South Pacific Study Vol. 13, No. 2, 1993

Electron Microscopic Observation of Clays of Calcareous and Noncalcareous Soils in Bangladesh

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Abstract

Electron microscopic observation of calcareous and noncalcareous floodplain soils of Bangladesh were carried out by TEM and SEM. Morphological changes in relation to clay formation and weathering process were investigated. Unweathered, partially weathered and weathered micaceous minerals accompanying with poorly crystallized kaolinite and halloysite and other primary minerals were observed in silt and coarse clay of both calcareous and noncalcareous soil. Smectite and vermiculite which are dominated in calcareous and noncalcareous soils respectively, were not distinguished by EM observation. Unique shaped diatom of different sizes were reported firstly.

Key words: Bangladesh soils, Calcareous and Noncalcareous, EM observation, Weathered mica, Diatoms

Introduction

The soils of Bangladesh are classified into 20 General Soil Types based on the mode of soil formation and broad morphological appearences. Among them calcareous and noncalcareous floodplain soils occupy more than 65% of the total land. The major deposits under these soils are derived from Brahmaputra, Ganges, Meghna and Teesta rivers having variable mineralogical compositions.

Some works have been done on clay mineralogy of some Bangladesh soils based mainly on X-ray diffraction analysis. The authors have been investigating systematically all 20 General Soil Types on their chemical and physical properties and also their mineralogical properties by X-ray, EM, DTA, TG etc.. In the works, X-ray analysis have revealed that clay mineralogically, noncalcareous floodplain soils are vermiculitic while calcareous floodplain soils are smectitic (to bepublished elsewhere). But there is no report on electron microscopic observation except some reports with limited number of soils done by HABIBULLAN *et al.* (1971) and KARIM (1984) up to now.

In this study the authors observed the common characteristics and general features of

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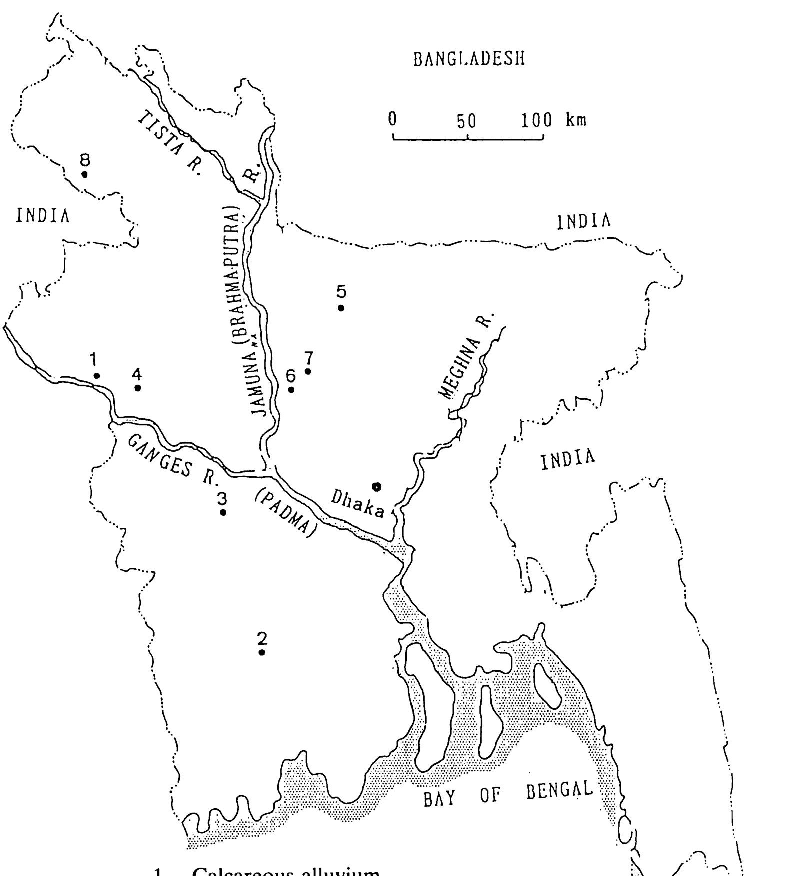
mineral particles of calcareous and noncalcareous floodplain soils in relation to clay mineral formation processes under both transmission and scanning electron microscope.

