SMECTITE-RICH PISOLITES OF THE ANDERSONVILLE, GEORGIA, AREA

Key Words—Bauxite. Gibbsite, Kaolinite, Montmorillonite, Pisolite, Smectite.

Pisolites have been described in the clay mineral literature as having a dominant gibbsitic/kaolinitic component accompanied by minor to trace amounts of quartz and/or opaque heavy minerals (Kaye, 1967; Valeton, 1972; Bárdossy *et al.*, 1978). This paper discusses the mineralogy, chemistry, petrography, and possible origin of a heretofore undescribed smectite-rich pisolite.

Smectite-rich pisolites were identified in four drill cores within the Andersonville mineral district which is approximately 40 km south of the Fall Line in the coastal plain of southwestern Georgia and along strike with major kaolin/ bauxite producing areas in the state (Figure 1). The cores penetrated 45–60 m of unconsolidated sediments of Eocene to Paleocene age (Jackson to Midwayian, respectively). Pisolites occur in a 1–1.5-m thick zone near the top of the kaolin/baux- ite-bearing Nanafalia Formation (Paleocene) at a depth of ap- proximately 35–40 m. They have also been found in the kaolin/ bauxite lenses that are mined commercially in the district. A thorough discussion of the field area stratigraphy is given by Zapp (1948, 1965) and Cofer and Manker (manuscript in prep- aration).

MEGASCOPIC AND PETROGRAPHIC DESCRIPTION

In hand sample the pisolites are light grayish green, spher- ical to ellipsoidal shaped concretions with diameters ranging from 5 to 20 mm and are contained in a slightly lighter color matrix. Pisolites and matrix are fairly well indurated in central portions of the zone of occurrence, but toward the upper and lower margins of the zone, both materials are considerably softer, and the pisolites are approximately 1 mm in diameter. Only those pisolites from core A (Figure 1) are extremely well indurated throughout.

Thin section examination shows the pisolites to consist of: (1) a central core containing a relatively high percentage of fine- to medium-grained quartz; and (2) an outer rim nearly devoid of quartz (Figure 2). Pisolites from core A contain ap- proximately 25% quartz in the central portion; those from B, C, and D contain 3–5% quartz. Shrinkage cracks traverse inner and outer portions of this pisolite (Figure 2). Within the pisolite, fine- to medium-grained quartz appears to have undergone solution as evidenced by the mineral's highly "fractured" and corroded state (Figures 3a and 3b). In addi- tion, many deteriorated grains are surrounded by clay min- erals arranged in concentric layers (Figure 4). The amount of
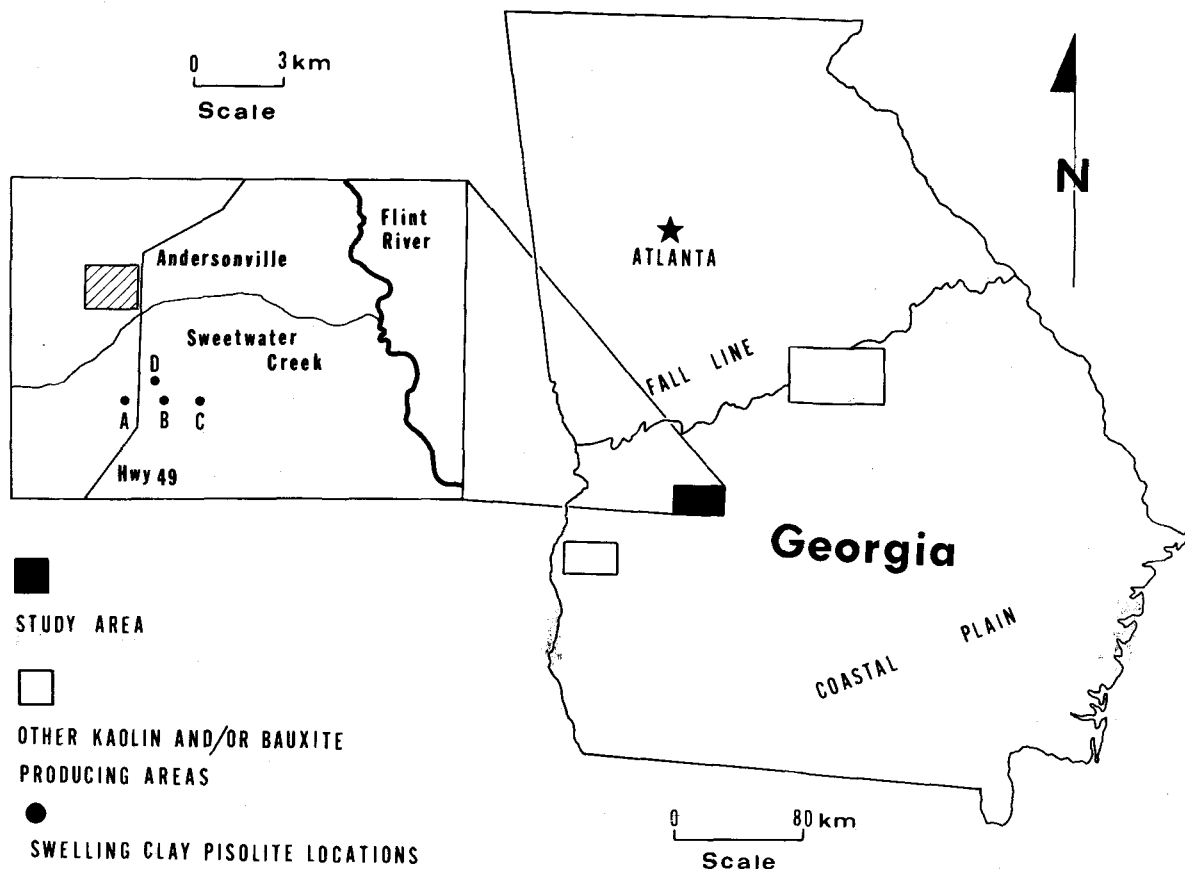

