Proceedings of the Iowa Academy of Science

Volume 79 | Number 3-4 Article 9

1972

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SYNOPSIS: This study involved five of the operating open-pit mines of Mahaska County, Iowa, which are located near the eastern edge of the Mid-Continent Basin. The mines were sampled from the underclay to the surface at two foot intervals and the clay fraction was separated and analyzed both qualitatively and quantitatively.

Results of this investigation showed that the major component present besides illite and kaolinite in the bulk sample was quartz. However, the quartz was not present in the less-than-two micron fraction. The clay fraction analysis varied from 38 percent to 60 percent kaolin and 17 percent to 26 percent illite with the remainder being chlorite and non-swelling mixed-layered material; chlorite was present in only eleven of the samples collected. The mineralogy was used as evidence that these rocks were deposited in near shore environment. This interpretation when considered along with stratigraphic work of others suggests that the rocks are in the Cherokee Group.

INDEX DESCRIPTORS: Penn. Clays, clay analysis, Mahaska County, Iowa clays.

This investigation involved the clay stratigraphy present in the Pennsylvanian rocks found in five of the presently operating open-pit mines of Mahaska County, Iowa. Iowa law requires coal mines to be filled in as mining operations cease and much valuable information would be lost if the mines were not sampled and analyzed during active operation.

This study involved the determination of the relative amounts of the clay minerals in the underclays and overclays associated with the Pennsylvanian coals presently mined in Mahaska County for clay sources of possible economic value, as possible aids to the interpretation and correlation of the Pennsylvanian clays in Mahaska County to the Mid-Continent Basin, and for correlation to the clay study of the Pennsylvanian underclays by Schultz (1968). Much of the Pennsylvanian stratigraphy exclusive of the clays was reported in the 1890's by the Iowa Geological Survey (1895). The geology of Mahaska County, based on the old shaft mines of the area, was originally reported by Bain (1895). The Pennsylvanian coal seam in Mahaska County has not been correlated with seams of adjacent counties; it is unfortunate that a pollen study has not been undertaken which would enable a correlation to be made. The coals have simply been tentatively correlated with the Lower Ford Coal in Wapello County. Schultz's study is the most complete study on correlations of the underclays of various geographical areas. Unfortunately, his study included only two samples from Iowa, both from southern Appanoose County.

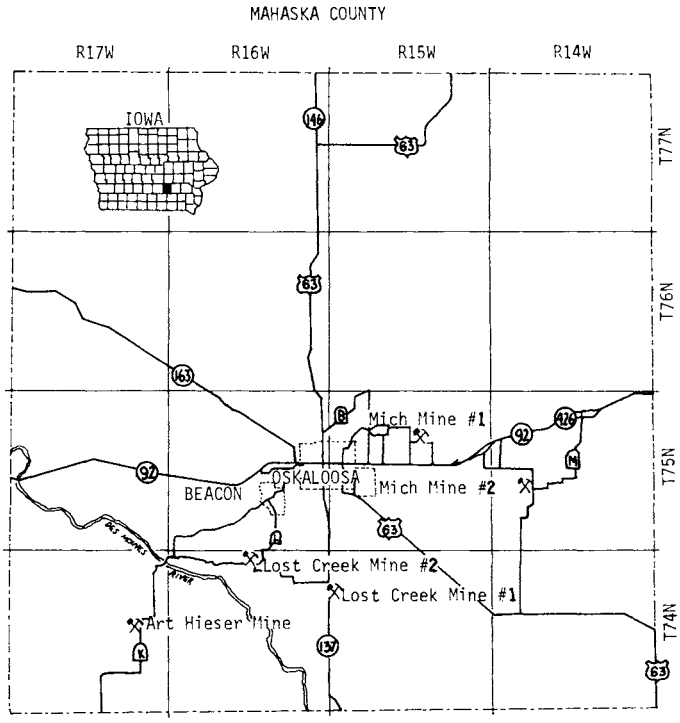

Figure 1. Map of Mahaska County showing mine locations.

LOCATION AND METHOD OF SAMPLE COLLECTION

The actual mine locations are given on the map in Figure I. More detail is given in the author's dissertation (Anderson, 1970). The location is near the eastern edge of the Mid-Continent Basin and not far from the Illinois Basin.