Materials and Methods

The calcareous and noncalcareous deposits are originating in the Assam hills, Himalayas and/or Peninsular Indian Shield that are ranging in age from 200 to 2000 years or more (FAO, 1971). According to HUIZING (1971), from the mineralogical viewpoint, the common characteristics of the floodplain deposits are to consist more than 50% of quartz, 5 to 30% feldspar, nearly 15% mica and 2 to 10% heavy minerals. Among the heavy minerals, amphibole, garnet and epidote are predominent. The Ganges calcareous deposits that are



1. Calcareous alluvium
2. Calcareous grey floodplain soil
3. Calcareous dark grey floodplain soil
4. Calcareous brown floodplain soil
5. Noncalcareous alluvium
6. Noncalcareous grey floodplain soil
7. Noncalcareous dark grey floodplain soil
8. Noncalcareous brown floodplain soil

Figure 1. Sample locations

Peninsular Indian Shield origin can be differentiated from the Brahmaputra noncalcareous deposits of Himalayan origin by their lower contents of amphibole, low biotite, generally low epidote/garnet ratio and by the presence of carbonate minerals. The lower Meghna river estuarine floodplain noncalcareous deposits are dominated by mica content of nearly 70%.

Soil samples were collected from both calcareous and noncalcareous groups of their alluvial, grey, dark grey and brown floodplain areas. Figure 1 shows the sample sites and Table 1 shows the depth and horizon of sampling and physiography of sample area. The soils are mostly fine silty loam to heavy clay in texture. Calcareous soils have high pH ranging from 7.19 to 8.36 with high exchangable Ca and base saturation degree. The pH of the noncalcareous soils ranged between 5.24 and 7.83. The general description and chemical properties of these soils are published by ALAM *et al.* (1993).

Table 1. Depth and physiographic description of samples

Sample No.	General Soil Type	Physiography	Horizon	Depth (cm)
1-1	Calcareous	Active Ganges	A_P	0-14
-2	Alluvium	floodplain	C_1	25-50
2-1	Calcareous Grey	Ganges tidal	A_{P1}	0- 8
-2	Floodplain Soil	floodplain	B_{21}	13-25
3-1	Calcareous Dark	Ganges river	A_{P1}	0-12
-2	Grey Floodpl. Soil	floodplain	B_2	20-55
4-1	Calcareous Brown	Ganges river	A_p	0-15
-2	Floodplain Soil	floodplain	B_{W1}	15-35
5-1	Noncalcareous	Active Brahma-	A_{Pg}	0-16
-2	Alluvium	putra floodplain	C_{1g} & C_{2g}	25-50
6-1	Noncal. Grey	Young Brahma-	A_P	0-15
-2	Floodplain Soil	putra floodplain	B_2	15-40
7-1	Noncal. Dark Grey	Old Brahma-	A_P	0-13
-2	Floodplain Soil	putra floodplain	B_{21}	25-37
8-1	Noncal. Brown	Himalayan pied-	A_P	0-15
-2	Floodplain Soil	mont plain	B_{21}	15-35

The soil samples were fractionated into coarse sand (2.0-0.2 mm), fine sand (0.2-0.02 mm), silt (0.02-0.002 mm) and clay (<0.002 mm) by repeated sonification-sedimentation-siphoning after treating with H_2O_2 to remove organic matter. Some of thus collected clay fractions were further separated into coarse and fine clays by centrifugation. Diluted suspensions of silt and clay fractions were spotted on to a copper grid supported by 4% collodion and coated with thin carbon for transmission electron microscope (TEM). For scanning electron microscope (SEM), samples were spotted on to brass plate. The prepared samples were observed using Hitachi H-700H and H-7010A for TEM and SEM respectively.

Results and Discussions

The common features of calcareous and noncalcareous floodplain soils with the morphological changes in coarser to finer particles were examined under both SEM and TEM. The monographs are presented in Figures 2 to 8.

X-ray analysis indicated that among the calcareous series (both top and sub soil), there seems no substantial differences in the mineralogical composition of their silt and clay fractions though the silt and clay contents are variable from sample to sample. The same observation was also found in noncalcareous series. But distinct differences in clay mineralogical composition were existed between calcareous and noncalcareous soils, ie, calcareous series are smectitic while noncalcareous ones are vermiculitic.

As a typical sample from both the groupes, dark grey ones are considered to be in most advanced weathering stage referring to their highest clay content and are taken for brief illustration.

Figure 2 shows the sequential general SEM picture of silt, coarse clay and fine clay particles of top soil of noncalcareous dark gray floodplain (Pl. a, b, c) and calcareous floodplain (Pl. d, e, f) soils. Weathered and unweathered micaceous minerals, poorly crystallized kaolinite (some well crystallized kaolinite also observed) and rod like shape halloysite and other unidentified minerals were observed in silt and coarse clay particles (Pl. a, b, d and e of Fig. 2 and Pl. a, b, c of Fig. 3). This findings is corelate with X-ray result of where they found 14, 10 and 7 A minerals other than large amount of quartz accompanying feldspar, amphibole (hornblende) and others in silt and clay fractions. From the Fig. 2 it is also clear that coarse clays were predominate with clay minerals with considerable amount of fragments of primary minerals whereas in fine clay, fragments of primary minerals were absent or very low. Smectite and vermiculite could not be distinguished by EM observation, as they had no definite shape though it is confirmed by the X-ray analysis that calcareous soils are smectitic and noncalcareous are vermiculitic.

