
Micromorphological Soil Study in the Boggy Formation

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Soils are natural bodies that occupy the upper part of the earth's surface and have been derived from rock or from material weathered from rock. The geological layers or strata are weathered by physical, chemical and biological processes. With time, soil horizons are differentiated by processes of additions, removals, transfers, and transformations. Often materials weather deeply and the horizons become thick, making it difficult to relate the soil horizons to the parent materials or rocks. In such a case, a micromorphological study of the soil horizons is employed to obtain information about soil formations. A study like this was made on some silty, leached, thick-surfaced soils of east-central Oklahoma. Brewer (1964) provides an excellent guideline for making these interpretative studies.

Photomicrographs were prepared and transfers and transformations were interpreted in relation to different soil horizons. Some are: (1) the relationship between soil and parent rock, (2) mineral constituents of the rock and their distribution in the soil profile, and (3) the determination of mineral losses and gains by physical and chemical determination and their relation to photomicrographs of each horizon in the soil profile. The soil utilized for this study occurs in the Dennis-Parsons-Bates soil association (1959) and is presently classified as a Choteau-variant. A profile was sampled from an upland flat on the Eastern Pasture Research Station, Muskogee, Oklahoma. The soil was underlaid by a noncalcareous siltstone of Pennsylvanian age. Most of the rocks in the Muskogee area are members of the Krebs Group, and the Boggy Formation underlies the sample area (Bell, 1961; Miser, 1954). These sediments are known to be locally very silty, micaceous, and highly cemented with iron oxides (Bell, 1961).

MATERIALS AND METHODS

Most of the information presented was from observations made from thin sections prepared by Gary Section Service, Tulsa, Oklahoma, and interpretations were made according to Brewer (1964). The percentages of sand, silt and clay were determined by the pipette method described by Kilmer and Alexander (1949). Free iron oxides were removed by the sodium citrate-sodium bicarbonate buffer method of Jackson (1956). The extracts were used to determine iron by the Tiron color method of

Jackson (1958). Magnesium oxide was extracted with HCl and determined by the sodium periodate color method of Hunter and Coleman (1960). The percentages of quartz and feldspar were determined chemically by the method outlined by Kiely and Jackson (1965).

RESULTS AND DISCUSSION

The soil, as seen in Figure 1, has a darkened A1 horizon about 14 inches thick, due to organic matter additions; a lighter highly leached A2 horizon to a depth of 36 inches resting on a yellowish, mottled, clayey B2t horizon that extends to 60 inches or more.

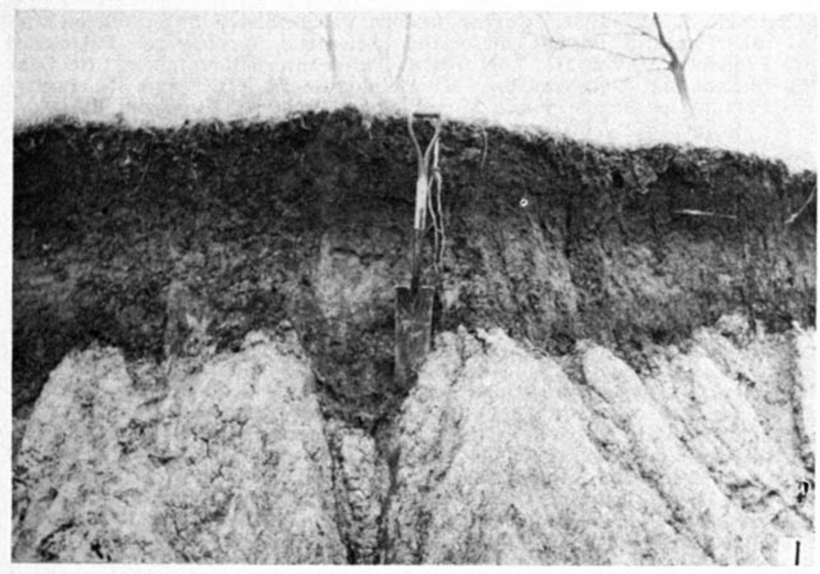


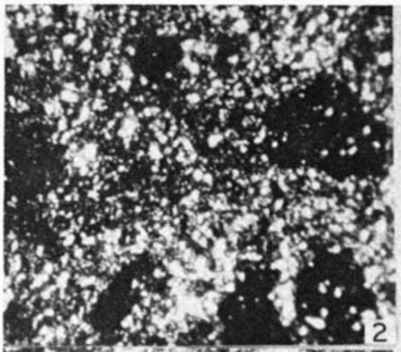
Figure 1. Roadside cut showing exposed profile of Choteau Series.

