CHAPTER - 4
TEXTURAL PROFILE

4.1. Introduction

Textural data of clastic sediments and rocks are fundamental to any study and hence significant to sedimentologists to understand the nature of sediments, type and extent of transportation and the environment of deposition. Further, several empirical procedures based on texture of modern clastics have been developed, successfully tested and extensively applied to gain a better insight of the environment of deposition of ancient analogues. A large number of reports on documentation of texture of clastics based on the above aspects are available (Folk, 1966).

However, texture in the context of soil studies and especially regarding differential weathering of parent rock due to variations of climate and geomorphic domain could be discerned from the gravel sand and mud content. Original particle size of rock minerals (but for quartz) will be transformed during progressive weathering due to formation of secondary minerals (especially clay minerals). This sets the stage for development of weathered detritus which is the penultimate stage of sediment formation.

From a pedological perspective, texture is an important property of soil. It indicates the degree of coarseness or fineness of the soil. Soil scientists by convention consider material <2 mm only for textural/chemical/mineralogic analysis. They analyze texture based on proportion of sand, silt and clay and represent it in USDA's textural triangle. Many properties of soil are related to soil texture. It is a useful index of several properties that determine a soil's agricultural potential (Harpstead et al., 2001).

The horizon to horizon textural variation may be used to work out the pedogenic and/or weathering history of soil and associated geomorphic surface. However, in what follows results and implications of gravel, sand and mud (GSM) variations in the various soil horizons of select profiles in NB and TB are presented.

4.2. Materials and Methods

Four profiles each from NB (NB-19, 24, 35 & 42; Table 1.1) and TB (TB-6, 33, 38 & 42; Table 1.2) were selected for the present study, out of which two each are from HL and ML. Among the two profiles in highland and midland one has charnockite as its bedrock and the other has GBG as its bed rock.

Samples (~1.5-2.0 kg) from A-horizon were collected using a trowel. Samples were chiselled off from the semi-indurated B and C-horizons and suitably labeled. About 100 to 200 gm splits from each of the air-dried samples were obtained using Jones sample splitter. Lumps or pieces of saprolitic material were gently crushed and broken by hand and subsequently oven-dried.

Two sieves, viz., ASTM 10, the gravel-sand fence and ASTM 230, the sand-mud fence were used to separate gravel- G (>2mm), sand-S (2 mm – 0.063 mm) and mud-M (< 0.063 mm) fractions. The fractions retained in sieves after wet sieving (Folk, 1961), were carefully collected, oven-dried (<60°C) and weighed. Mud content was estimated by taking the difference in weight between initial weight of sample and the sum of weights of gravel and sand. The data gathered was represented in gravel-sand-mud chart of Folk, 1961 (Fig. 4.1).

4.3. Results and Discussion

The results of textural analysis (G, S and M in %) is given in Table 4.1 and depicted in Figure 4.2. Mean content of G, S and M (in %) of various horizons and profiles in NB and TB is given in Table 4.2 and Fig. 4.2.

The remarkable aspect of G-S-M plot in NB and TB is the higher content of gravel and mud in NB, and higher amount of sand but poor amount of mud in TB. In NB, mean gravel content in A-horizons is 43% (range= 21-64%; n=2) and in B-horizons it is 35% (range= 12-76%; n=7). These values are relatively higher than the corresponding horizons in TB. In TB, mean gravel content in A-horizon is 13% (range= 2-34%; n=4) and in B-horizon it is 19% (range= 5-36%; n=3). However, the gravel content of C-horizon of NB is 23 and that of TB is 47%. (Table 4.2)