In Figure 4, stacking of layer structure of micaceous mineral with cleavage planes and fracture (Pl. a), partialy weathered mica (Pl. b) and highly weathered mica (Pl. c) are clearly shown. Plate d, may explain the high weathered siliceous particles. These figures are also inaccordance with the 10 and 14 A peacks of X-ray analysis. It is also assumed by the presence of unweathered mica that the weathering processes is not severe in these soils.

Figure 5 gives an idea about the morphological figure of soil particles in top and sub soils of noncalcareous darkgrey (Pl. a, b, c, d) and calcareous dark grey (Pl. e, f, g, h) floodplain soils. Coarse clay and fine clay were separately photographed by TEM. Morphologically there is no acute difference in their coarse clay except in their size where noncalcareous clay had bigger particles than calcareous one. In the fine clay fraction, the clays are more aggrigated in calcareous soil than noncalcareous soil.

Figure 6 shows the general characteristics of the other floodplain soils (alluvial, grey and brown floodplain soils) of their silt fractions and Figure 7 shows the charateristics of whole clay fractions. From the Figure 6 and 7 we do not get any substantial difference in size and shape among the other floodplain soil except in whole clay of noncalcareous brown floodplain soil (Pl. e of Fig 7) where round shaped particles were observed. It may be due to its piedmont deposition that differ from the deposition of river origin.

The existence of diatoms, a common feature of water logged soil, are shown in Figure 8. The silt and clay fraction of the floodplain soils both in top and sub soil have diatom. Different size and shape of diatoms in different soils were observed by both TEM and SEM.

There is no report before this about the existence of diatoms in Bangladesh soils.

As the authors have not made detailed examination on primary minerals (parent materials) of present samples, the whole weathering sequence procceded could not be clarified in this study. But from the present observation of electron microscopy with the aid of X-ray analysis, some aspects of clay mineral formation by weathering may partially become clear. Mainly the weathering of micaceous minerals to vermiculite or smectite and to kaolinite and halloysite were understood. X-ray diffraction also gave chlorite peak that could not distinguished from EM photographs.

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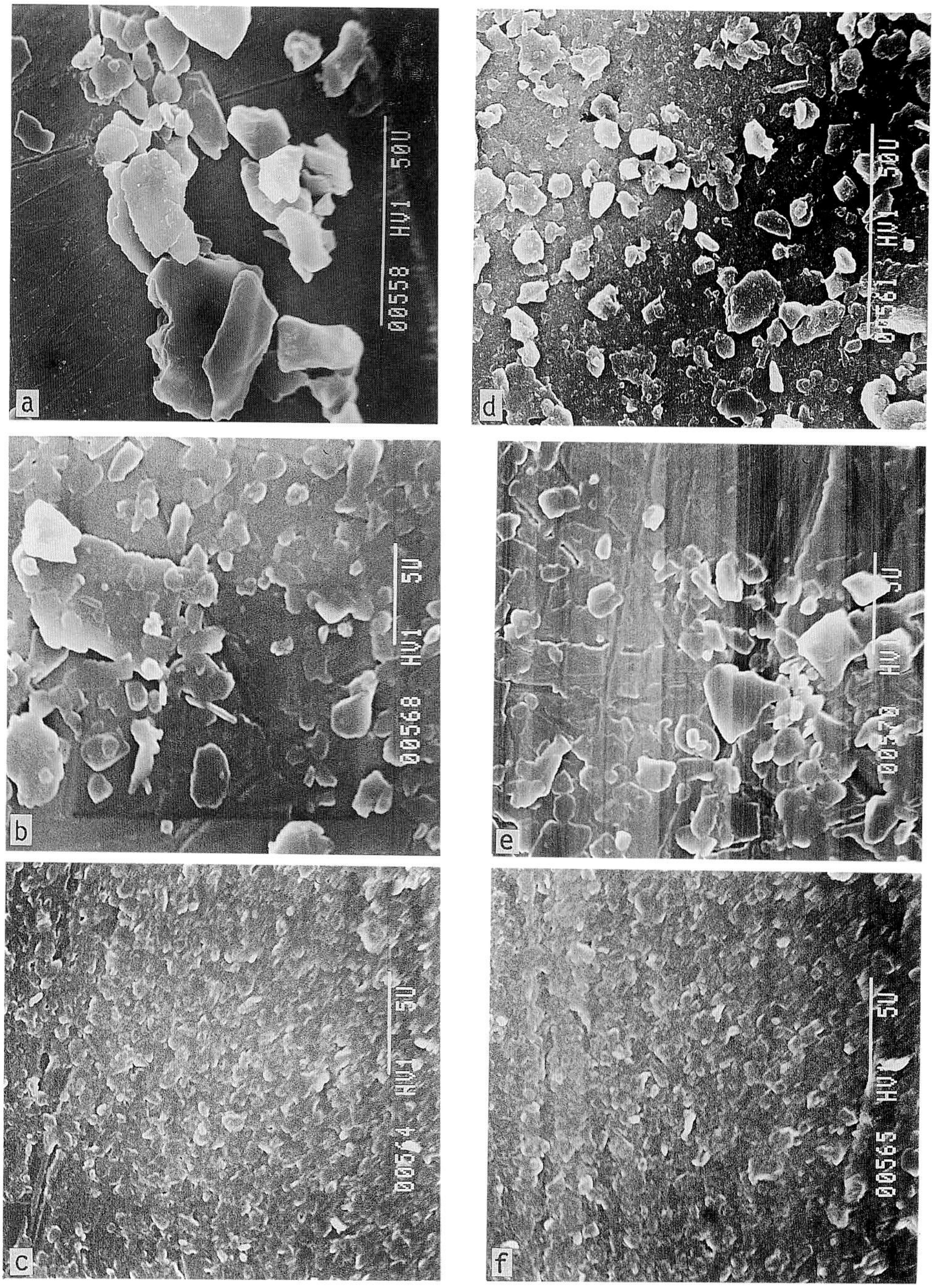

