

# THE NATURE OF CLAY SOILS FROM THE MEKONG DELTA, AN GIANG PROVINCE, SOUTH VIETNAM

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**Abstract**—Soil samples from near Long Xuyen, South Vietnam, considered to be typical of the clayey alluvial soils of the Mekong Delta, were investigated to determine the soil mineral content and soil type. The soils are of fairly uniform composition, consisting mainly of clay minerals and quartz, the predominant clay minerals including illite and chlorite with lesser amounts of kaolinite and smectite. The small hydrous iron oxide content, indicated by fluorescence background intensity, verified that the soils are not latosols but are clayey estuarine soils amenable to future development as arable land.

The method of specimen preparation enabled direct quantitative analysis of the soil samples by X-ray diffraction with the aid of the results of mechanical analysis and of previous analyses of comparable soil samples from the Delta and nearby areas. A method for the quantitative determination of quartz was used that is independent of the powder crystallite orientation. A study of surface replicas of the soil samples by electron microscopy was made to illustrate the fabric of the soil. The undisturbed soil fabric consists mostly of somewhat randomly-oriented large domains of clay minerals with some blocky quartz particles. Nanno-fossils were present in all samples.

## INTRODUCTION

THE PREVALENCE of lateritic soils (latosols) in Indochina are sometimes used as a basis of argument against the development or improvement of river control because continued exposure of latosols through cultivation often leads to irreversible induration of the soil. The main purpose of this investigation is to characterize the nature of the soils of the Mekong Delta in order to determine whether the land may be subject to further development. In addition, analysis procedures are presented which have been found to be helpful in determining the mineralogical composition of these soils.

During March and April of 1967 soil samples were taken from an area of the Mekong Delta about 15 miles west of Long Xuyen encompassing about 10 miles of the Delta south of the Hau-Giang River (Fig. 1). Core drill samples were obtained at depths varying from about 2 ft to more than 40 ft below the ground surface for the purpose of determining the engineering characteristics of the soil. The surface elevation of the Delta area sampled

varied from about 0.6 to 1.0 m above mean sea level.

Many of the soils of Southeast Asia are relatively simple soils comprised of only a few predominant minerals, as described by Maignien (1966). Although nearly all of the soils previously investigated (Post, 1968) contained small amounts of sesquioxides the predominant portion of the soils often consisted of only two or three minerals permitting the direct quantitative analysis of the soils by X-ray diffraction in conjunction with mechanical analysis. Only the equivalent  $\text{Fe}^{3+}$  content and organic content had to be determined by chemical analysis. The predominant soil minerals were quartz and kaolinite with lesser amounts of feldspar, illite, and mixed-layer clays. The indurated laterites also contain large amounts of hematite and hydrated ferric oxides.

The approximate mineral content of the soil samples was determined by the senior author by an X-ray spectrometric powder technique (Post, 1969) using an oriented powder sample in which the powder was pressed into a specimen holder.

