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Studies on a Catena in Coimbatore district — III. Quantitative evaluation of changes during profile development by index mineral method *

by

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Synopsis: This third paper of the series on the studies of a catona in Coimbatore district deals with the quantitative evaluation of clay formation, clay migration and volume change during the course of profile development using fine sand fraction as index mineral.

Introduction: Calculation of relative losses and gains of different elements by assuming oxide of one element as static was one of the earliest attempts in evaluating quantitatively changes during soil development. Palmer (1934), Hardy and Rodrigues (1939 a, b) and Harrison (1934) calculated losses due to weathering, assuming alumina as the stable radical, while Joffe and Pugh (1934) and Harrison (1934) assumed oxide of titanium as constant, for such calculations. Harrison also used ferric oxide as immobile radical in soil formation studies. In some instances, silica was assumed to be constant during profile formation. As pointed out by Barshad (1955), immobile nature of any of these elements may be altered due to migration of clay size particles containing these elements.

Molecular ratios such as Silica : Alumina ratio, Silica : Ferric oxide ratio, Silica : sesquioxide ratio and many others have long been used to calculate losses and gains of materials in the course of soil development. Jenny's (1981) 'leaching' and 'shifting' factors are other attempts in quantitative approach in the problems of soil formation.

Marshall and Haseman (1948) developed a more rational method for evaluating changes during soil development by using index minerals such as zircon, tourmaline, garnet, anatase and rutile of non-clay fraction of the soil samples in profiles. For this purpose Barshad recommends also estimation of quartz, albite, microcline and whole size fraction. The present paper deals with quantitative evaluation of clay formation, clay migration and volume change during soil development by using fine sand - a whole size fraction as index mineral. This has been used by Barshad in his III example to study erosion.

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Materials and Methods: Seven profile samples collected from a catena near Chettipalayam in Coimbatore district were made use of in calculating changes in soil formation. Profile morphology and physical properties of these samples have already been presented in two previous papers. The procedure given by Barshad (1955) was adopted for calculating clay formation, clay migration and volume change. The method is based on the assumptions that clay is formed from the non-clay fraction and that the amount of clay formed is proportional to the loss in the non-clay fraction. The clay originally present at each horizon is calculated on assuming that the clay content of the parent material represents the original clay content of the parent material. The non-clay fraction and the index mineral have been calculated excluding the calcium carbonate content.

Results and Discussion: The results, given in the Table I, reveal interesting indications regarding the changes that took place during the development of the catena. Among the members of the catena, III profile presents a unique picture. There is clay accumulation in the lower horizons of this profile. Since the quantity of clay accumulated in the lower horizons could not be accounted for from the amount of clay migrated from present top horizon, a layer of soil material to a thickness of 12·4 inches would have been eroded to result in the present profile. There could have also been clay accumulation in this profile due to migration from upper reaches of the catena. But redeposition of soil material within the catena is in general, not observed.

In the case of other profiles, there is only removal of clay away from the profiles due to relatively higher rate of erosion. Hence, there is no gain of clay in the lower horizons of these profiles.

It may be appropriate here to point out the view of Robinson (1936), while discussing the role of normal erosion in soil profile development. He states that removal of finer fractions might take place along the surface of soil itself or along the surface of water table. In either case, the result would be to produce a surface horizon relatively richer in coarser fractions than the parent material. The effect would be more pronounced under arable or partially arable conditions than under a closed cover of vegetation.

Relative clay formation: This is an index showing how much clay has been formed from 100 gm of the non-clay originally present in the horizon. The relative clay formation increases with depth in the hill top and lower members of VII and valley profiles. But decrease in clay formation is observed with depth in II and IV profiles. A different trend of clay formation is noticed in III profile, where the quantity of clay formed drops in the second horizon but rises in the third horizon to decrease in the fourth horizon.