Fig. 2. SEM photographs of silt,coarse clay and fine clay of noncalcareous floodplain (a,b,c respectively) and of calcareous floodplain soils (d,e,f respectively)

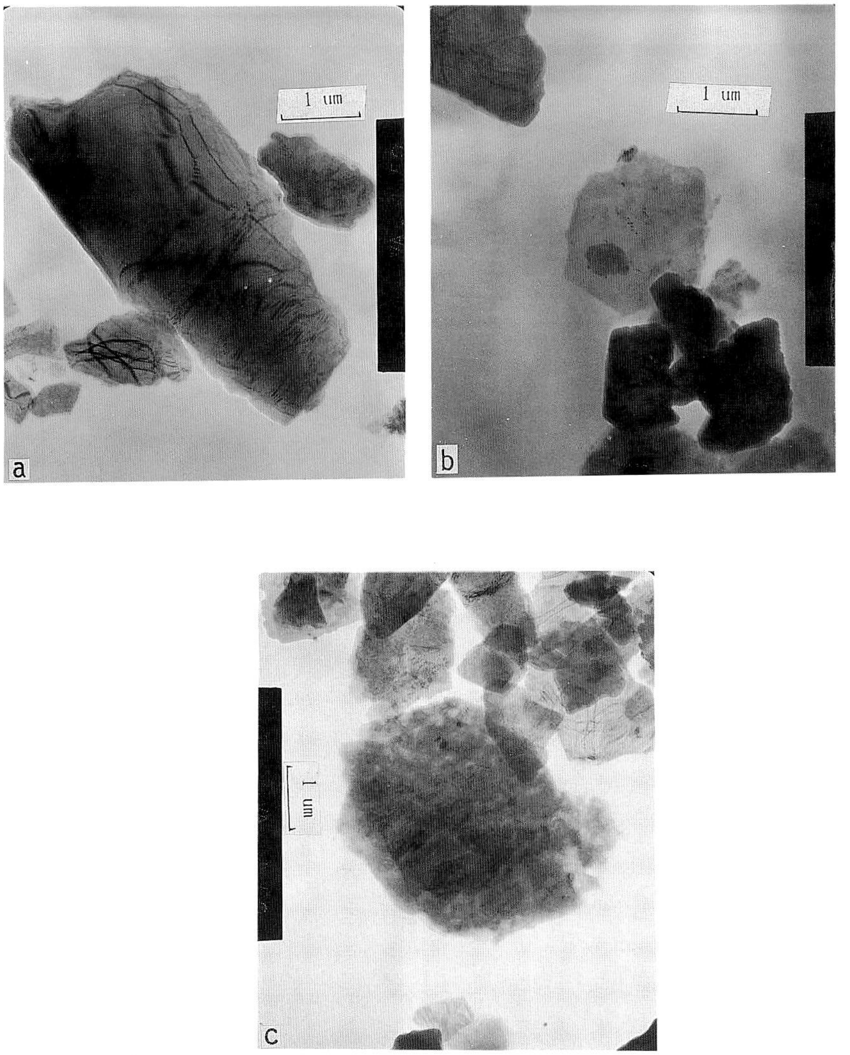

Fig. 3. TEM photograph of unweathered mica (a),kaolinite (b) in silt of noncalcareous dark grey floodplain soil, and weathered mica (c) in calcareous dark grey floodplain soil