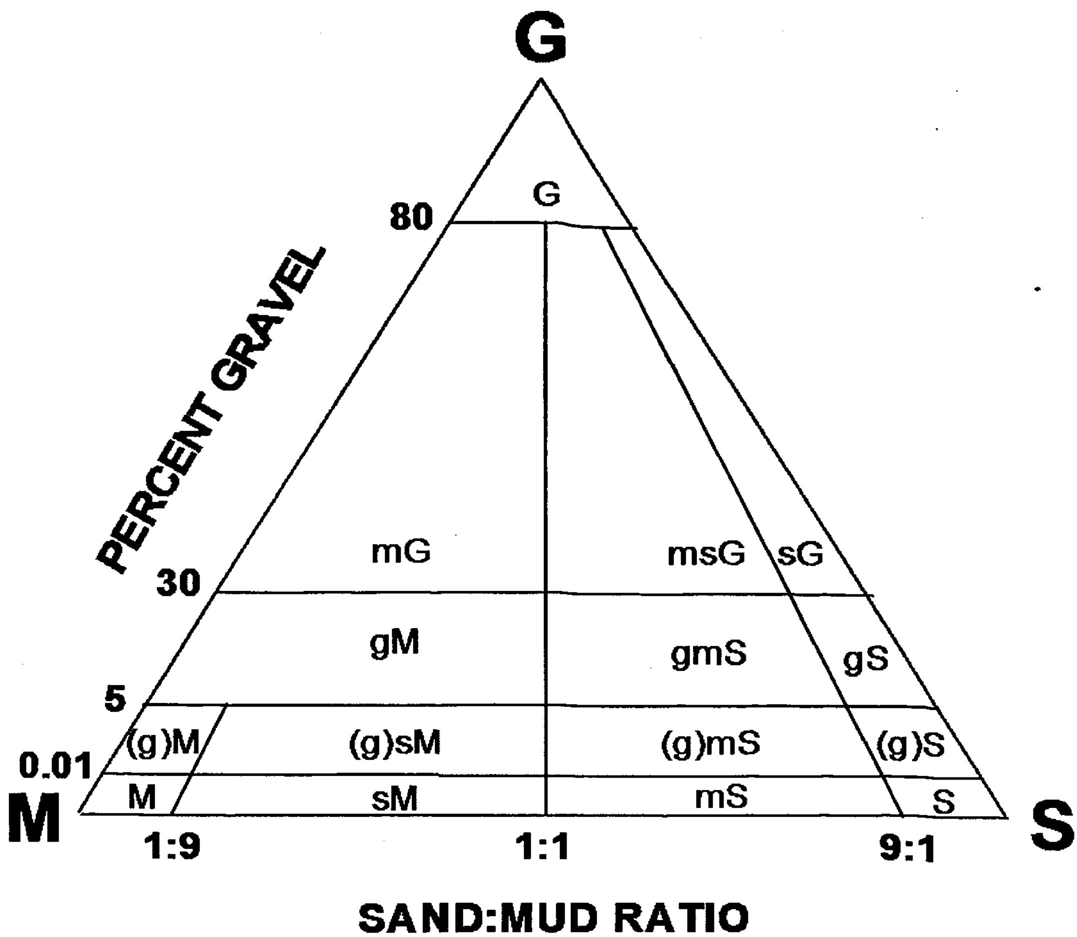

Fig. 4.1: Textural classification of granular mixtures of gravel, sand and mud. G: gravel; mG: muddy gravel; msG: muddy sandy gravel; sG: sandy gravel; gM: gravelly mud; gmS: gravelly muddy sand; gS: gravelly sand; (g)M: slightly gravelly mud; (g)sM: slightly gravelly sandy mud; (g)S: slightly gravelly sand; M: mud; sM: sandy mud; mS: muddy sand; S: sand (After Folk, 1961).

Table 4.1: Up-profile variation of textural class in weathering profiles of Neyyar and Tambraparni basins (terminology after Folk, 1961)

Sl. No	Profile / Sample No	Horizon / sub horizon	Gravel %	Sand %	Mud %	Texture code
1	NB 19-1A	A	64.15	19.86	15.99	msG
2	19-1	BL1	21.96	22.70	55.34	gM
3	19-2	BL2	29.23	39.05	31.72	gmS
4	19-3	C1	20.57	59.22	20.21	gmS
5	NB 24-1	BL1	11.96	54.95	33.09	
6	24-2	BL2	25.57	38.42	36.01	gmS
7	24-3	C1	No data	No data	No data	gmS
8	NB 35-1	BA	76.18	18.16	5.66	msG
9	35-2	BL2	64.06	19.77	16.17	msG
10	35-5	C1	26.50	65.55	7.95	gmS
11	NB 42-1	A	21.20	48.95	29.85	gmS
12	42-3	BL1	16.12	53.79	30.09	gmS
13	42.6	C1	23.22	63.80	12.98	gmS
14	TB 6-1	A	12.42	64.80	22.78	gmS
15	6-2	BC	36.20	53.28	10.52	msG
16	6-3	C1	62.75	34.83	2.42	sG
17	TB 33-1	A	1.62	82.66	15.72	(g)mS
18	33-2	BC	5.24	80.62	14.14	gmS
19	33-3	C1	45.96	51.05	2.99	sG
20	TB 38-1	A	2.18	66.26	31.56	(g)mS
21	38-2	B	16.10	52.20	31.70	gmS
22	38-3	C1	4.97	79.01	16.02	(g)mS
23	TB 42-1	A	34.29	57.79	7.92	msG
24	42-3	Ck1	81.73	17.29	0.98	G
25	42-5	Ck2	38.66	58.92	2.42	sG