Figure 1. Map of Georgia showing location of study area and its relationship to kaolin/bauxite-producing areas. Inset shows locations of cores within study area where smectite-rich pisolites were observed.
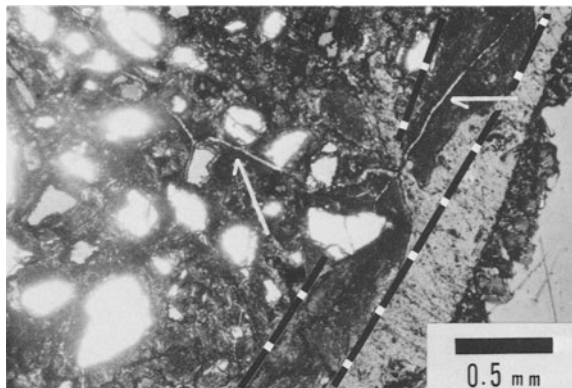
397

Figure 2. Photomicrograph of a thin section of core A pisolite showing quartz-rich core (white grains) and quartz-deficient rim (bordered area). Shrinkage cracks are indicated by arrows.

quartz deterioration varies with the size of the particle; larger grains (i.e., 0.5 mm) appear corroded and embayed around their margins, whereas smaller grains (<0.5 mm) display the effects of solution throughout and commonly appear as "ghosts." Matrix material also contains fine- to medium-grained quartz in approximately the same concentration as in the concretions.
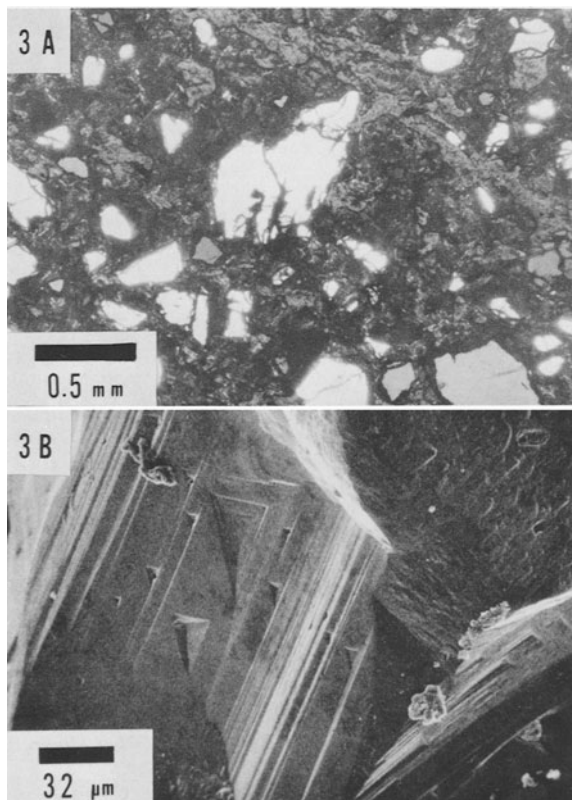