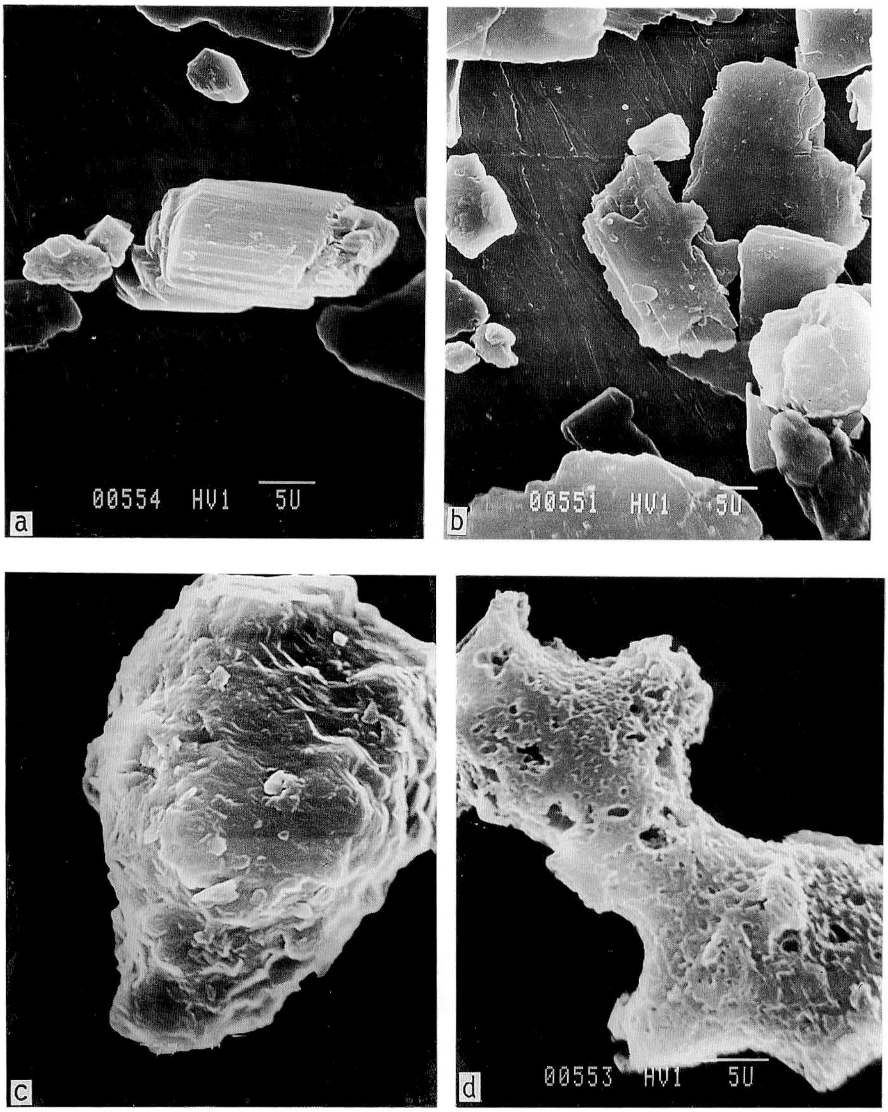

Fig. 4. SEM photographs from silt fraction of noncalcareous (a,b,d) and calcareous (c) floodplain soils