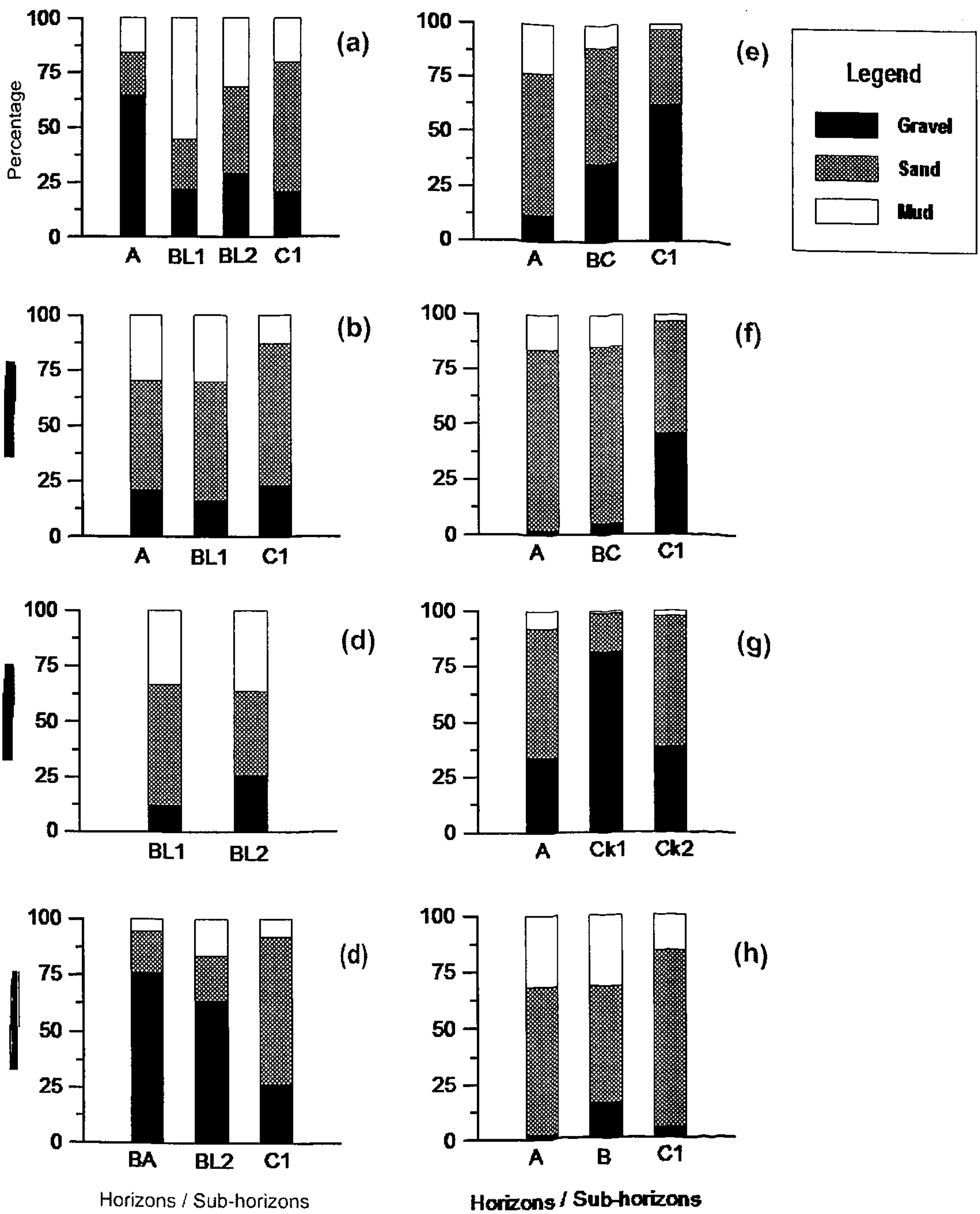

Fig. 4.2: Percentage of gravel, sand and mud (%) in different horizons of weathering profiles in NB and TB.
a, b, c and d are NB-19, NB-42, NB-24 and NB-35 respectively.
e, f, g and h are TB-6, TB-33, TB-42 and TB-38 respectively.