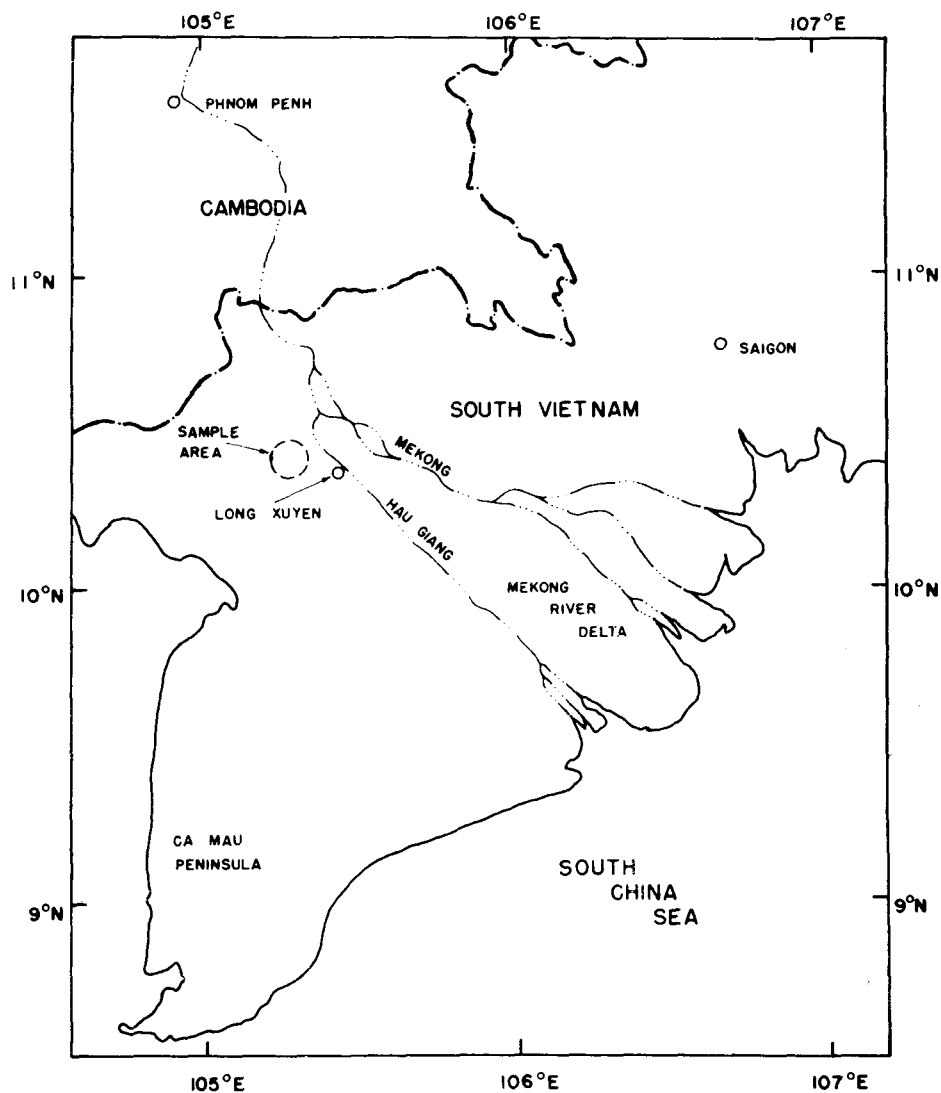


Fig. 1. The Mekong Delta area of South Vietnam.

The clay mineral suite was identified according to the scheme of Warsaw and Roy (1961), which involves the comparison of basal spacings of soil samples, untreated, treated with ethylene glycol, heated to 325°C, and to 550°C. Selected diffraction peak heights were compared with soil mineral contents in the manner suggested by Tatlock (1966). The method was considered suitable because the soil minerals generally showed an intermediate-to-high degree of crystallinity. The total clay-size content ( $< 5\mu$ ) of the soil samples was determined by hydrometer analysis.

#### X-RAY DIFFRACTION ANALYSIS

*Ferric oxides.* When iron is contained in only one type of mineral, the amount of mineral in an aggregate may be estimated by measuring the fluorescence background intensity, as shown by Tatlock (1966). When iron is also present in other minerals as well the method may be invalid (Post, 1969).

The X-ray fluorescence background caused by hydrous ferric oxide is attributed partly to radiation scatter caused by iron fluorescence but also scatter caused by the poorly crystalline nature of

the material. Pure hematite appears to cause only about one-half of the fluorescent background as an equivalent amount of goethite. All varieties of chlorite minerals investigated by the author have given low fluorescent backgrounds, indicating that the presence of chlorite in a soil sample should not increase the fluorescence background significantly.

Although the soils of the Mekong Delta do contain iron-bearing minerals such as chlorites, extremely weathered tropical soils usually contain only sesquioxides near the soil surface (Maignien, 1966) and, in humid climates, the ferric oxide hydrates to form goethite and lepidocrocite which are stable soil minerals (Deer *et al.*, 1962; Brown, 1961).

Soil samples for calibration purposes were chosen which appeared to be comparable to the Mekong Delta soils, including soils from the Saigon area.

Diffractograms were made for seven tropical soils of known mineralogical composition and equivalent ferric iron content (Post, 1968), the fluorescent backgrounds of the diffractograms were measured, from  $15^\circ$  to  $20^\circ 2\theta$ , and the results were plotted (Fig. 2). Crushed Ottawa sand was used to establish normal radiation background.

The previous X-ray analyses of Southeast Asian soils were made with a General Electric XRD-5 diffractometer and the analyses of the Mekong Delta soils were made with a Picker Nuclear X-ray diffractometer, using nickel-filtered copper radiation.

**Quartz.** The crystallite orientation of quartz in a pressed powder sample is quite variable; however,

by making use of four particular calibration peaks for quartz and taking the average value of the diffraction intensities, a close approximation of the quartz content in a mineral aggregation may be obtained (Post, 1969). Calibration curves representing relatively unweathered quartz may be derived using diffraction intensity data obtained with a permaquartz slab. The four calibration curves may be considered linear, representing an approximately random powder orientation, so that direct computations can be made.

The four quartz calibration peaks, 110, 102, 112, and 211, used in this investigation, had peak heights of 48, 52, 86, and 54 units giving an average of 60 units representing 100 per cent quartz. It has been observed that the four diffraction peaks tend to act in pairs as differing crystallite orientation is achieved during sample preparation. By using this quartz analysis procedure diffractogram data secured at different times, and from different apparatus, may be readily correlated. From correlations with petrographic analyses and analyses of prepared mixtures of minerals, values appear to be accurate to within 10 per cent of the total quartz content of the aggregate samples.

**Clay minerals.** Calibration curves for the quantitative analysis of the Mekong Delta soils were derived from the results of analyses of comparable soils of a previous soil mineral investigation (Post, 1968). The results of mechanical analyses of the soil samples were used to determine the total clay-size contents.