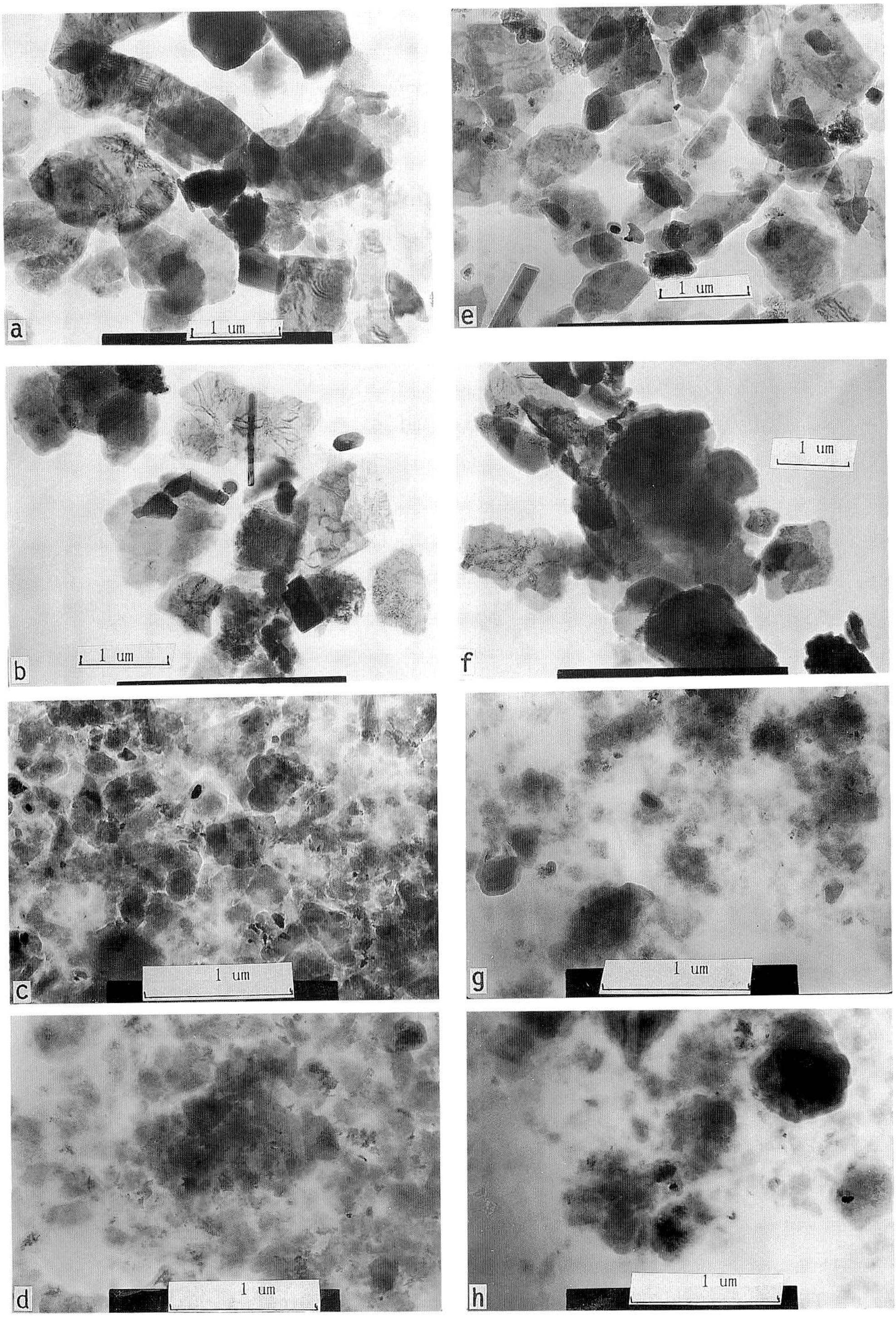

Fig. 5. TEM photographs of noncalcareous floodplain soil (a: top and b: sub soil's coarse clay, c: top and d: sub soil's fine clay) and calcareous floodplain soil (e: top and f: sub soil's coarse clay, g: top and h: sub soil's fine clay)