Figure 3. a. Photomicrograph of a thin section showing deteriorated (embayed and corroded) quartz (white grains) in central portion of core A pisolite. b. Scanning electron micrograph of solution features on quartz grain from central portion of core A pisolite.
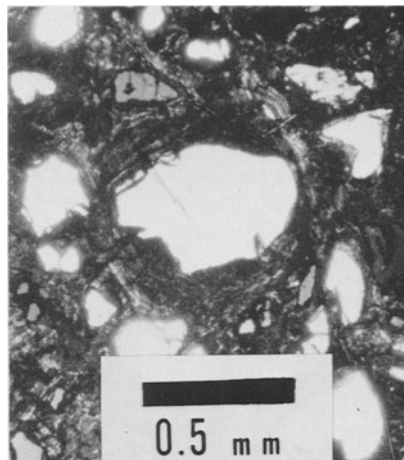

Figure 4. Photomicrograph of a thin section showing concentric layering of clay minerals around a quartz grain.

ANALYTICAL METHODS

The pisolites were ground to <0.625 mm and dispersed in distilled water by ultrasonic agitation. This process effectively separated quartz grains from the clay minerals. Slurried material was placed on a petrographic slide, oven dried at 60°C and examined with a Philips X-ray diffractometer equipped with a curved graphite-crystal focusing monochrometer and Ni-filtered CuKα radiation at 40 kV and 20 mA. All slides were treated with ethylene glycol in a closed chamber for 1 hr at 60°C and re-examined.

Electron microprobe data using a MAC 400-S instrument were obtained from ten evenly spaced points across two pisolites from core A. Potassium and sodium concentrations were not determined.

CLAY MINERALOGY AND CHEMISTRY

X-ray powder diffraction (XRD) data indicate the presence of three clay mineral types. Kaolinite was identified in all pisolites by its 7.16-Å and 3.57-Å peaks. Gibbsite (detected in core A pisolites only) was determined by its 002 spacing at 4.85 Å. A swelling clay was identified in all samples by a 13.0-Å spacing, which expanded to 17.0 Å upon glycolation. An attempt was made to separate material from cores and rims of the pisolites and the matrix. Only pisolites from core A were

Table 1. Peak height ratios calculated from X-ray powder diffraction data.

Sample (Core)	Peak height ratios[1]		
	Matrix	Rim	Core
A	0.2	0.5	0.9
		7.9[3]	2.4[3]
		4.4[4]	2.2[4]
B	0.1	[2]	0.4
C	0.3	[2]	0.3
D	0.1	[2]	0.1

[1] Ratio of 13.0 Å/7.2 Å used for calculation of all peak height ratios unless otherwise noted.
[2] Isolation of this material for XRD not made.
[3] Ratio of 7.2 Å/4.8 Å used for calculation.
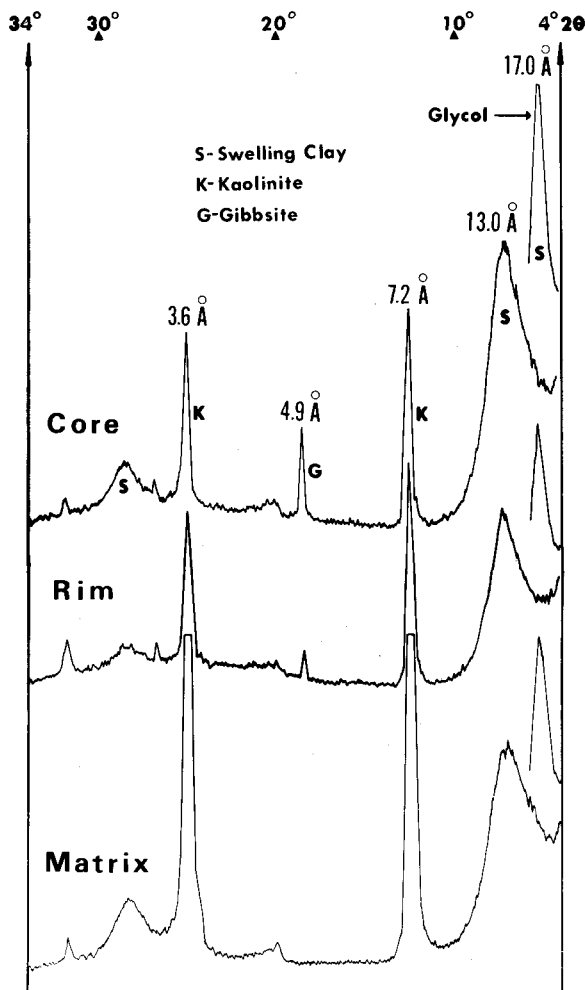[4] Ratio of 13.0 Å/4.8 Å used for calculation.