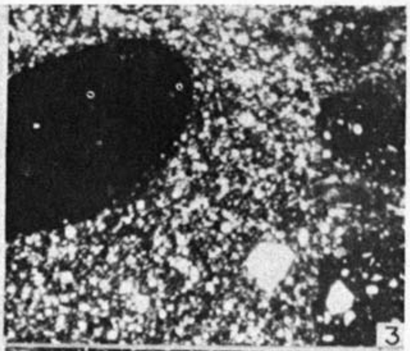
The percentages of sand, silt and clay for each horizon are presented in Table I. An abundance of silt was found in all horizons and in the parent rock. Low clay contents were found in the surface horizons with accumulations in the B2t horizons.

The results of the photomicrograph observations are presented in Figures 2-9 on the following pages. The above table should be kept mentally in mind when looking at the figures.

TABLE I. PERCENTAGE OF SAND, SILT AND CLAY

Horizon	Depth in inches	Sand 2.0-0.05 mm	Silt 0.05-0.002 mm	Clay <0.002 mm
A1	0-14	23.0	66.1	10.9
A21cn	14-20	22.2	63.4	14.4
A22cn	20-26	23.9	59.7	16.4
B21t	26-30	13.1	45.2	41.7
B22t	30-38	13.4	45.5	41.1
B3t & C	38-60	28.0	38.0	34.0
R	60-65	25.7	59.0	15.3





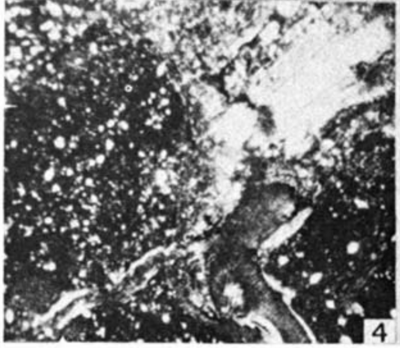
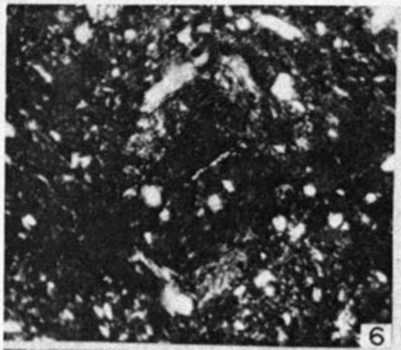


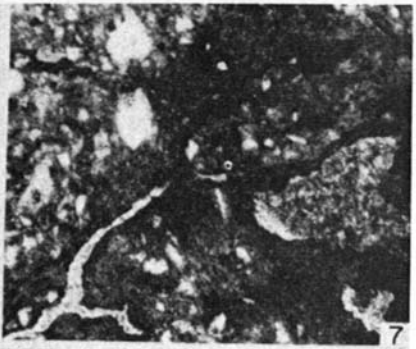
Figure 2. Thin section of the A1 horizon viewed under cross-polarized light at 30X. Bright-colored, loosely packed, fine quartz grains and dark, rounded iron-manganese oxide concretions make up the soil matrix. The dark background is the pore space resulting from the loose packing. No large pores or clay was observed in the thin sections.

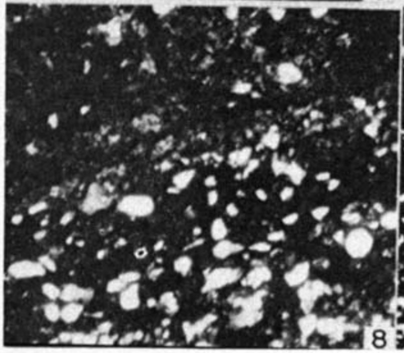
Figure 3. Thin section of the A2 horizon viewed under cross-polarized light at 30X. The grains are the same type as in the A1 horizon, but they are more closely packed. There are fewer small pores, more larger pores and much bridging between the grains.

Figure 4. Thin section of the B2t horizon viewed under cross-polarized light at 30X. The brightly illuminated coating around the void (lower right) and the channel to the left of this feature is highly oriented clay. Percolating water, carrying clay, has deposited the clay around these features. The light area above the void is a pure clay mass. Most of the other soil matrix is fine sand and silt with very little clay apparent at this magnification.

Figure 5. The same thin section as Fig. 4 at a 45-degree angle to the planes of polarization of light. At this position some of the clay has become extinct. Notice the darkened areas when comparing with the other section. These areas are segments of the coatings where the clay particles are oriented parallel to the planes of polarization. These bands seem to sweep across the coatings when the microscope stage is rotated.