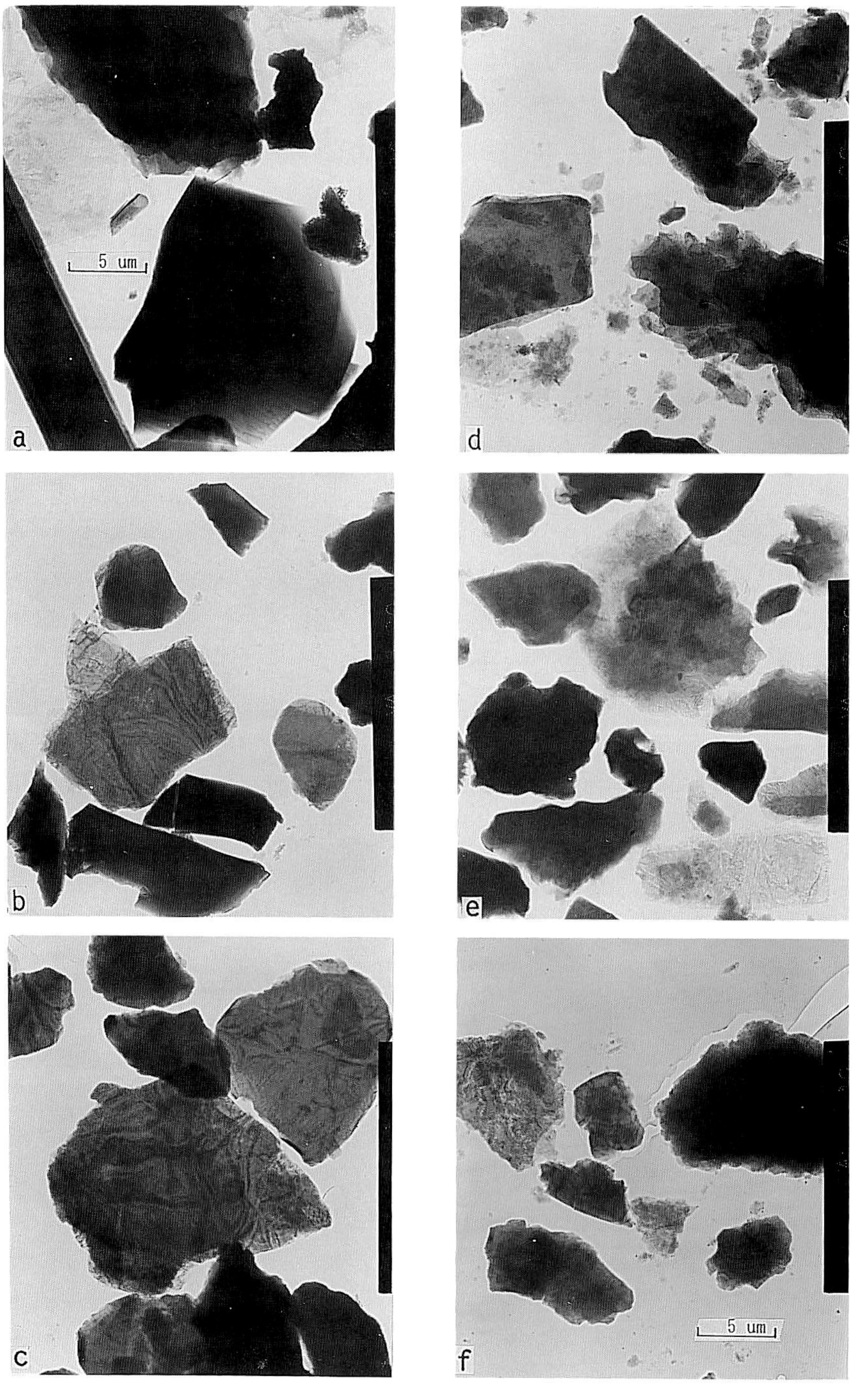

Fig. 6. TEM photographs of silt of other noncalcareous (a: alluvium, b: grey, c: brown) and other calcareous (d: alluvium, e: grey, f: brown) floodplain soils

