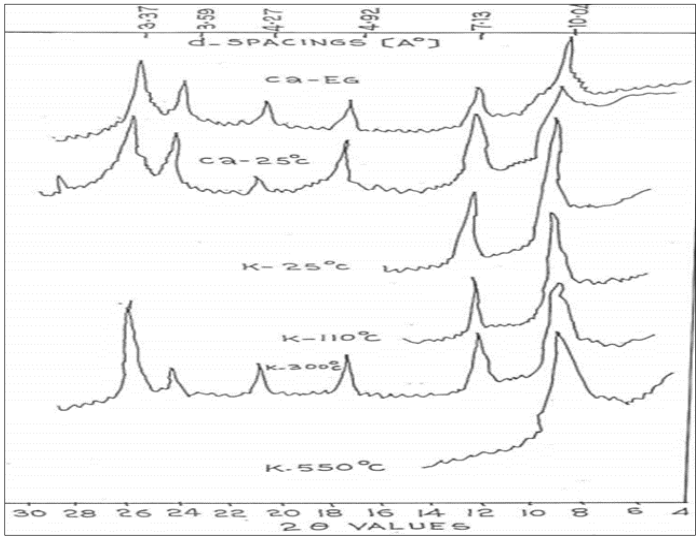

Fig 5: X-Ray diffractograms of pedon- 5

Pedon 6

X-ray diffract grams at different treatments were presented in Fig. 6. A strong diffraction peak in Ca-saturated ethylene glycerol around 15.23 A° was observed. These observations indicated the presence of smectite in clay fraction. Sharp diffraction reflections at 10.04 A° d-spacing in Ca-saturated ethylene glycerol and in all the treatments were observed. The first order reflections were observed in 4.92 A^0 d-spacing in Ca-saturated ethylene glycerol, Ca-saturated and K-550 °C treatments. Sharp reflections were observed at 3.32 A^0 d-spacing in Ca-saturated ethylene glycerol solvated, Ca-saturated and K-300 °C treatments. Kaolinite was observed as dominant by the presence of the following peaks with different d-spacings. First order peaks were identified at 7.13 A° d-spacing in all the treatments except at K-550 °C treatments. Second order peak 3.59 A° d-spacing was identified in Ca-saturated ethylene glycerol, Ca-saturated and K-300 °C treatments.

