CLAY MINERAL CONTENT OF GULF COAST OUTCROP SAMPLES

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ABSTRACT

Clay samples were taken from formations outcropping between Corpus Christi and Uvalde, Texas, during the annual field trip of the Corpus Christi Geological Society in 1953. The geologic age of the formations sampled ranges from Quaternary to Upper Cretaceous. Both surface and near-surface samples were taken. The results of examination of these samples by use of x-ray diffraction and electron microscope techniques indicate marked differences in the relative proportions of montmorillonite, kaolinite, and illite. Comparison of surface and near-surface samples indicates the probable course of weathering.

INTRODUCTION

The clay mineral content of a number of samples taken from formations outcropping in the Gulf Coast area of southwest Texas was investigated by means of x-ray diffraction techniques and by means of the electron microscope. The samples were collected during the annual field trip in 1953 of the Corpus Christi Geological Society. Figure 1 is a map of southwest Texas showing the route followed by the Society from Corpus Christi to San Antonio and from San Antonio to Uvalde. The formations studied by the Society and sampled for the present work range in geologic age from Quaternary to Cretaceous.

The samples were investigated for the purpose of determining the distribution of clay minerals within the geologic section sampled and the possible effect of environment on the alteration of clay minerals. The geologic history of this southwest Texas Gulf Coast area has been such that one might expect little variation in clay mineral content from one horizon to the next. With the exception of occasional volcanic ash falls, the geologic history has been one of long continued introduction of sediment by the Rio Grande and the gradual uplift of the local region with subsequent stream erosion and redeposition of sedimentary materials. One might expect, therefore, a rather thorough mixing of the various clay minerals, particularly in the younger formations.

Differences in clay mineral composition, on the other hand, might arise if alteration of clay minerals occurred in response to a particular environment. The environment bringing about the alteration of the clay minerals might be that prevailing at any stage in the erosion and the redeposition

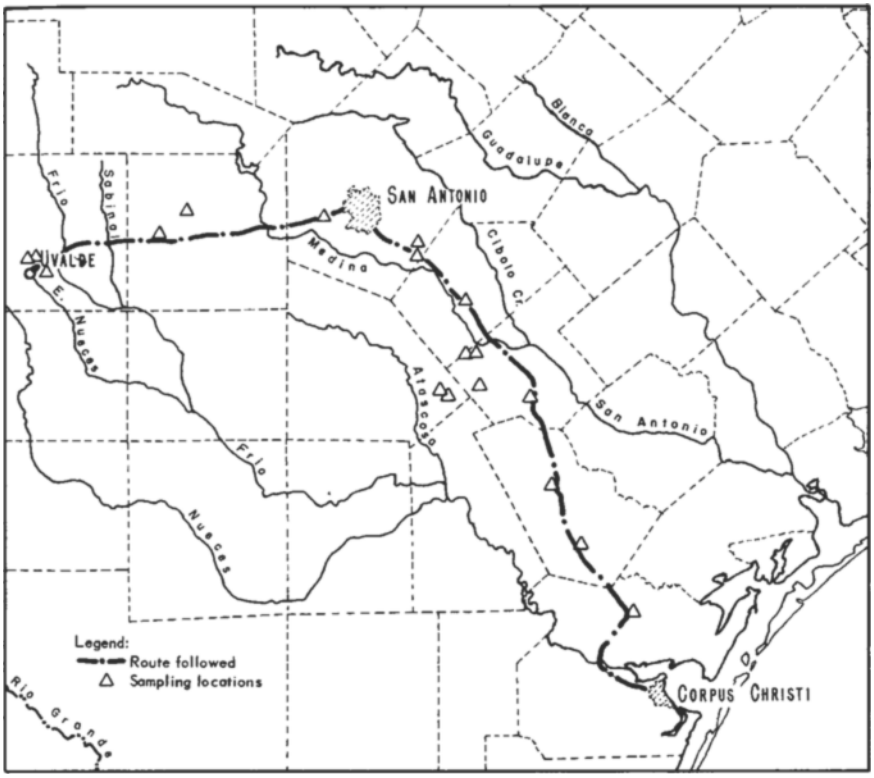

FIGURE 1. — Map showing area sampled.

cycle of the clay materials. Thus, the possibility exists that new minerals might be formed in the weathered zone at different periods in the geologic history of the area as a result of changes of climate which may have occurred. Indeed, the available evidence indicates that clay minerals do respond to different environments of weathering. With regard to the environment of deposition, the work of Millot (1949, p. 252-258) in France suggests that the micaceous minerals are to be found in marine environments and kaolinite in lacustrine environments where there is active leaching. In addition to the possible effects of the environment of erosion and of the environment of deposition, a knowledge of the changes in clay minerals after deposition as they are buried under succeeding formations would appear to be essential to an understanding of the distribution of clay minerals in the sedimentary sequence. Alteration might be associated either with time, that is, geologic age, or with depth of burial.