At each mine location, samples were taken at two foot intervals starting with the underclay and proceeding up the section to as near the surface of each pit as possible. When the bulk of the material appeared homogeneous, samples were taken at intervals of two feet; however, in the event of appearance of different lithologies, each layer was sampled, even if only two or three inches thick. Due to the size and visible variability in the rock sequence, two columns were sampled in both the Art Hieser Mine and Lost Creek #2 Mine. At two locations the upper portion of the sequence

This investigation was conducted at The University of Iowa under Dr. George McCormick and partially covered by a grant from the Iowa Academy of Science during the 1969-70 school year.

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was left unsampled due to the dangerous condition of the overhanging material.

PROCEDURE

The clay literature is full of contradictions on procedures for clay sample preparation and analysis to avoid losses due to grinding, water loss, etc.; many of these are referenced in the author's dissertation. A linear diffractometer chart of the bulk sample was recorded to identify the minerals present in the sample. The clay fraction was then separated using a modification of Jackson's procedures (1956) based on carbonate removal with sodium acetate, pyrite and organic removal with H_2O_2, free iron oxide and hydroxide removal with sodium dithionite-citrate-bicarbonate, dispersion of the clay minerals in sodium carbonate at pH 9.5 and separation of the less-than-two micron clay minerals by centrifugation. The diffractometer slides were prepared by placing about 2 ml of clay mineral-ethanol suspension on a clean glass slide and letting the ethanol evaporate.

Late in the study a second method of preparing samples by slaking in water was tried on a few samples for comparison. Slaking is completed by placing the sample in water for a few minutes, washing several times until the clays no longer flocculate, letting sit ten minutes and then removing a dropper full of the resulting suspension from just below the liquid surface. If the clay fraction continued to flocculate after repeated washings, a little calgon was added to help form the suspension; this suspension was then placed on a glass slide and the water allowed to evaporate.

Qualitative and quantitative identification of the slides using CuK_α radiation on a GE XRD-5 X-ray diffraction unit was a five step operation. First, a linear chart from 4° to 36° 2θ to check for kaolinite and illite was made. Based on the similarity in the charts, it was decided to use approximately five slides per profile for the remaining tests; any great variations would then be checked by analyzing more samples for that profile. Second, the slides were glycolated by placing them in a closed container with saturated vapors of ethylene glycol for 24 hours and then analyzing from 4° to 16° 2θ to check for the presence of montmorillonite at 17 A°(5.2° 2θ). Third, the selected slides were heated to 300°C for one hour and another linear chart was recorded; a shift of a 14 A° peak to a 10 A° would verify the presence of vermiculite. Fourth, the slides were heated to 500°C for one hour; the increase and persistence of the 14 A° peak would confirm the presence of chlorite. But the presence of chlorite must be considered with caution, since Jackson's method (1956) by his own admission produces some chlorite-like material. Fifth, a logarithmic function diffractometer chart was recorded of a second untreated slide made from the clay-ethanol suspension for quantitative analysis based on a 1/1 ratio of the peak areas as discussed by Schultz (1954).

RESULTS AND THEIR IMPLICATIONS

The five mines, which are situated along a 30 mile line crossing the county diagonally (Figure 1) from NE to SW show interesting variations. Mich Mine #1 was mainly a light