There appears to be very little consistency in the more common methods which are used for quanti-

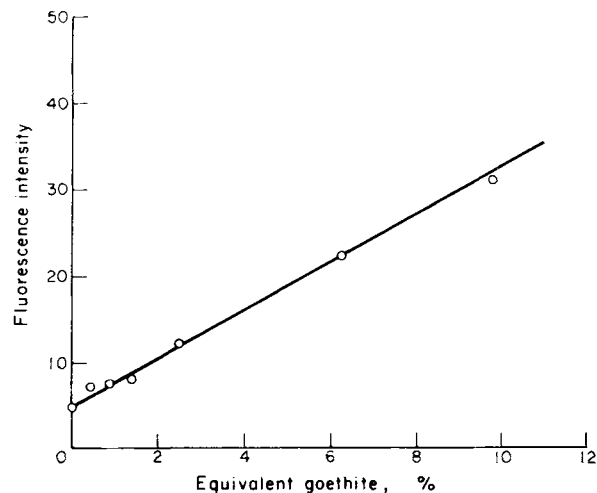


Fig. 2. Plot showing relationship between X-ray fluorescence background intensities, and equivalent goethite contents derived from chemical analyses.

tative analysis of clay mineral aggregations (Pierce and Siegel, 1969). For this reason comparable soils of known composition were considered necessary for direct quantitative analytic procedures. By choosing soil samples which consisted essentially of two, three, and four-mineral systems, including only one clay mineral, it was possible to compare the kaolinite 001 and 002 diffraction peak heights with the kaolinite mineral content, which was determined by hydrometric analysis. When diffraction peaks from other minerals cause interference with the kaolinite 001 peak the 002 peak may be used.

The kaolinite present in the soil samples used to derive data for Figure 3 was considered to have an intermediate degree of crystallinity, as determined by the shape and number of diffraction peaks present. It was observed that the soil samples containing larger amounts of kaolinite often appeared to show a higher degree of crystallinity than the ordinary soil samples, as shown in Fig. 3.

From the investigation of material from a quarry near Bangkok, which contained primarily quartz, kaolinite and illite, we observed that the diffraction peak intensity of illite (002) was very nearly the same as that of kaolinite (001) for comparable amounts of illite and kaolinite, both of which showed a high degree of crystallinity.

The relative intensity of the 7 Å and 10 Å diffraction peaks for equal amounts of kaolinite and illite was taken as 3:2, as suggested by Schultz (1964) for peak area ratios for kaolinite of an

intermediate degree of crystallinity. The 10 Å peaks were quite sharp suggesting the presence of a hydromica with a high degree of crystallinity.

It is particularly difficult to determine relative portions of kaolinite and chlorite present in an aggregation unless the kaolinite 002 reflection and the chlorite (004) reflection appear as separate peaks, or the chlorite (001) reflection can be used. Although soils which are predominantly chloritic are uncommon, analysis of a Moroccan soil composed mainly of such chlorite indicated that the diffraction intensity of the chlorite (002) reflection may be given a ratio of about 3:5 in comparison with the kaolinite (001) reflection for comparable amounts of chlorite and kaolinite having approximately the same degree of crystallinity.

The relative intensity of basal reflections for equal amounts of chlorite and kaolinite was taken as 3:5 on the basis of previous estimates. The amounts of chlorite and kaolinite in the soil samples were then determined from the 7 Å diffraction peak intensity, assuming that the regular-mixed-layer clay reflections exerted only a small influence on the 7 Å peak height. The two mineral amounts were estimated by prorating the 7 Å peak height according to the relative heights of the chlorite (004) reflection and the kaolinite (002) reflection, increasing the chlorite proration by  $\frac{2}{3}$  and using Fig. 3.

There is ordinarily an appreciable difference between diffraction peak ratios of diffractograms made from pressed powder samples and those made from oriented slides, especially with poorly

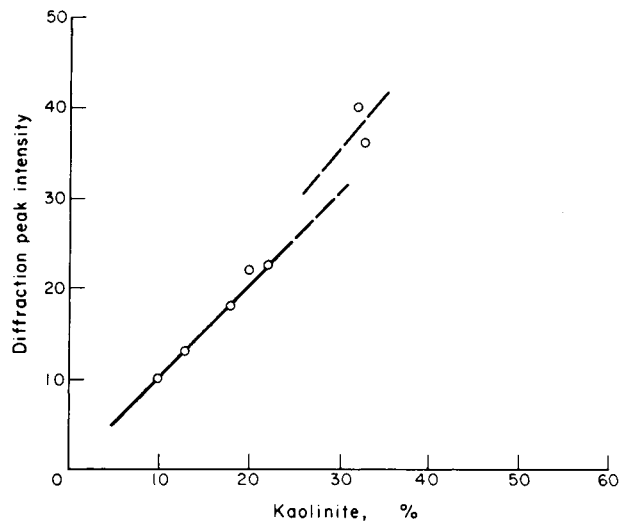


Fig. 3. Plot showing approximate kaolinite content of soils and (001) diffraction peak intensities of the kaolinite.

crystalline clay minerals such as smectites which commonly occur in soils. Thus, oriented sample slides become requisite for the quantitative analysis of smectities. The relative intensity of (001) basal reflections of illite and smectite for oriented slides is considered to be about 4.5:1 by Schultz (1964), and to vary between 3:1 and 5:1 by Pierce and Siegel (1969), that is, five units of 17 Å glycolated smectite gives one unit of 10 Å peak when an oriented slide sample is heated to 300°C. The relative intensity of the smectite (001) basal reflections for the Delta soils treated in the same manner appeared to be only about 2:1, however, the presence of small amounts of vermiculite that appear to grade into smectite made the method of analysis inaccurate.