Further, the nature of the parent material is probably important in determining the type of clay minerals derived from it. This influence is illustrated in the geologic section from which the present samples were taken. Beds of volcanic ash and associated bentonite occur throughout the section and are particularly extensive in the Jackson and Catahoula formations. Available evidence indicates that the bentonite resulted from devitrification of the ash. It seems probable that montmorillonite is the predominant clay mineral in these bentonites, although they may not have been investigated by modern methods of clay mineral analysis.

In the present work two types of samples were studied, surface and near-surface. The first type, collected from the surface of the ground, was taken for the purpose of determining the final product of weathering under the semi-arid conditions prevailing in the area. The second type, taken from road cuts and stream banks, permitted an investigation of the effect of the environment of deposition. These samples ranged from nonmarine to marine. The facies of typical Gulf Coast formations vary from nonmarine inland to marine toward the coast. Uplift and consequent erosion have destroyed the nonmarine facies of the older formations so that their outcrops now expose marine facies. The available geologic data indicate that, of the samples taken, those from the Cretaceous and from the Eocene, with the exception of that from the Manning formation, were from marine environment. The remainder of the samples were probably from nonmarine facies of Upper Tertiary and Quaternary formations.

METHODS OF ANALYSIS

X-ray diffraction examination of the suite of samples was made by means of an x-ray recording goniometer using oriented clay films, supplemented where necessary by x-ray powder diagrams obtained with cameras of special design. Oriented clay films give enhanced first and higher order basal reflections, the most diagnostic reflections of clay minerals. The diffracted rays were scanned up to 30° 2θ which, when Cu $K\alpha$ is used, is sufficient to include one or more higher order reflections.

The oriented films were prepared by evaporation of a suspension of the clay in water on a glass slide at room temperature. The film was examined by x-rays without further treatment, after solvation with ethylene glycol, and after heating to 550°C. Brindley (1951) states that this combination of glycol and heat treatment permits the detection and semi-quantitative estimation of the montmorillonite, kaolinite, and illite groups of clay minerals, the chlorite minerals, the palygorskite-sepiolite group of minerals, and vermiculite.

Electron micrographs were made of each of the samples by Dr. W. O. Milligan and Dr. H. P. Studer of The Rice Institute using a Philips electron microscope. Plates, needles, tubes, and laths can be distinguished in the electron microscope. These distinctions assist in the identification of clay minerals and in some instances permit the recognition of clay minerals present in concentrations too low to be detected by x-ray methods.

RESULTS OF THE INVESTIGATION

The results of the examination of the near-surface samples by means of x-rays are presented in Figure 2. With one exception, montmorillonite, kaolinite, and illite are the predominant clay minerals in these samples. The exception is palygorskite in the sample from the Lissie formation. No chlorite or vermiculite minerals were found in any of the samples.

The distribution of clay minerals varies markedly both qualitatively and quantitatively among the samples. The predominance of montmorillonite in the samples of the younger formations and its relative absence in those of the older formations is probably more apparent than real. The sampling was evidently too scattered to include known beds of bentonite in the older formations. Kaolinite predominates in the Queen City, Carrizo, and Wilcox samples of lower Eocene age, whereas, with the exception of the Austin chalk, the Cretaceous samples contain mixtures of illite and kaolinite.

Within the limitations of the method, the results of examination by means of the electron microscope confirm the results of x-ray diffraction as to the predominant clay minerals present. In addition, the electron micrographs reveal a number of other interesting features. The samples showing needles or laths are indicated on the right-hand side of Figure 2. Needles are present in the samples from Austin, Navarro, Lapara, Goliad, Lissie, and Beaumont formations. Only in the Lissie Sample, however, was the concentration sufficient to permit identification by x-ray analysis. Plate 1A is a micrograph of the Lissie sample showing the palygorskite