Table 4.2: Range and mean of gravel, sand and mud in NB and TB

Mean values	Gravel %	Sand %	Mud %	Texture code
Mean A of NB	43 (range: 21-64, n=2)	34 (range: 20-49, n=2)	23 (range: 16-30, n=2)	msG
Mean B of NB	35 (range: 12-76, n=7)	35 (range: 18-55, n=7)	30 (range: 6-55, n=7)	msG
Mean C of NB	23 (range: 21-27, n=3)	63 (range: 59-66, n=3)	14 (range:8-20, n=3)	gms
Mean A of TB	13 (range: 2-34, n=4)	68 (range: 52-81, n=4)	19 (range:11-32, n=4)	gms
Mean B of TB	19 (range:5-36, n=3)	62 (range: 58-83, n=3)	19 (range: 5-36, n=3)	gms
Mean C of TB	47 (range: 5-82, n=5)	48 (range: 17-79, n=5)	5 (range: 1-16, n=5)	sG
Grand mean: NB	34	44	22	msG
Grand mean: TB	26	59	15	gms
TB – 38	8	66	26	gms
Mean of A&B: NB	37	35	28	msG
Mean of A&B: TB	15	65	19	gms
Neyyar river: Mean (Sebastian, 1999)	11	88	1	gS
Tamraparni river: Mean (Sebastian, 1999)	11	89	0	gS

msG : muddy sandy gravel ; gM : gravelly mud; gmS : gravelly muddy sand ;
(g)mS : slightly gravelly muddy sand; gS: gravelly sand; ; sG : sandy gravel G : gravel.

In NB, gravel fraction in A- and B-horizons largely consists of quartz grains, usually with a reddish brown coating of limonite fragments. The higher content of gravels in A- and B-horizons is due to the presence of limonite grains or lumps derived from laterite. Gravel in C-horizons here consists of saprolite/saprock fragments, strongly weathered feldspar (Todd, 1968), quartz and alterite grains. Rock fragments *per se* are absent. Gravel-sized grains with ferruginous coat in C-horizons of NB derived from GBG, as in NB-35 and NB- 42, appear to be weathered garnet. The C-horizon in NB, being an incipiently weathered zone, does not contain any limonite lumps and hence has a lesser gravel content (23%). The higher amount of gravel (43%) in A-horizon appears to be a lag deposit formed by preferential removal of finer grains by sheet erosion caused by copious rainfall.

In TB, gravel fraction in A- and B-horizons consists of quartz grains (less often with iron oxide coating), alterite, calcrete grains (at times nodular) and rock fragments. Here, gravel in C-horizons consists of saprolite/saprock fragments, 'slightly- to moderately weathered' feldspar (Todd, 1968) quartz, lesser amount of calcrete and partially altered grains of garnet, often with an unaltered core. Rock fragments are often present. Limonite grains are conspicuously absent.

Sand content in A-horizons in NB has a mean value of 34% (range= 20-49%; n=2) and that of sand in B-horizons is 35% (range= 18-55%; n=7). C-horizons here possess an average sand content of 63% (range= 59-66%; n=3). Sand content in horizons of TB shows a different trend. Average content of sand in A-, B- and C-horizons in TB are 68% (range= 52-81%), 62% (range= 58-83%) and 48% (= 17-79%) respectively (Table 4.2). Sand sized grains in NB consist of quartz (often iron stained), limonite, alterite, saprolite grains. Sand fraction in TB consists of quartz, saprock/saprolite grains, limonite, alterite, lesser calcretes grains and fresh to slightly weathered feldspars (Todd, 1968).

Inter-basinal difference in texture between NB and TB is best displayed by the mud content. Content of mud in A-horizons of NB averages at 23% (range= 16-30%; n=2) and that of B-horizon is 30% (range= 6-55%; n=7). Average amount of mud in C-horizon is 14% (range= 8-20%; n=3). Mud content in TB is considerably lower. Mean mud content amounts to 19% each in A- and B-horizons. Mud in C-horizon in NB is substantially low at 5% (range= 1-16%; n=5).

Figure 4.3, is a plot of G: S: M in A, B and C horizons/sub-horizons in profiles of NB and TB. Figures 4.3 (a) and 4.3 (b) display data of profiles in ML and HL in NB respectively. Here, progressive weathering from C- to B-horizon clearly indicates enrichment of gravel and/or mud. Plots 4.3 (c) and 4.3 (d) show data points of profiles in ML and HL of TB respectively. Weathering of C-horizon to B- or A-horizon points out that progressive weathering results in enrichment of sand. An exception is profile TB-38 (a site that enjoys humid climate) where C- to B-horizon transition is accompanied by enrichment of gravel and mud, a pattern similar to profiles in NB.