#### ELECTRON MICROSCOPY

The electron microscope was used to study the morphology of the specimens by microscopy of replicas of the surface of the specimens. Replication was effected in the manner previously described by Sloane (1966).

With the exception of Sample 3, all electron microscope studies were performed on platinum-palladium pre-shadowed direct carbon replicas of vertical fracture surfaces of undisturbed core samples. Replicas of core samples 5, 6, 7, and 8 were prepared. Due to lack of undisturbed core material, sample 3 was prepared as a direct replica of an oriented slide used in the X-ray identification of soil mineralogy.

All replicas were embedded in heat-softened polystyrene discs to prevent fragmentation during removal of the replicas from the samples by submersion in concentrated hydrofluoric acid. Embedded replicas were cleaned of soil particles by floating on alternate baths of concentrated HF and 0.1N NaOH. When apparently clean, embedded replicas were washed on several distilled

water baths. Replicas were removed from the polystyrene by immersion in ethylene dichloride and were cleaned of all vestiges of polystyrene in several fresh baths of ethylene dichloride before picking them up on standard 400-mesh copper support grids.

Replicas were scanned at low magnification (2,200× to 10,000×) and photomicrographs taken using Hitachi HS-7S and Philips 300 electron microscopes.

#### RESULTS OF ANALYSIS

*Soil mineralogy.* The general soil type of the area sampled has been classified by Moorman, on his General Soil Map of Vietnam, published by the U.S. Army Engineer School (1967), as consisting of acid alluvial soils (acid sulfate soils). More recently the soil type has been described for the U.S. Army Engineer School (1967) as fine-textured Gray-Hydromorphic and associated soils from alluvium on level to gently sloping plains. The soil clay-size content (< 5μ) of the Delta soil samples varied from 68 per cent to 92 per cent, as shown in Table 1. The engineering soil classifications are given according to the Unified Soil Classification system, commonly used in civil engineering.

Nearly all of the non-clay portion of the soil samples consisted of quartz, some of which appeared to consist of particles smaller than 5μ in size. The material > 5μ size consists mostly of quartz. The non-clay mineral diffraction peaks observed also included goethite (130), 2.69 Å, feldspar, 3.18 Å, (002), gibbsite (020), 4.85 Å, gypsum ((020) and (141)), 7.56 Å and 3.06 Å, and argonite (021), 3.27 Å. Lepidocrocite is also believed to be present, however, there does not appear to be more than 3.0–4.5% hydrous ferric oxide present in the soil, including both goethite and lepidocrocite. The predominant feldspar ap-

Table 1. Soil sample descriptions and results from mechanical analyses

Soil sample	CH soil class.	Sample depth (ft.)	Moisture content (%)	Dry density	Specific gravity	% Finer than 5μ
1	CH	16.5	90	49.0	2.68	71
2	CH	5.8	29	87.0		68
3	CH	6.8	79	53.7	2.68	84
4	CL	38.8	24	98.9	2.72	
5	CH	6.8	71	56.6	2.68	92
6	CH	27.0	75	53.4	2.65	75
7*	CH	2.4	37	78.2	2.68	84
8	CH	16.0	81	87.0		68

\*Sample 7—100% of material passing No. 10 sieve, 98.2% the No. 40 sieve, and 90.4% the No. 200 sieve.

peared to be a sodic plagioclase, possibly oligoclase. A typical diffractogram showing the more predominant clay mineral basal reflections is shown in Fig. 4. The scan was made using an oriented slide with an untreated soil sample.

The predominant clay minerals include chlorite and illite with lesser amounts of kaolinite, smectite, and regular-mixed-layer clays. There appears to be some vermiculite present in some of the soil samples also, indicated by a diffraction peak at about 16 Å, largely obscured by the 17 Å peak, upon glycolation of soil samples.

It has been suggested by Bradley (1953) that clay minerals, especially three-sheet clay minerals, may be transported long distances by surface waters which are acid, and Weaver (1958) suggests that these clay structures, stripped of their inter-layer bonding ions such as  $K^+$ ,  $Ca^{2+}$ ,  $Na^+$ , and

$Mg^{2+}$ , may be considered detrital in origin. The basic clay mineral structures appear to have been restructured by cation adsorption under marine conditions in the Mekong Delta area.

The illite diffraction pattern appears to include a persistent 2.98 Å peak indicating that the restructured hydromica is intermediate between illite and muscovite with its (025) reflection. Separate diffraction peaks for the chlorite (004) reflection and the kaolinite (002) reflection verified the presence of both clay minerals, also united in a broad 7 Å reflection.