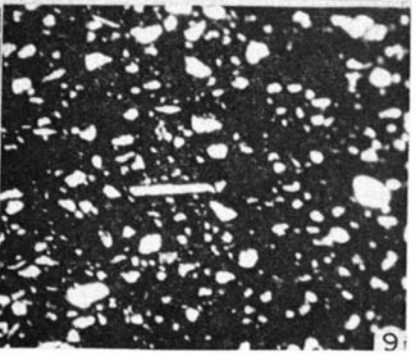


Figure 6. Thin section of the B2t horizon viewed under cross-polarized light at 100X. This horizon is the zone of maximum clay accumulation, and has a clayey matrix as indicated by the flecked appearance and the bright ring that suggests a coating of oriented clay. Notice the extinction band at the top of the circle. Again, this feature was water-deposited. It has since been filled with other soil material, and although not readily apparent, a new channel now bisects the circle from left to right.

Figure 7. Thin section of the lower B2t horizon viewed under plain light at 100X. Most of the soil matrix is clay with some sand and silt grains. Under plain light, oriented clay does not have distinguishing properties. However, dark coatings of manganese oxide are readily seen around the void and channels. Its effect has greatly darkened much of the surrounding material and has obscured much of the clay that is apparent under cross-polarized light.

Figure 8. Thin section of the B3t & C horizon viewed under cross-polarized light at 100X. This horizon is a transition between soil and parent material. The figure shows part of both soil and parent rock, and indicates a discontinuity between the upper and lower part. The lower part is a partially weathered siltstone fragment. The upper part is a clayey mass resting abruptly on the fragment. Water, carrying clay, slowed down to move past the fragment and the clay was deposited against the fragment causing the clay build-up.

Figure 9. Thin section of the R horizon viewed under cross-polarized

> light at 100X. The dark area represents cementing agents and not void space. The mineral grains are set in a mass of cementing agents, mostly iron-manganese oxides. The grains are angular and uniform in size, much like the surface grains. They are dominantly quartz and feldspar, with minor amounts of amphiboles and pyroxines. The elongated mineral in the center has optical properties of anthophyllite.

Evidence of both iron and manganese oxides in thin section, prompted chemical analysis to determine the percentages of each compound. The results are given in Table II. Iron oxide percentages were found to be high throughout the soil profile, but were highest in the parent rock. Manganese oxide percentages showed a definite increase with depth in the profile and were also highest in the parent rock. This suggests that possibly the iron oxides are remaining throughout the profile, while the manganese oxides are being removed by weathering processes and are only higher as the depth approaches that of the parent rock.

The distribution and kind of feldspars in the profile was also determined. The results are presented in Table III. As was expected, the unweathered rock was highest in feldspar minerals. Sodium feldspars were more abundant than potassium feldspars and no calcium feldspars were dectected in the profile.

TABLE II. PERCENTAGE OF IRON AND MANGANESE OXIDES

Horizon	Depth in inches	Percent Fe_2O_3	Percent MnO_2
A1	0-14	5.2	0.05
A21cn	14-20	6.9	0.05
A22cn	20-26	5.7	0.06
B21t	26-30	4.3	0.08
B22t	30-38	4.3	0.08
B3t & C	38-60	6.2	0.15
R	60-65+	7.5	0.15

TABLE III. PERCENTAGE OF TOTAL FELDSPARS IN THE FINE SAND, VERY FINE SAND AND COARSE SILT FRACTIONS.

Horizon	Depth in inches	Total Na_2O	Total K_2O	Quartz/ Feldspar
A1	0-14	7.5	5.3	6.8
A21cn	14-20	7.9	5.3	6.5
A22cn	20-26	6.9	5.6	7.0
B21t	26-30	7.5	4.4	7.4
B22t	30-38	7.3	4.5	7.5
B3t & C	38-60	8.3	4.8	6.7
R	60-65+	10.7	6.9	4.7

SUMMARY

Since the initial stages of rock weathering, many losses, gains and transformations have taken place in the profile. Still many of the characteristics of the rock are retained by the soil. The surfaces are the most weathered but have retained the silty texture of the rock and have very low clay contents. The horizons are also high in sesquioxides, especially iron oxides, in the form of concretions.

The B horizons have received clay accumulations as seen in Figures 4, 5, 6. The clay originated from transformations of minerals in place and clay transferred from the A horizons, either from clay in the parent rock or from the chemical weathering of primary minerals.

The B3t and C horizon is the least weathered and most like the parent rock. It even contains some unweathered siltstone fragments, and some clay accumulation.

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