Further, a plot of average content of G, S and M in A, B and C horizons of NB and TB is shown in Figure 4.4a. The behavior of mean values between the basins is interesting in the backdrop of variable climate. The mean G: S: M of A- and B-horizons (43:34:23 and 35:35:30 respectively; Table 4.2 and 4.3) of NB plot in the fields of 'muddy sandy gravel' (msG). The corresponding plot of C-horizon (G: S: M=23:63:14) is in the field of 'gravelly muddy sand' (gms). The plot of mean G: S: M in horizons in TB gives a different picture. The mean G: S: M data in A horizon (13:68:19) as well as B-horizon (19:62:19) falls in the category of 'gravelly muddy sand' (gmS). The corresponding figure for C-horizon in TB has a G: S: M proportion of 47: 48: 5 i.e. sandy gravel (sG) (Table 4.3).

An overall averaging of GSM values in these basins is reflective of the general trend. The average G: S: M value for all horizons in NB is 34: 44: 22 (msG-muddy sandy gravel) and that of TB is 26:59:15 (gms-gravelly muddy sand) (Table 4.2). The generalized trend of C- and B-horizons clearly indicates that pathways of textural change in NB and TB are in different directions (Fig. 4.4b). Progressive weathering in NB (under humid climate) from C- to B-horizon is directed towards enrichment of gravel and mud. On the contrary, weathering in TB (under semi-arid climate) result in generation of sand. The type of soil generated by weathering of rocks has been related to rainfall by many workers (e.g., Jenny and Leonard, 1934; Jenny, 1941; Bryan, 1967; Ramirez, 1990; Brady et al., 1999).

The profile TB-38 is a case in point with a mean G: S: M proportion of 8: 66: 26 (Table 4.3). Even though located within Tamraparni Basin, this site is situated close to Kerala Tamil Nadu boarder and receives higher rainfall of 2542 mm as against 697 mm in rest of the basin. This is reflected in the higher mud content at this location.