The following X-ray data sources were used for the identification of clay minerals. The X-ray powder diffraction data used for the identification of illite (hydromica) were taken from tabulations by Grim (1968), the data for kaolinite from Brown (1961), and the data for chlorite from Brown

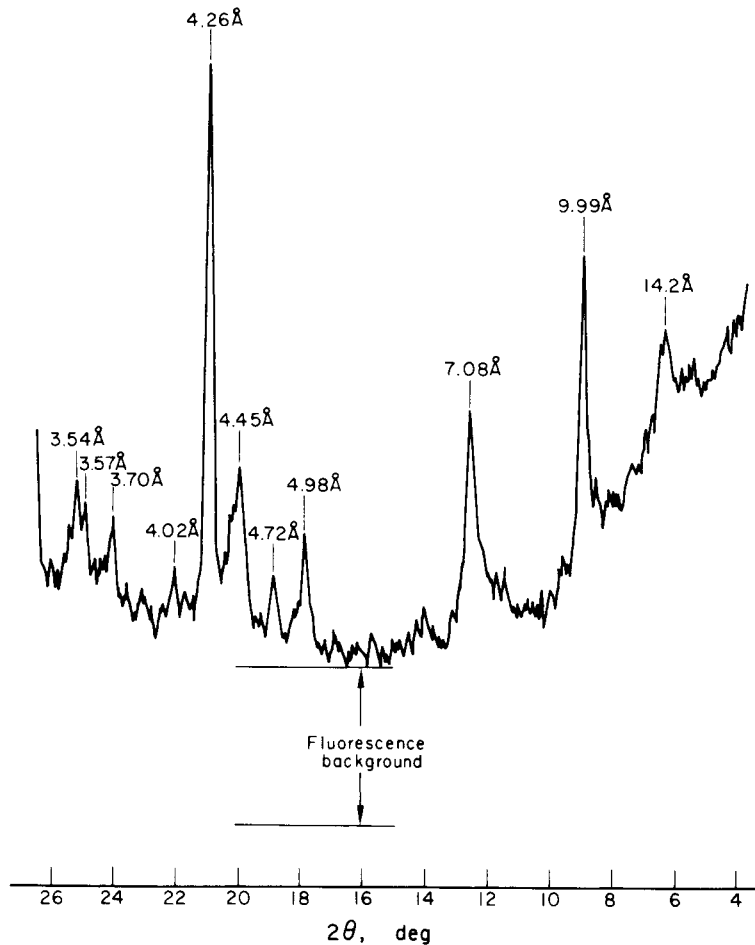
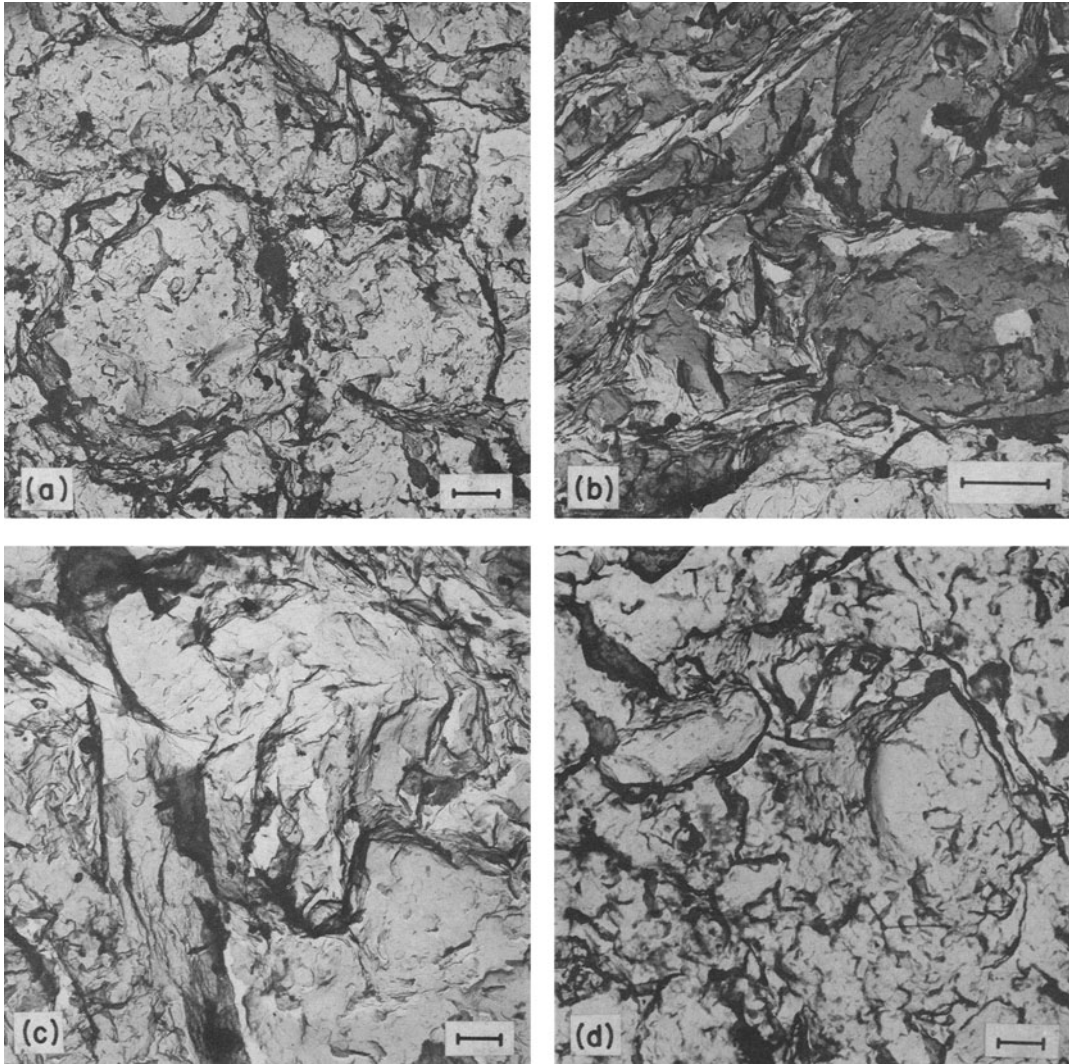


Fig. 4. X-ray diffractogram of whole Mekong Delta soil sample 3, derived from an oriented slide of air-dry untreated soil at ambient temperature.