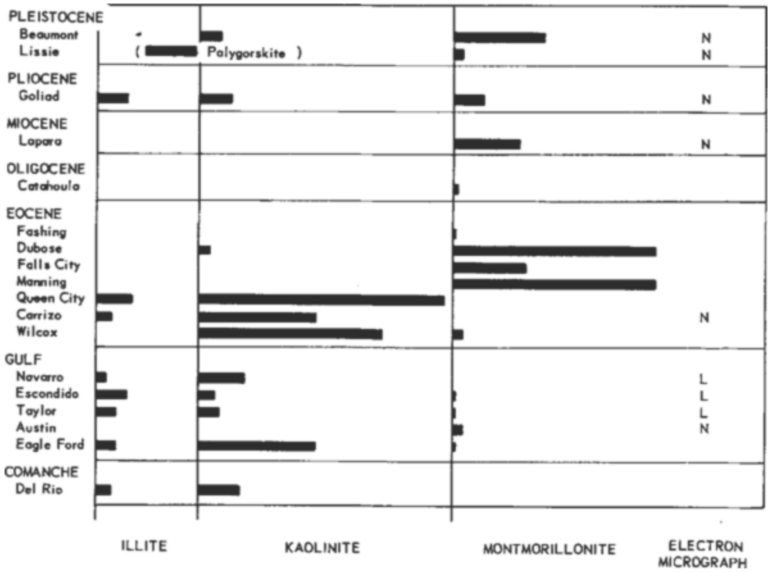

FIGURE 2. — Outcrop samples — near-surface.

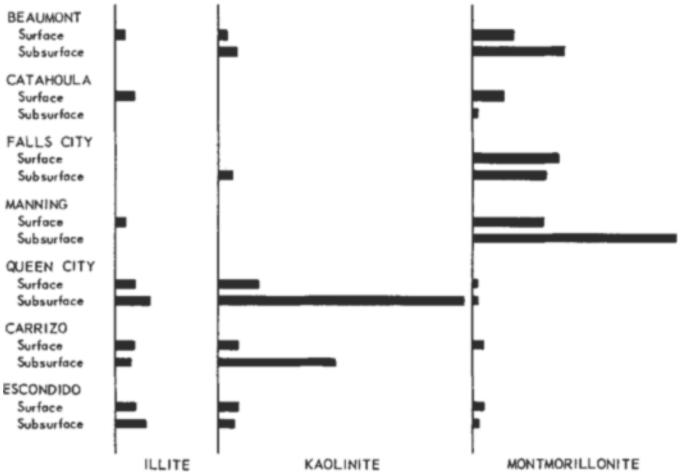

FIGURE 3. — Comparison between surface and near-surface samples; outcrop samples.

needles mixed with montmorillonite. Plate 1B, a micrograph of the Dubose sample, shows montmorillonite together with a large proportion of structures which are probably shards. These shards, or shardlike structures, are found in all of the samples of Upper Eocene and younger formations.

With regard to the role of environment of deposition on the distribution of these clay minerals, it is felt that only tentative conclusions can be drawn from these samples. Too few locations have been sampled to permit firm conclusions, and in this respect the work reported here is of the nature of a progress report. The results suggest, however, several interesting relations. The occurrence of palygorskite in the sample from the Lissie formation probably resulted from a particular environment, since it was not found in the older formations. Grim (1953) has found this mineral in western playas, an environment which may not be incompatible with that of the Lissie formation. The occurrence of shards in the samples from Upper Eocene and younger formations suggests devitrification of volcanic ash as the source of the montmorillonite in these samples. Since some of the samples were from marine environment whereas others were from nonmarine environment, it appears that the devitrification process may take place either in fresh or salty water. The samples, however, differ in the relative proportions of montmorillonite and amorphous material, indicating that alteration did not always occur to the same degree.

No clay mineral or clay mineral assemblage characteristic of marine environment appeared from these results. Some of the samples from marine environment are predominantly montmorillonite, some are predominantly kaolinite, and one or two are predominantly illite. There is the possibility, however, that montmorillonite which was deposited as such in