Figure 5. X-ray powder diffraction patterns of the core, rim, and matrix material of core A pisolite showing the presence of kaolinite (K), gibbsite (G), and smectite (S). Patterns of gly-colated samples are also included. (CuKα radiation.)

Table 2. Chemical analyses of two core A pisolites.[1]

	P-1	P-2	Average
SiO_2	54.46	52.75	53.61
Al_2O_3	19.80	19.18	19.49
Fe_2O_3 + FeO	5.59	5.57	5.58
MgO	1.21	1.29	1.25
CaO	1.36	1.08	1.22
K_2O	[2]	[2]	
Na_2O	[2]	[2]	
H_2O+ / H_2O- } [3]	17.43	17.55	17.49
Total	99.85	97.42	98.64

[1] Obtained by electron microprobe.
[2] No analytical data obtained.
[3] Obtained by loss on ignition at 1000°C for 1 hr.

Plots of elemental concentration vs. probe position within the pisolite were made, but no meaningful trends were detected for the two samples.

DISCUSSION

A possible origin for these smectite-rich concretions is the addition of Si^{4+}, Fe^{2+}, Mg^{2+}, and Na^+ to gibbsite by reaction with seawater during submergence of the originally bauxitic material. Marine conditions are indicated by the presence of glauconite and marine microfossils in the montmorillonite-rich sandy kaolin directly overlying the smectite-rich pisolites. However, information regarding the mechanism for transformation of gibbsite to montmorillonite is lacking, and no evidence has been found in ancient or recent sediments to show that this reaction takes place. Perhaps the occurrence of montmorillonite-rich concretions as described above indicates that the transformation of gibbsite and/or kaolinite to montmorillonite is indeed possible.

ACKNOWLEDGMENTS

Department of Earth Science   J. P. MANKER
Georgia Southwestern College   H. E. COFER
Americus, Georgia 31709

REFERENCES

Bárdossy, Gy., Csanády, A., and Csordás, A. (1978) Scanning electron microscope study of bauxites of different ages and origins: *Clays & Clay Minerals* **26,** 245–262.

Grim, R. E. (1968) *Clay Mineralogy:* McGraw-Hill, New York, 596 pp.

Kaye, C. A. (1967) Fossiliferous bauxite in glacial drift, Martha's Vineyard, Massachusetts: *Science* **157,** 1035–1037.

Valeton, I. (1972) *Bauxites, Vol. 1:* Developments in Soil Science, Elsevier, New York, 226 pp.

Weaver, C. E. (1968) Relations of compositions to structures of dioctahedral 2:1 clay minerals: *Clays & Clay Minerals* **16,** 51–61.

Weaver, C. E. and Pollard, L. D. (1973) *The Chemistry of Clay Minerals:* Elsevier, New York, 213 pp.

Zapp, A. D. (1948) Geology of the Andersonville bauxite district, Georgia: *U.S. Geol. Surv. Open-File Report,* 60 pp.

Zapp, A. D. (1965) Bauxite deposits of the Andersonville district, Georgia: *U.S. Geol. Surv. Bull.* **1199-G,** 37 pp.

sufficiently well indurated to isolate all three materials without cross contamination. XRD patterns from the rim, core, and matrix material of core A pisolites are shown in Figure 5. Additional XRD data are summarized in Table 1 by the use of peak height ratios which may be used as a semiquantitative indicator of the relative abundance of various clay minerals in pisolites and matrix. The ratios in Table 1 show that smectite is a significant component in pisolites from cores A, B, and C; however, core D pisolites contain relatively minor amounts of this phase.

Elemental analyses obtained by microprobe are given in Table 2. Based on analytical data of Weaver and Pollard (1973), Weaver (1968), and Grim (1968), the smectite can be classified dioctahedral (with a choice of either montmorillonite or nontronite). In addition, XRD data (i.e., the 060 reflection at 1.49 Å) confirm that the clay is dioctahedral. Nontronites generally contain 7–30% Fe, whereas montmorillonites are generally Fe-poor (i.e., they contain 1–6% Fe). According to iron concentrations given in Table 2, the swelling clay component in the pisolites is montmorillonitic. Trioctahedral smectites (e.g., hectorite, saponite) were not considered to be valid choices due to their high Mg content of 10–25%.