**Fig. 5.** Micro-morphology of Mekong Delta clays. (a) Sample 5, (b) Sample 7, and (c) Sample 8 showing the rather large domains of clay minerals. (d) Sample 3 (oriented slide) showing larger clay domains apparently broken down to smaller grains by dispersion treatment. Scale bars shown are  $1\mu$ .

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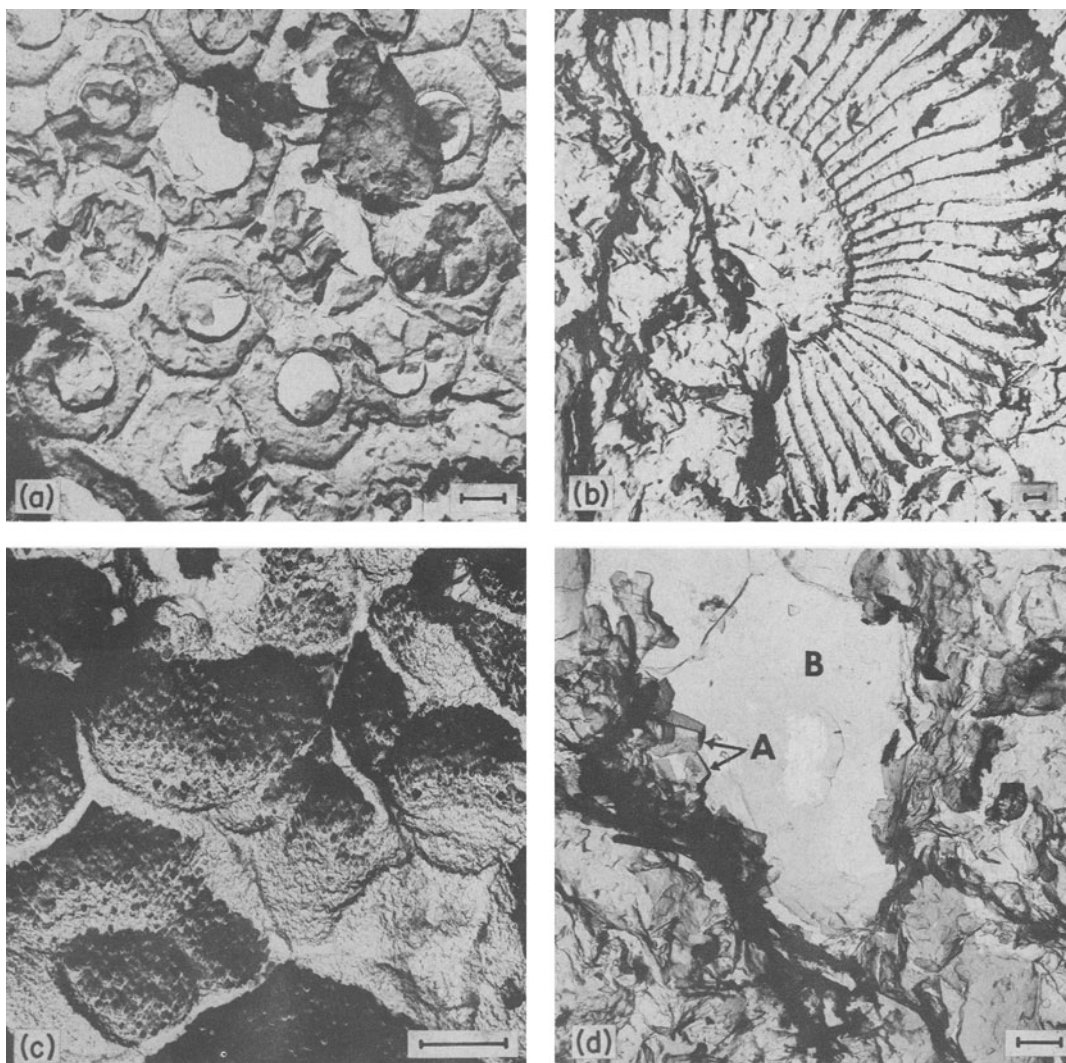


Fig. 6. Specific Features of Mekong Delta clay textures. (a) Sample 5b (iron-rich), Coccolith (Thoracosphaerida); (b) Sample 5b. Coccolith (Cyclococcolithus ?); (c) Sample 5b, Hydrous iron oxides; (d) Sample 8, zeolites (?) at A, chlorite domain at B. Scale bars are  $1\mu$ .



(1961). According to Hey's classification the chlorite is probably clinochlore. The data for smectite, vermiculite, and mixed-layer clays were taken from the same sources.

**Quantitative analysis.** The quantitative analysis of the soil samples from the Mekong Delta was undertaken with the aid of comparable previous soil mineral analyses (Post, 1968) and the results of mechanical analyses of the soil samples, as previously described.