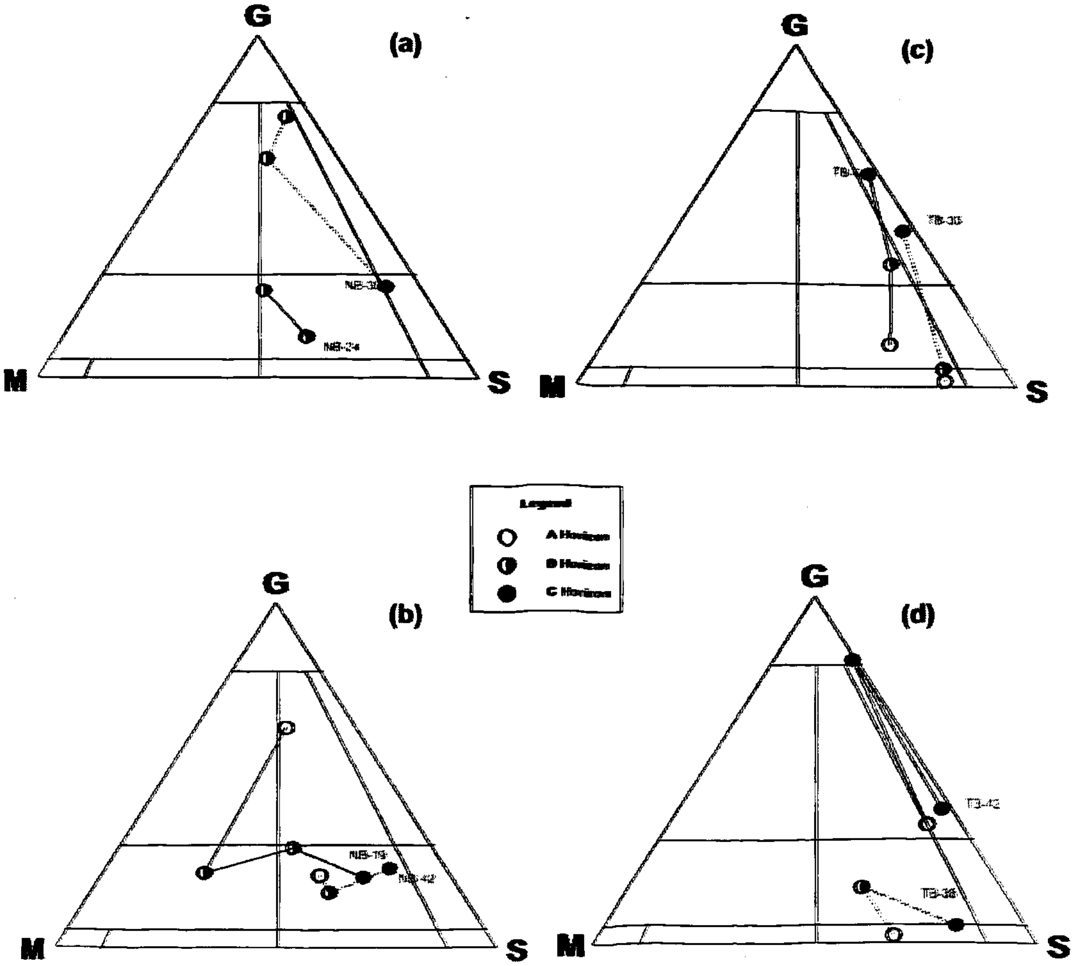

Fig. 4.3: Textural classification (after Folk, 1961) of gravel (G), sand (S) and mud (M) mixtures in A, B & C horizons of weathering profiles developed over charnockite (solid line) and garnetiferous biotite gneiss (broken line) in (a) midland of NB, (b)highland of NB (c) midland of TB and (d) highland of TB. See fig. 3xx for textural classification.