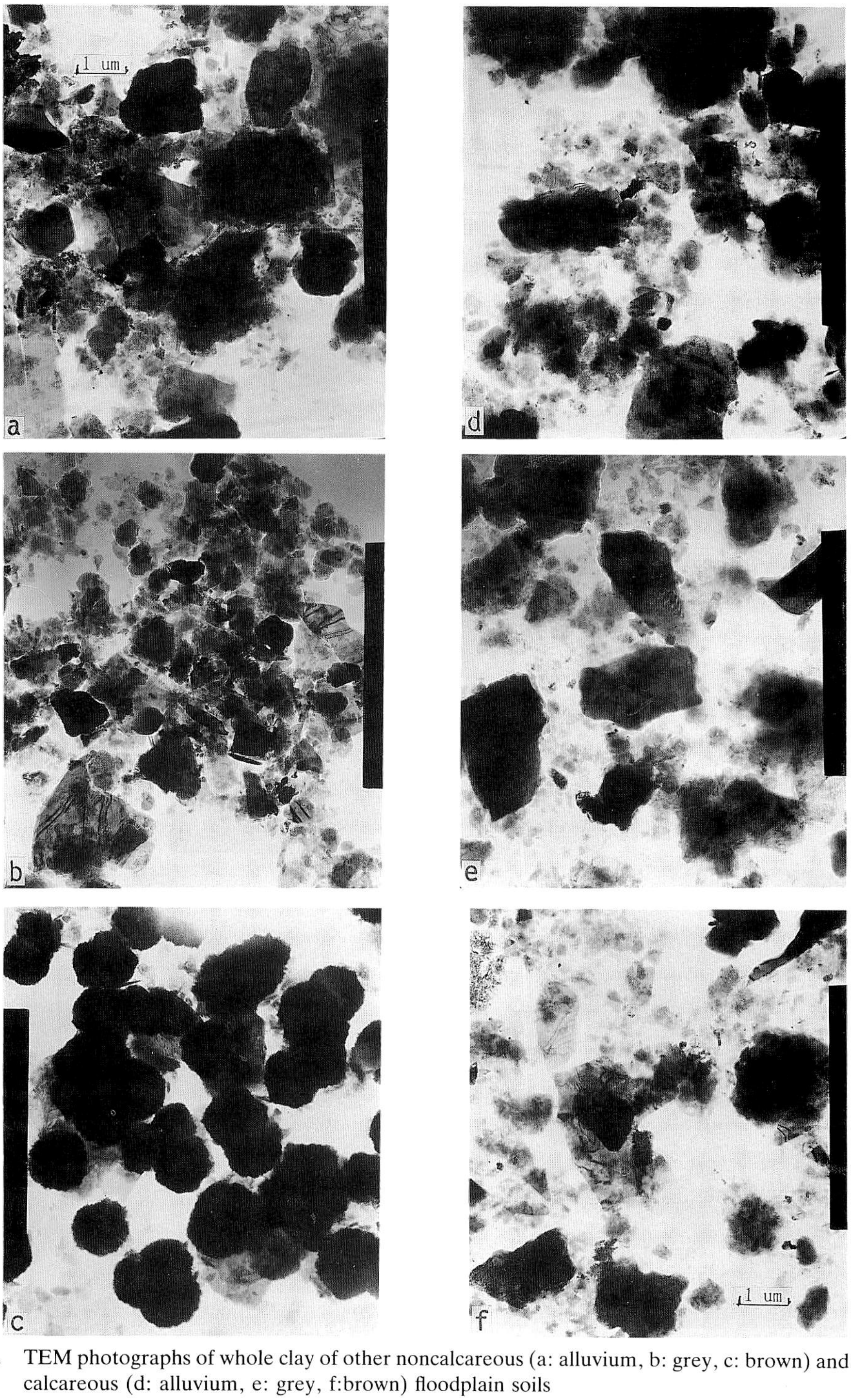

Fig. 7. TEM photographs of whole clay of other noncalcareous (a: alluvium, b: grey, c: brown) and other calcareous (d: alluvium, e: grey, f:brown) floodplain soils

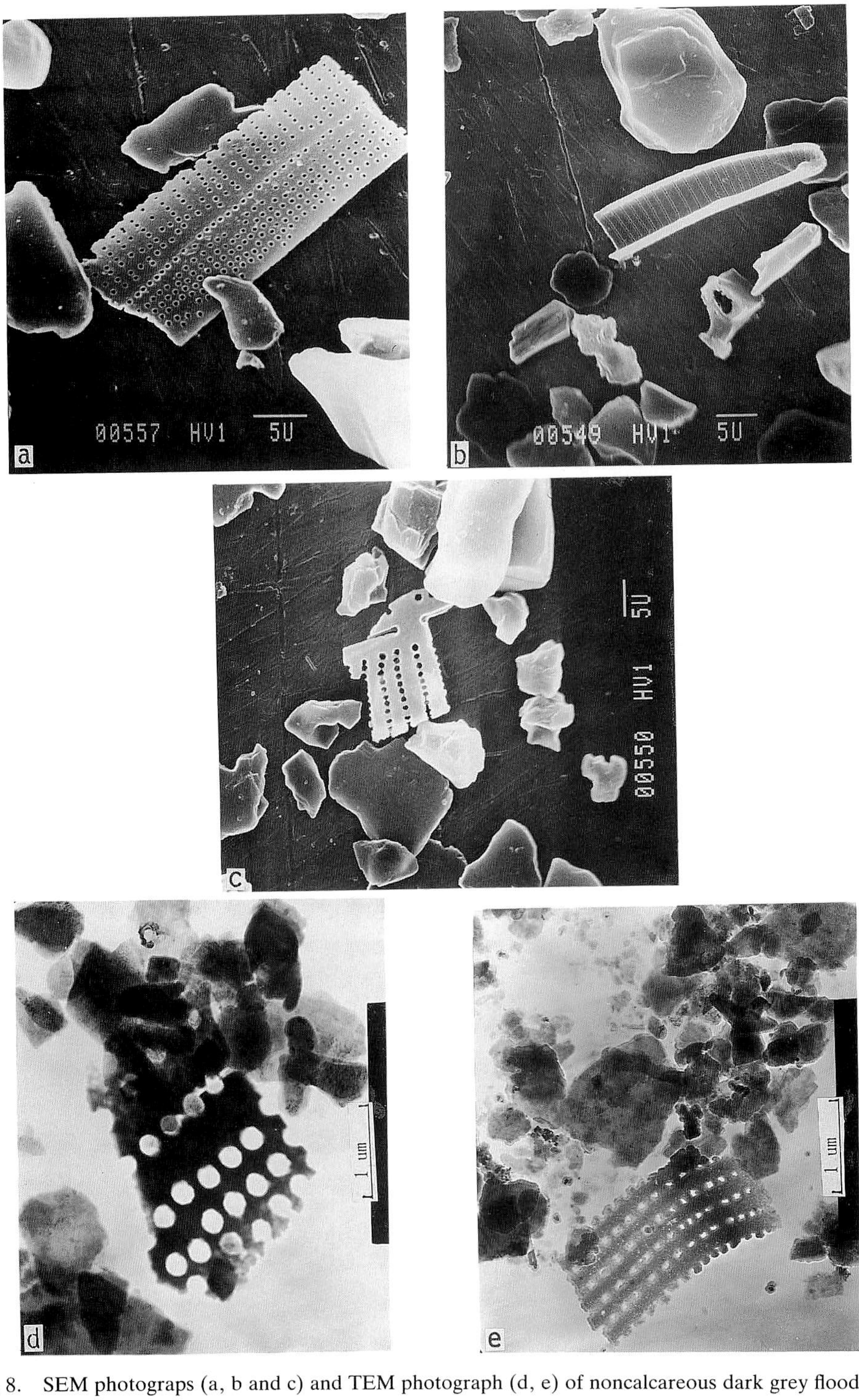

Fig. 8. SEM photograps (a, b and c) and TEM photograph (d, e) of noncalcareous dark grey floodplain soil showing diatoms