Because of the chlorite present in the delta soils the calibration curve derived from the kaolinite (001) reflection could not be used directly. Also, the presence of regular-mixed-layer clays in the delta soil samples appeared to cause additions broadening of the 7 Å reflections. However, the separate chlorite (004) and kaolinite (002) reflections enabled an estimate to be made of the relative proportions of the two minerals present in the soil samples. Estimated mineral contents of the complete soil samples are given in Table 2.

Table 2. Approximate mineral content of soil samples

	Mineral content, %	
	Range	Av.
<b>Predominant constituents</b>		
Quartz	20-35	25
Illite (hydromica)	15-30	25
Chlorite	10-15	10
Kaolinite	5-10	10
Smectite	5-10	5
Minor Constituents, each less than 5% include: vermiculite, regular-mixed-layer clays, and hydrous ferric oxides (3.0-4.5%, probably goethite and lepidocrocite).		
Trace minerals include: feldspar, gypsum, aragonite, gibbsite, and possibly zeolite.		

The amount of illite present in the soil samples was derived on the basis of the relative intensity of the kaolinite 7 Å or 3.57 Å, and illite 10 Å diffraction peaks, as previously described.

The amount of smectite-vermiculite present could be roughly estimated by noting the 10 Å peak height gain upon heat treatment of the oriented sample slide to 325°C and prorating the amount of the 16 Å and 17 Å diffraction peaks of the "glycolated" slide.

Small amounts of mixed-layer clays further limited the accuracy of the smectite content determinations. The mixed-layer clays appeared to include corrensite as indicated by the presence of a persis-

tent 12 Å diffraction peak after the heat treatment at 500°C.

**Electron microscopy.** Results of the electron microscopy study are shown in Figs. 5 and 6. Figure 5 shows details of the micro-morphology of Samples 5, 7, 8, and 3. Figure 6 shows specific features of interest in Samples 5b (iron-rich area) and 8.

In Fig. 5(a, b, c) it can be seen that the undisturbed soil fabric consists of rather large domains of predominantly clay minerals; the domains varying in size from about 7-11 μ and in a rather randomly-oriented fabric. Quartz grains are evident in Fig. 5(a) at upper left and upper center and as inclusion in clay domains in Fig. 5(b, c). In Fig. 5(d) the fabric, after mechanical dispersion followed by ultrasonic dispersion, is rather well oriented and, further, shows evidence that the larger clay domains have apparently been broken down to smaller grain as a result of the dispersion treatment. The procedures used to secure soil particle dispersion have been described in detail by Sloane (1966). The largest particles found for the dispersed sample were slightly over 6 μ in size.

Figure 6(a, b) shows two types of nanno-fossils found in non-iron-rich portions of Sample 5b. Both are coccoliths, Fig. 6(a) showing a portion of a type of Thoracosphaerida and Fig. 6(b) a type of Coccolithida (possibly *Cyclococcolithus*). Coccolithophorids of both families were found in all samples examined electronoptically. According to Jeffords and Zingula (1960) and Smith and Gartner (1965) these genera co-existed only in mid-Eocene times. This suggests that the Delta sediments are, at least in part, redeposited soils because the Mekong Delta appears to be comparable to the nearby Chao Phraya Delta, which is believed to have formed during the late Tertiary period (Moh *et al.*, 1969).

Figure 6(c, d) show details of an iron-rich portion of Sample 5b, and Fig. 6(c) shows finely-botryoidal masses of what are believed to be hydrous iron oxides. Figure 6(d) shows a small clump of regular crystals (at A) which may be zeolite adjacent to a platy crystallite of chlorite (at B).

## CONCLUSIONS

The formation of the present suite of minerals in the Delta soils has occurred mainly in an estuarine environment and has been enhanced by intermittent heavy flooding of the Delta surface. Alteration of the Mekong River sediment deposited in a marine environment has produced a mixture of detrital and authigenic soil minerals. The small ferric oxide content of the Delta soils indicates that

they are not latosols and thus are not subject to irreversible induration upon use as latosols often are.

Extremely weathered tropical soils of South-east Asia, and derivative estuarine soils, appear to consist of intermediate-to-highly crystalline minerals which are readily amenable to X-ray diffraction analysis, the soils generally consisting of only a few predominating soil minerals.

Generally, the ferric oxide content of extremely weathered tropical soils may be estimated by the X-ray fluorescence background intensity generated when using the spectrometric powder diffraction method of mineral analysis. The quartz content of mineral aggregates may be closely estimated by making use of the diffraction peak intensities of the interrelated (110), (102), (112), and (211) reflections, regardless of powder crystallite orientation, when a pressed powder sample is used.

Direct quantitative analysis of kaolinite, illite, and chlorite mineral in the soil samples is possible because of the high degree of crystallinity of the clays, but the presence of additional less well crystallized clay minerals seriously interferes with the analysis procedure. The Delta soil samples consisted mainly of quartz, kaolinite, chlorite, and illite with lesser amounts of smectite and vermiculite and traces of a large variety of soil minerals.

Electron-optical examination of replicas of the Delta soils shows that the undisturbed fabric largely consists of somewhat randomly-oriented domains of clay minerals, ranging from 7 to 11  $\mu$  in size, with some blocky quartz particles in the 0.2 to 2.5  $\mu$  size range. Further, the presence of nanno-fossils (coccolithophorids) of mid-Eocene age in the more recent sediments of the Delta suggest that the soils are, in part, redeposited.