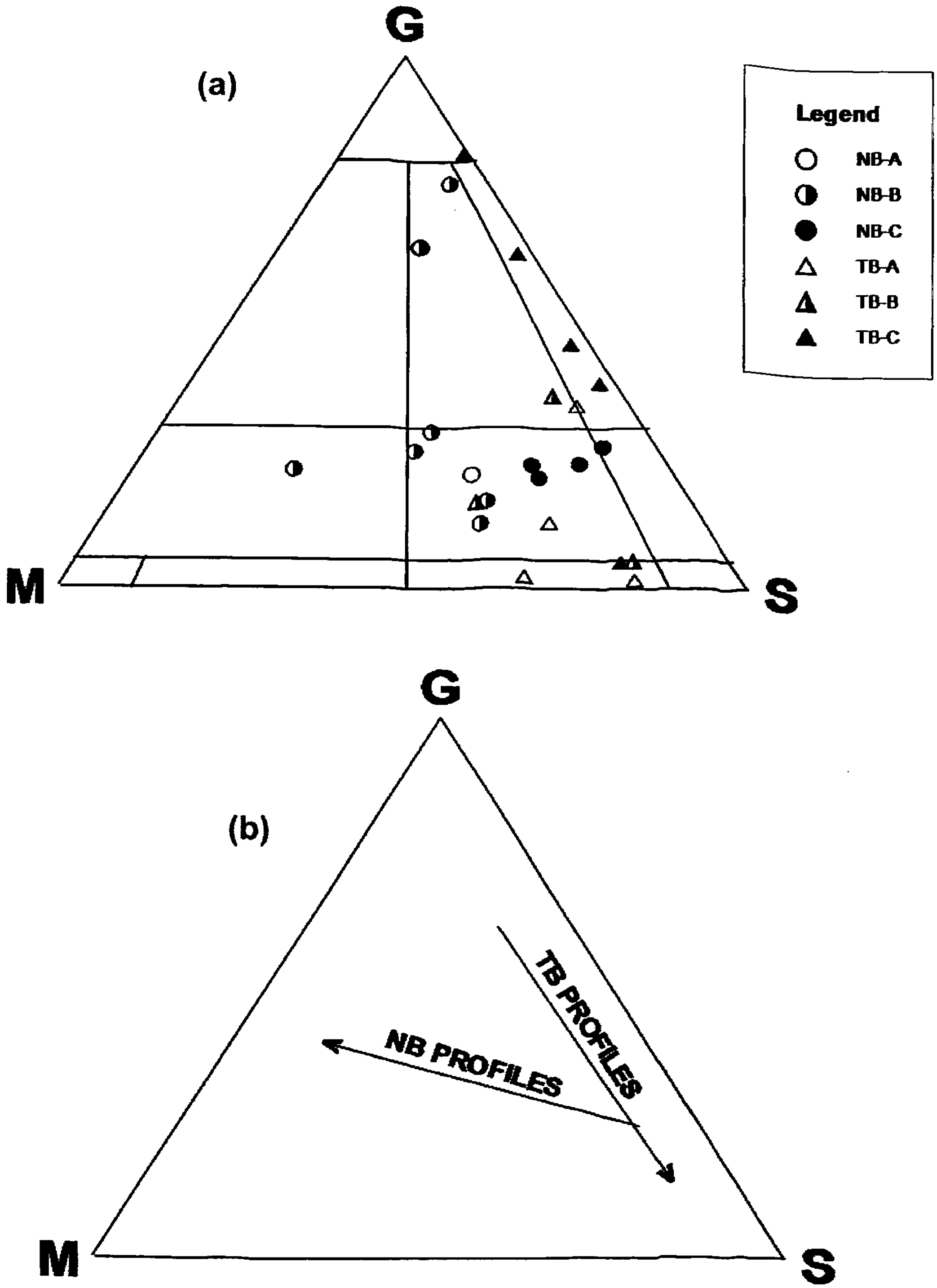

Fig. 4.4: (a) Distribution of gravel, sand and mud in A, B and C horizons in NB and TB.
(b) Generalized trend of gravel, sand and mud distribution in C and B horizons in NB and TB

Table 4.3: Horizon / Subhorizon specific textural classes based on gravel: sand: mud proportions in Neyyar and Tambraparni basins (terminology after Folk, 1961)

PROFILE	HORIZON / SUBHORIZON								
	Ck2	Ck1	C1	BC	B	BL2	BL1	BA	A
NB 19	-	-	gmS	-	-	gmS	gM	-	msG
NB 24	-	-	-	-	-	gmS	gmS	-	-
NB 35	-	-	gmS	-	-	msG	-	msG	-
NB 42	-	-	gmS	-	-	-	gmS	-	gmS
TB 6	-	-	sG	msG	-	-	-	-	gmS
TB 33	-	-	sG	gmS	-	-	-	-	(g)mS
TB 38	-	-	(g)mS	-	gmS	-	-	-	(g)mS
TB 42	sG	G	-	-	-	-	-	-	msG

gmS: Gravelly muddy sand; msG : Muddy sandy gravel; sG : Sandy gravel; G : Gravel; (g)mS : Slightly gravelly muddy sand

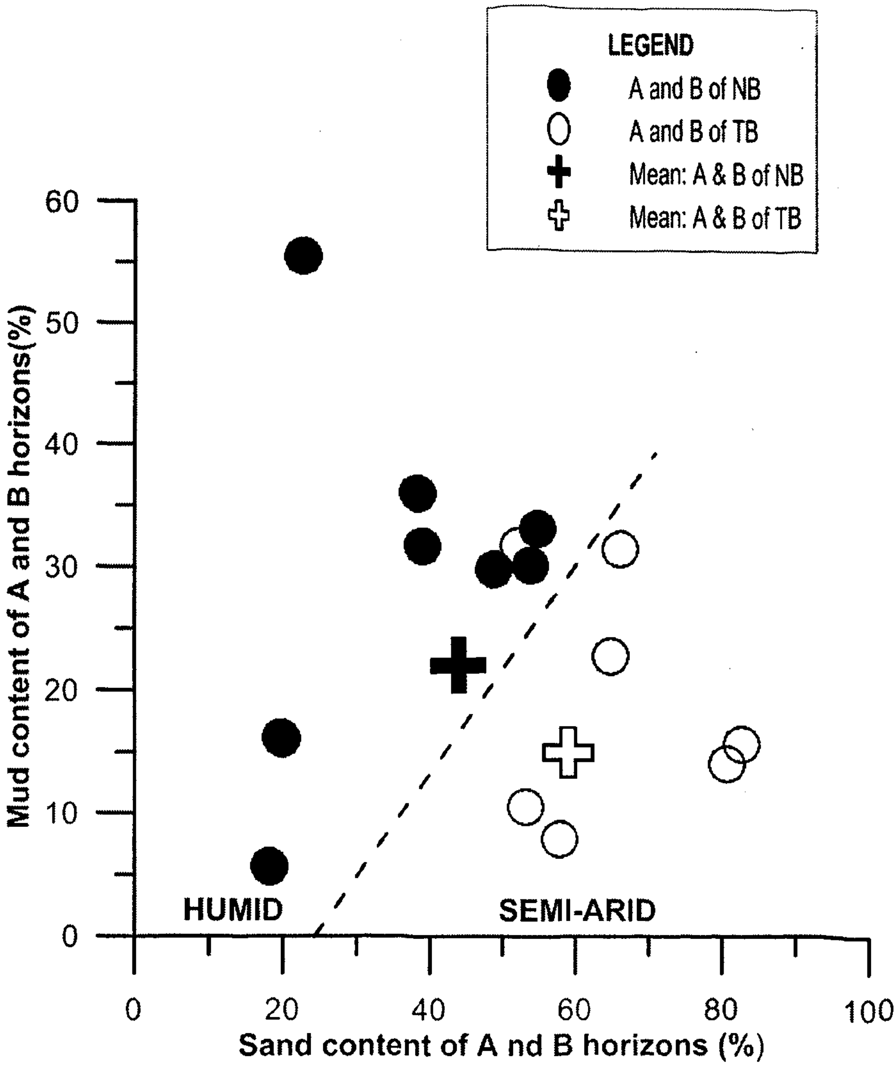

Fig. 4.5: Plot of sand vs mud content (%) in A and B horizons in Neyyar and Tamaraparni Basins. Note segrgation of data plots to humid and semi-arid climaic domains (this study).