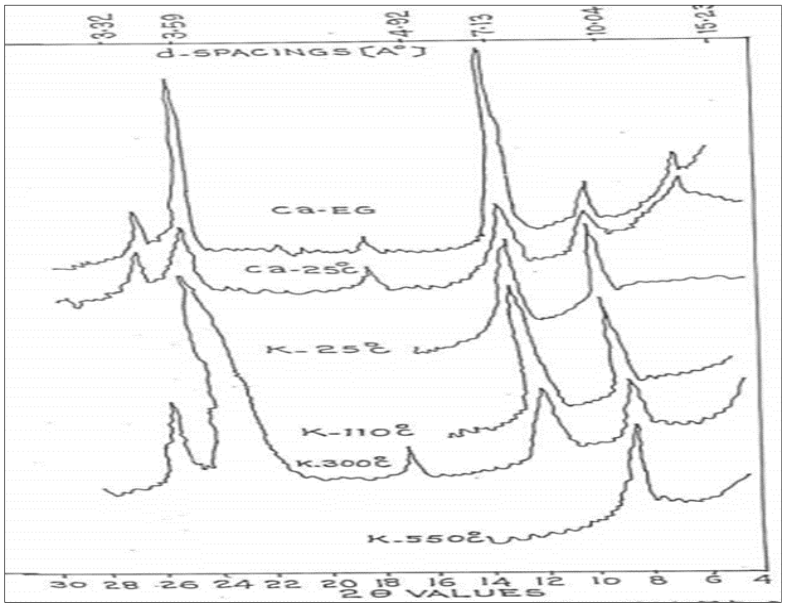

Fig 6: X-ray diffractograms of pedon-6

Pedon 7

Diffraction pattern of clay were presented in Fig.7. Strong and sharp peaks were observed at 7.13 A° d-spacing in Ca-saturated ethylene glycerol solvated. Ca-saturated and K-300 °C treatments indicated the presence of kaolinite. Presence of illite was identified by the peaks at 10.04 A^0, 4.92 A° and 3.32 A° d-spacing in Ca-saturated ethylene glycerol solvated, Ca-room temperature. K-300 °C treatments confirmed the presence of illite. Presence of feldspars was indicated by strong peaks 3.05 A^0 and 3.14 A" d-spacings in Ca-saturated ethylene glycerol, Ca-saturated and K-300 °C treatments. The soils of the study area synthesized smectite, kaolinite, illite, feldspars and quartz. In some soils smectite was absent but illite and kaolinite were present in all the pedons. All the

minerals analysed from X-ray diffractograms and relative proportion of minerals was calculated from semi-quantification method. Smectite was ranged from 17.20 to 67.54 per cent, kaolinite content varied from 14.11 to 74.32 per cent. Illite was present in all the pedons which varied from 14.56 to 50.00 per cent.

Pedons 2, 3 and 4 (black soils) showed higher proportions of smectite (52.94, 67.24 and 67.54 per cent) followed by illite (32.94, 26.72 and 14.56 per cent) and kaolinite (14.11, 14.65 and 7.94 per cent), hence grouped under smectite mineralogy at family level (Soil Survey Staff, 1998) [9] of taxonomy. It is the characteristic feature of the Vertisols to be dominated by smectite type of clay (Thakur *et al*, 1999) [11]. Dominance of smectite appeared to be due to its retention in neutral to alkaline soil reaction and saturated calcium and magnesium (Sahu and Mishra, 1996) [7].

Red soils (pedons 1, 6 and 7) showed dominance of kaolinite up to 79.76 per cent followed by illite (20.23, 21.50 and 18.90 per cent). Feldspar observed in pedon 7 6.75 per cent. Smectite is also present in pedon 6. Kaolinite was the dominant mineral in these red soils. Hence qualified for kaolinitic clay mineralogy. Dominance of kaolinite was reported by Sahu *et al*. (1990) [8], Oscher and Buol (1998) [3] and Okusami *et al*. (1998) [4] in red soils of different areas.

In case of sandy soil, illite was the dominant mineral followed by kaolinite and quartz (26.47 per cent) which might have been derived from marine sediments by physical weathering. Hussain *et al*. (1998) [1] reported the presence of illite next to kaolinite.

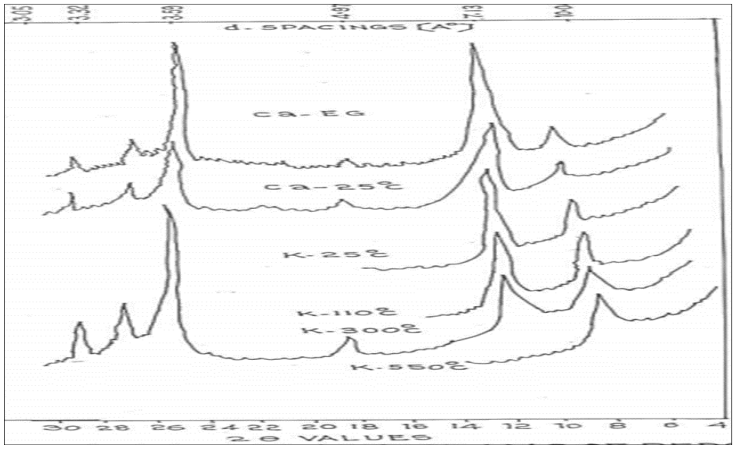

Fig 7: X-ray diffractograms of pedon-**7**

Conclusion

X-ray diffraction analysis of the clay fraction revealed that smectite was the dominant clay mineral in pedons 2, 3 and 4 (black soils). In pedons, 1, 6 and 7 (red soils), kaolinite was dominant. In case of sandy soils, kaolinite was the dominant mineral followed by quartz and illite.

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