Electron micrographs of reworked and dispersed Delta soil show evidence of considerable particle degradation as compared to the undisturbed fabric. This suggests that the data given for percentage of less than 5  $\mu$  sizes may be in considerable error.

*Acknowledgments*—The Mekong Delta soil samples used in this investigation were secured from the U.S. Army Corps of Engineers. The writers wish to acknowledge the assistance of Mr. Fred Jacobs, Development & Resources Co., Sacramento, California, for his assistance in securing the soil samples; the Department of Civil Engineering, Sacramento State College, for financial assistance; the Departments of Anatomy and Metallurgy,

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**Résumé**— Des prélèvements de sol près de Long Xuyen, Sud Vietnam, considérés comme étant typiques des sols argileux alluvionnaires du delta du Mékong, ont été étudiés afin de déterminer la teneur en minéraux et la type de sol. Les sols sont d'une composition assez uniforme, consistant principalement en minéraux argileux et an quartz, les minéraux argileux qui dominent comprenant de l'illite et de la chlorite en plus petites quantités que la kaolinite et la smectite. La faible teneur en oxyde de fer hydraté, indiquée par l'intensité de la fluorescence du fond, a permis de vérifier que les sols n'étaient pas des latosols, mais étaient des sols argileux de l'estuaire susceptibles d'être transformés en terre arable.

La méthode de préparation des spécimens a permis une analyse quantitative directe des prélèvements de sol par diffraction des rayons X, avec l'assistance des résultats des analyses mécaniques et d'analyses antérieures de prélèvements de sol comparables effectués dans le Delta et les régions avoisinantes. Pour la détermination quantitative du quartz, on a utilisé une méthode indépendante de l'orientation de la poudre de cristallite. Une étude des répliques en surface des prélèvements de sol par microscopie électronique a été effectuée pour illustrer la structure du sol. La structure du sol qui n'a pas été remuée consiste principalement de grandes zones de minéraux argileux dont l'orientation est quelque peu désordonnée, avec quelques particules de quartz. Les nanno-fossiles sont présents dans tous les prélèvements.

**Kurzreferat**— Bodenproben aus der Gegend von Long Xuyen, Südvietsnam, die als typisch für die tonigen Alluvialböden des Mekongdeltas angesehen werden können, wurden untersucht zur Bestimmung des Mineralgehaltes und der Bodenart. Die Böden sind von recht einheitlicher Zusammensetzung und bestehen hauptsächlich aus Tonmineralen und Quarz, wobei die hauptsächlichsten Tonminerale Illit und Chlorit darstellen, mit geringeren Mengen an Kaolinit und Smektit. Der geringe, durch Fluoreszenzhintergrundintensität angezeigte Gehalt an wässrigem Eisenoxyd bestätigte, dass die Böden nicht Laterite sondern tonige, ästuarische Böden sind, die einer zukünftigen Entwicklung als Ackerland zugänglich sein dürften.

Die Methode der Probendarstellung ermöglichte die unmittelbare quantitative Analyse von Bodenproben durch Röntgenbeugung mit Hilfe von Ergebnissen der mechanischen Analyse und früherer Analysen vergleichbarer Proben aus dem Delta und umliegenden Gebieten. Es wurde eine quantitative Bestimmungsmethode für Quarz verwendet, die unabhängig von der Orientierung der pulverförmigen Kristallite ist. Es wurde eine Untersuchung von Oberflächenhachbildungen der Bodenproben mittels Elektronenmikroskopie durchgeführt um die Textur des Bodens klarzustellen. Die ungestörte Bodentextur besteht hauptsächlich aus eher zufallsmässig orientierten, grösseren Bereichen von Tonmineralen mit einigen blockartigen Quarzteilen. In allen Proben waren Nanno-fossile enthalten.

**Резюме** — Почвенные образцы из района Лонг Ксуена (Южный Вьетнам), которые рассматриваются как типичные для глинистых аллювиальных почв дельты Меконга, были исследованы с целью определения их минерального состава и типа почв. Почвы характеризовались существенно однородным составом, их главные компоненты — глинистые минералы и кварц; преобладающими глинистыми минералами являются иллит и хлорит, подчиненную роль играют каолинит и смектит. Малое содержание гидратированных окислов железа, установленное по интенсивности флуоресценции, свидетельствует о том, что изученные почвы не являются латозольными, а представляют собой глинистые эстуариевые почвы, пригодные для будущего использования в качестве пахотных.

Метод приготовления образцов делал возможным прямой количественный анализ образцов почв с применением рентгенографии и с использованием результатов механического анализа и предварительных анализов аналогичных почвенных образцов из Дельты и прилегающих районов. При этом использовался метод количественного определения кварца, не зависящего от преимущественной ориентировки кристаллитов порошка. Исследование реплик с образцов почв методом электронной микроскопии позволило выявить их строение. Структуры неразрушенных почв характеризуются наличием беспорядочно ориентированных больших доменов глинистых минералов й небольшим количеством собранных в блоки частиц кварца.

Во всех образцах отмечено наличие ископаемых остатков.