The soil profiles under study in NB and TB are developed over charnockite or GBG (Sections 3.5 and 3.6). The data in Tables 4.1 & 4.2 and Figs. 4.2 & 4.3 indicating lesser control of bedrock lithology on G: S: M content of soil horizons.

In a typical 'in situ' soil, the A-horizon has a texture, dominated by sand or mud, while gravel is far less common. In fact, during transportation process gravel is concentrated, while finer constituents are carried away. Thus, gravel content is a measure of extent of denudation of soil. The A-horizon in the NB is a case in point. Dominance of gravel in A-horizons of NB profiles is suggestive of denudation or wasting which enriches the gravel content (Thrivikramaji, 1986). The process of hydrolysis, which is essentially water-driven, is dominant in tropical and subtropical regions (Tardy, 1992), which tend to decompose and destroy the primary alumino-silicate minerals to form secondary clays.

The difference in texture between NB and TB is interpreted as the consequence of a larger content (~8–20%) of mud in the C-horizon of NB compared to its lesser presence (~2–3%, excluding that of TB-38) in the C-horizons of TB. This is attributed to the difference in rates and patterns of weathering under distinctly differing climates (humid vs. semi-arid) of the two basins. In other words, the higher mud content in NB is a sign of efficiency of chemical weathering under tropical humid climate. Lower mud content, lesser degree of alteration of feldspar and garnet and presence of rock fragments in TB are additional evidences for retarded chemical weathering under semi-arid conditions. The study of formation of clay minerals under humid and semi-arid climate on either side of WG by Deepthy and Balakrishnan (2005) and the studies on intense chemical weathering under humid climate by Curtis (1990) support the above findings.

A plot of sand vs. mud (in %) of A- and B-horizons in profiles of NB and TB gives interesting results (Fig. 4.5). Data of NB and TB as well as their mean values show least overlap reflecting the humid and semi-arid environs of the samples.

4.4. Summary

The effect of weathering on similar bed rocks (viz., Charnockite and GBG) under differing climates is the focus here in the foregoing. Four soil profiles each were selected from NB (humid) and TB (semi-arid) to study the up-profile variation in G (gravel)-S (sand)-M (mud) variability. Among the four profiles, the major findings are summarized below.

1. The G, S and mud M percentage were plotted in the Folk (1961) classification diagram to identify the dominant textural classes.

2. In NB, A-horizons are enriched in gravel (21-64%) than in TB (2-34%). The higher gravel content in the A-horizons of NB is a result of presence of limonite fragments as well as denudation of soil leading to enrichment of this size class as a lag deposit.

3. The B-horizons in NB show a wide range in texture i.e. muddy sandy gravel (msG) - gravelly muddy sand (gmS) - gravely mud (gM). In contrast, in TB, B horizons have muddy sandy gravel (msG) and gravelly muddy sand (gmS).

4. The saprolite/saprock (C-horizon) of NB gives rise to a detritus of gravelly muddy sand (gmS). In TB, all samples (except TB-38) are sandy gravel (sG) or gravel. However, in TB 38 the C-horizon is slightly gravelly muddy sand (gmS).

5. In profiles of midland in NB (NB-19, NB-42) an overall enrichment of mud is seen in the advanced weathering zone of B than C-horizons. On the contrary, in the highland (NB 35) there is an overall increase in gravel content. On the other hand, the TB profiles transformation of C to B proceeds in the direction of increase in sand content in both midland and highland.

6. Profile TB-38, located in the highland, has attributes more or less like the profiles in NB. i.e., an increase in mud content from C to B (16-31%) - perhaps an imprint of higher rate of chemical weathering in more humid climate but unlike other locations of TB studied.

7. In TB lower up profile mud content may be due to subdued chemical weathering in a semi-arid climate. The weathered rock is only partially kaolinised and the sand sized quartz grains and rock fragments are physically freed from the matrix without undergoing significant decomposition.

8. The study also reveals that climate has a direct influence on texture of detritus in the profiles developed in tropical humid and semi-arid climates.

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