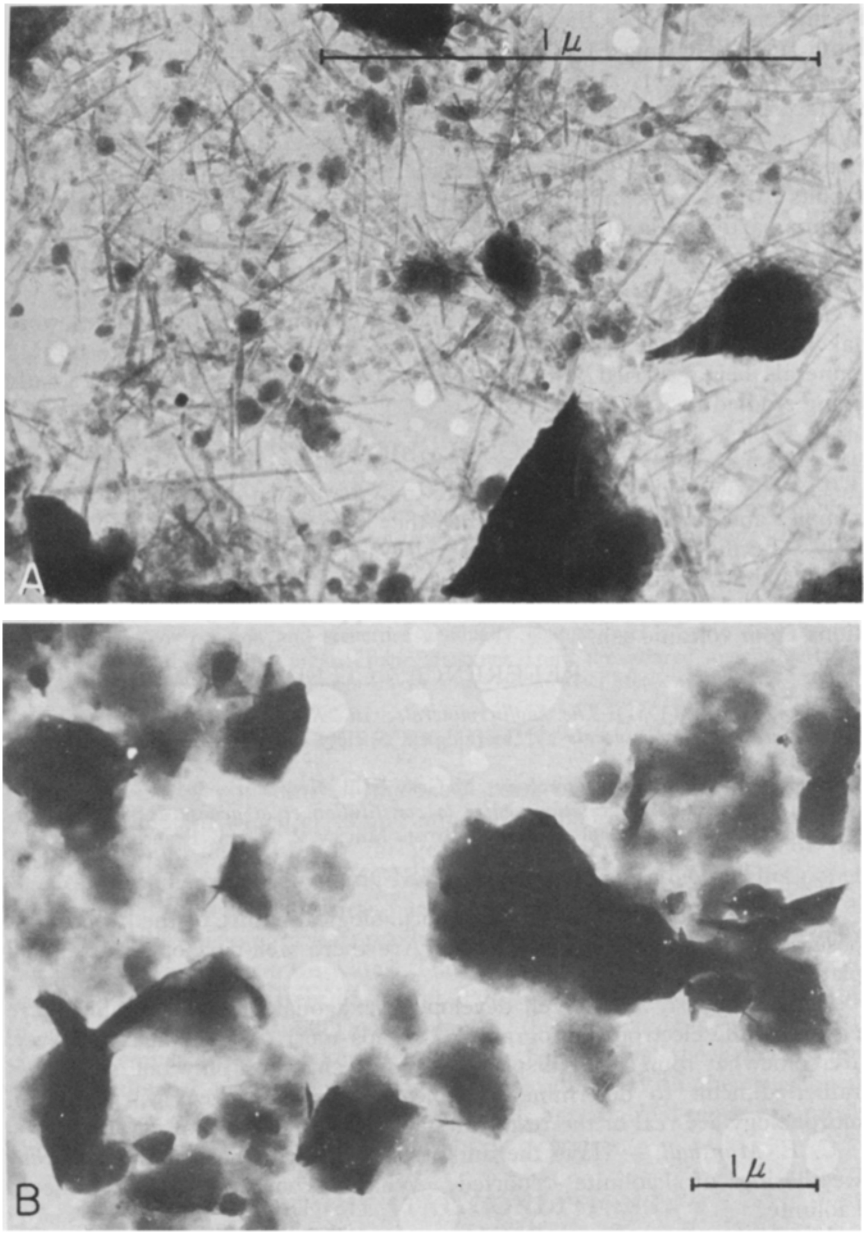

PLATE 1. — Electron micrographs: (A) Palygorskite needles and montmorillonite; Lissie formation. (B) Shards associated with montmorillonite; Dubose sample.

marine environment, rather than as ash which later altered to montmorillonite, may be changed to some other mineral in a marine environment.

Figure 3 presents a comparison of the distribution of clay minerals in surface and near-surface samples from a number of the sampling locations. With a few exceptions there is good qualitative agreement between the two types of samples although there are quantitative differences. The results of this work must be interpreted with caution, because the samples from a particular locality may not have been taken from the same clay bed. There is no indication in the results, however, of radical alteration of clay minerals.

The locations from which some of the present suite of samples were taken lie within the watershed of the Guadalupe River. The fate of clay minerals being carried into San Antonio Bay by this river is currently being studied in API Project 51.

CONCLUSIONS

The following tentative conclusions may be drawn with regard to these samples and for the area from which they were taken:

1. The distribution of clay minerals varies qualitatively and quantitatively among the samples.
2. The abundance of montmorillonite appears to be related to alterations from volcanic ash.

REFERENCES CITED

Brindley, G. W. (1951) *The kaolin minerals:* In *"X-ray identification and crystal structures of clay minerals":* Mineralogical Society of Great Britain, Monograph, Chap. 2, p. 32-75.

Grim, R. E. (1953) *Clay mineralogy:* McGraw-Hill, New York, 384 p.

Millot, Georges (1949) *Relations entre la constitution et la genèse des roches sédimentaires argileuses:* Géol. Appliq. et Prosp. Min., v. 2, Nancy, France, 352 p.

DISCUSSION

Thomas F. Bates. — What is the morphological nature of the kaolinite as observed in the electron microscope? Are there well-developed hexagonal plates?

M. S. Taggart, Jr. — Well developed hexagonal plates of kaolinite are visible in the electron micrographs. Perhaps most of the plates, however, are somewhat rounded or display hexagonal shape on only one side. It is rather difficult to determine at times whether apparent variations in morphology are real or the result of stacking of a number of crystals.

C. E. Marshall. — Have the authors any information on the apparent weathering of kaolinite reported? What becomes of the weathered kaolinite?

M. S. Taggart, Jr. — We have no information on the weathering of kaolinite other than that given in the report. The weathered kaolinite is eventually eroded and carried to either San Antonio or Corpus Christi Bay where it is deposited.