Quantitative evaluation by the index mineral (fine sand) method of clay formation,

Profile		Horizon in inches	Depth in inches	Present volum per horizon (cc)	Bulk Density (g/cc)	Present Weight of soi per horizon (g)	Weight of Index minera per horizon (g)	Present Weight of clay per horizon (g)	Present Weight of non-clay per horizon (g)	Original Weight of non-clay per horizon (g)
Hill top profile	...	0—5	5	12·7	1·55	19·6	6·9	1·2	18·4	22·9
		5—11	6	15·2	1·41	21·4	8·4	2·1	19·3	27·9
		11—21	10	25·4	1·40	35·6	10·1	2·1	33·5	33·5
Profile No. 2	...	0—9	9	22·9	1·43	32·7	12·4	3·6	29·1	35·6
		9—23	14	35·6	1·27	45·2	15·7	8·1	37·1	45·1
		23—33	10	25·4	1·23	31·2	10·1	7·1	24·1	29·0
		33—43	10	25·4	1·40	35·6	10·3	6·0	29·6	29·6
Profile No. 3	...	0—4	4	10·2	1·40	14·3	5·5	2·1	12·2	15·9
		4—17	13	33·0	1·31	43·2	13·3	11·1	32·1	38·5
		17—24	7	17·8	1·25	22·3	6·5	6·8	15·5	18·8
		24—35	11	27·9	1·25	34·9	9·6	11·4	23·5	27·8
		35—45	10	25·4	1·42	36·1	11·4	3·1	33·0	33·0
Profile No. 4	...	0—9	9	22·9	1·29	29·5	9·1	5·8	23·7	52·1
		9—39	20	50·8	1·25	63·5	17·1	12·3	51·2	98·0
		39—49	10	25·4	1·40	35·6	5·8	2·4	33·2	33·2
Profile No. 5	...	0—4	4	10·2	1·64	15·7	4·6	2·1	13·6	18·1
		4—20	10	40·6	1·36	55·2	11·3	10·6	44·6	44·6
Profile No. 7	...	0—6	6	15·2	1·52	23·1	7·1	1·8	21·3	25·0
		6—11	5	12·7	1·39	17·7	8·1	2·0	15·7	28·5
		11—21	10	25·4	1·40	35·6	8·7	5·0	30·6	30·6
Profile No. 8	...	0—11	11	27·9	1·40	39·1	11·8	4·2	34·9	42·6
		11—19	8	20·3	1·42	28·1	7·5	4·7	24·1	41·8
		19—25	6	15·2	1·34	20·4	4·6	3·8	16·6	16·6

clay migration and volume change during development of soil material of Chettipalayam profiles

Loss in non-clay due to soil formation (g)	Weight of clay formed (Loss x 0·866) (g)	Original weight of clay per horizon (g)	Total clay in the absence of clay migration (g)	Loss or gain of clay per horizon (g)	Weight of parent material per horizon (g)	Original volume per horizon (cc)	Change in volume per horizon (cc)	Relative clay formation (g)	Relative clay loss or gain (g)	Relative change in volume (cc)
− 4·5	3·9	1·4	5·3	− 4·1	23·8	17·4	− 4·7	17·0	−23·6	−27·0
− 8·6	7·4	1·7	9·1	− 7·0	29·7	21·1	− 5·9	20·7	−33·2	−28·0
0·0	0·0	2·1	2·1	0·0	35·6	25·4	0·0	0·0	0·0	0·0
− 6·5	5·6	7·2	12·8	− 9·2	42·8	30·6	− 8·0	15·7	−30·1	−26·1
− 8·0	6·9	9·1	16·0	− 7·9	54·3	30·6	− 4·0	15·3	−20·0	−10·1
− 4·9	4·2	5·9	10·1	− 3·0	34·9	24·9	+ 0·5	14·5	−12·0	+ 2·0
0·0	0·0	6·0	6·0	0·0	35·6	25·4	0·0	0·0	0·0	0·0
− 3·7	3·2	1·2	4·4	− 2·3	17·4	12·3	− 2·1	20·1	−18·7	−17·1
− 6·4	5·5	3·6	9·1	+ 2·1	42·0	29·6	+ 3·4	14·3	+ 8·9	+11·5
− 3·3	2·9	1·8	4·7	+ 2·1	20·6	14·5	+ 8·3	15·4	+14·5	+23·3
− 4·3	3·7	2·6	6·3	+ 5·1	30·4	21·4	+ 6·5	13·3	+23·8	+30·4
0·0	0·0	3·1	3·1	0·0	36·1	25·4	0·0	0·0	0·0	0·0
−28·4	24·6	3·8	28·4	−22·6	55·9	39·8	−16·9	47·2	−56·8	−42·5
−46·8	40·5	7·1	47·6	−35·3	105·0	74·7	−23·9	41·3	−47·3	−32·0
0·0	0·0	2·4	2·4	0·0	35·6	25·4	0·0	0·0	0·0	0·0
− 4·5	3·9	4·3	8·2	− 6·1	22·5	16·5	− 6·3	21·5	−37·0	38·2
0·0	0·0	10·6	10·6	0·0	55·2	40·6	0·0	0·0	0·0	0·0
− 3·7	3·2	4·1	7·3	− 5·5	20·1	20·7	− 5·5	12·8	−26·6	−26·6
−12·8	11·1	4·7	15·8	−18·8	33·1	23·6	−10·9	40·8	−58·5	−46·2
0·0	0·0	5·0	5·0	0·0	35·6	25·4	0·0	0·0	0·0	0·0
− 7·7	6·7	9·7	16·4	−12·2	52·32	30·0	−11·1	15·7	−31·3	−28·5
− 7·7	15·3	6·2	21·5	−16·8	33·26	24·8	− 4·5	36·6	−67·7	−18·1
0·0	0·0	3·8	3·8	0·0	20·4	15·2	0·0	0·0	0·0	0·0

Maximum clay formation occurs in the IV profile, while minimum rates are seen in III and II profiles.

Relative clay loss or gain per 100 cc of the parent material: This gives us an idea regarding the clay loss or gain in different horizons of the profile. The loss of clay in the horizon may be due to migration within the profile or away from the profile. The gain may be because of accumulation from the horizons of the same profile or may be because of redeposition from other sites of the catena. The clay content increases with the formation in the weathering of non-clay fraction.

All the profiles studied in the catena except III profile lose clay. The relative clay loss follows general pattern of the relative clay formation in different horizons. As the formation of clay increases, there occurs an increase in relative loss of clay from the horizons of these profiles and the relationship shows a very high correlation ($r = 0.8989$). In the case of III profile, there is loss of clay only in the top horizons. The amount of clay gained increases with the depth in this profile. The maximum clay loss occurs in the second horizon of the valley profile, while minimum occurs in the third horizon of the II profile.

Relative change in volume of the horizon: This is change in volume of each horizon during profile development. When the present volume of horizon is compared with the original volume, the volume has been reduced in all the profiles of the catena with an exception in the case of III profile. Generally the percentage of reduction in volume occurs according to the quantity of clay lost during the course of soil formation. Reduction in volume is only noticed in the top horizon of III profile and volume has increased in the subsequent three horizons. The increase in volume in these horizons follows the pattern of accumulation of clay in them.

The present study of the quantitative evaluation of clay formation, clay migration and volume change provides a compelling evidence of the role played by the forces of normal erosion in the development of the catena. It also suggests the need for recognition of normal erosion as one of important factors of soil development and especially landscape of the tract.

Summary: Quantitative evaluation of clay formation, clay migration and volume change during the course of profile development was attempted using index mineral method given by Barshad. The fine sand - a whole size fraction was used as index mineral in calculating changes in seven profiles of a catena near Chettipalayam in Coimbatore district. The results indicate

an interesting picture of profile development in the catena. The present study emphasises the need for recognising normal erosion as one of the chief factors in profile development in this part of country.

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