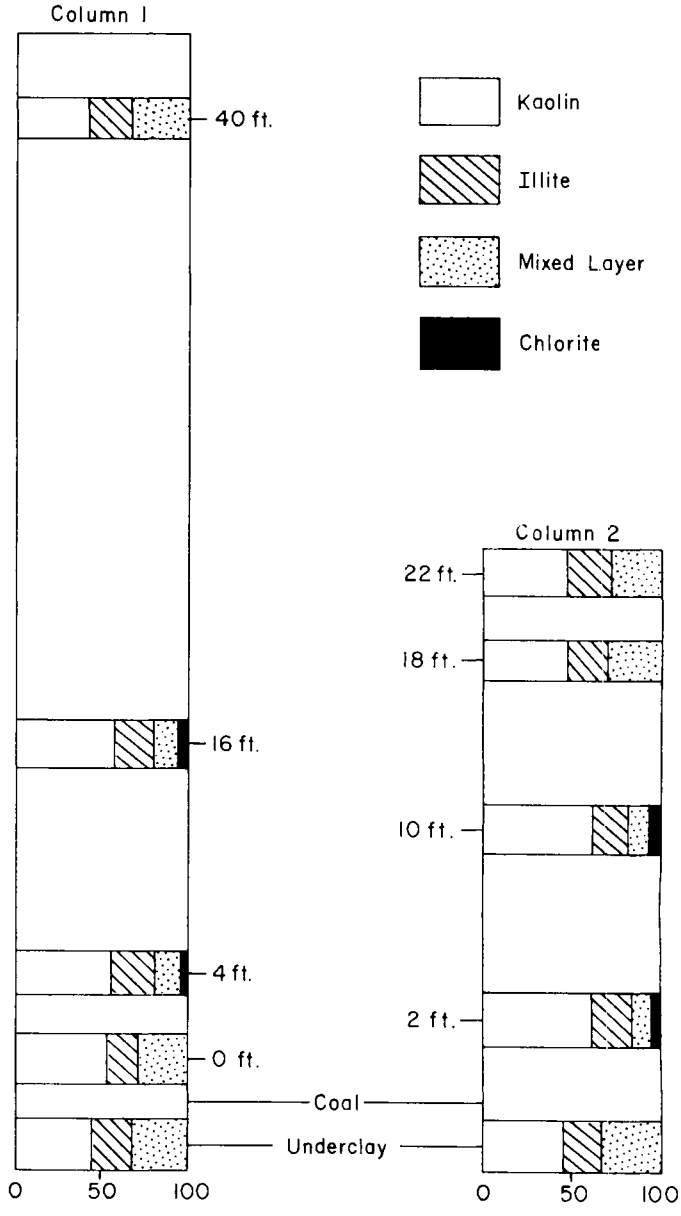

Figure 2. Lost Creek Mine #2.

brown soft clay material from the coal seam to the top of the pit with some bedding present; another mine that was located, but filled in before it was sampled, contained about a hundred feet of this brown material. Mich Mine #2 contained some darker material, but the stratigraphy of the three remaining mines is very similar; these mines contain dark grey to black shales with a two foot layer of limestone above the coal seam. The vertical separation of the limestone from the coal varies from six feet above the coal seam in Lost Creek #1 to less than a foot in Lost Creek Mine #2; the limestone was not continuous for the entire length of the Art Hieser Mine.

While the mines varied in physical appearance, the qualitative analysis of the bulk sample charts indicated that the

mineralogy in all five mines was very similar, despite the variation in physical appearance. The major constituent of the bulk samples, besides kaolinite and illite, was quartz with lesser amounts of calcite; the low intensity of the bulk sample peaks resulted in unsuccessful attempts at more refined identification. However, the quartz peaks were definitely absent in the less-than-two micron clay fraction charts. Qualitative analysis of the linear charts prepared by Jackson's method (1956) indicates that the clay fraction contains kaolinite, illite, mixed-layered material and a few samples with a small peak at 6.2° that might be chlorite. Comparison of the shape and intensity of the diffractometer peaks of samples prepared by Jackson's method and the slaking method discussed earlier indicated the former destroyed the illite structure, and forms a chlorite-like structure with a 14 A° spacing, as it is not present or is not as intense in the slaked samples. This investigator recommends that the slaking method be used in future investigation because of the time saved, one-half to one hour as compared to five days for Jackson's procedures; plus the fact there is less apparent damage to the clay structures. Glycolation indicated little material that might be montmorillonite. The heat treatment at 350°C indicated no shift that could be attributed to vermiculite; hence no vermiculite was reported. Interpretation of the charts after heating the slides to 550°C indicated that only eleven samples had a 14 A° peak that persisted at the same intensity or showed some increase in the intensity. Chlorite, while it is questionable as the increase is less than expected and also questionable because of Jackson's procedure, was reported for these samples.

The quantitative determination of kaolinite percentage on the logarithmic diffractometer charts ranged from 38 percent to 60 percent and the illite percentage varied from 26 percent to 17 percent. Bar graph representations of the results are given in Figure 2-4. These figures show the clay fraction analyses of the stratigraphic columns of the mines sampled in this study. The numerical figures along the side of each column represent the position as measured from the coal seam.

The percent kaolinite, illite and chlorite may now be used for possible interpretation of the environment. Murray (1954) suggests the kaolinite content increases to a maximum of about 50 percent for non-marine deposits; as the deposit becomes brackish or deep basin marine, the kaolinite percentage decreases and the illite increases. Using this information the clays of Mahaska County are of a near shore environment due to the high kaolinite percentage; this is consistent with its location in the Mid-Continent Basin. Manos (1967) identified five cycles of deposition during Marmathon time in the Mid-Continent Basin to the west of this investigation; however, he feels the Marmathon Strata were deposited from open sea circulation environment. Landis and Van Eck (1965) indicate Mahaska County is probably in the older Cherokee Group. Since the Mid-Continent Basin is quite ill-defined at the northeastern boundary, the high kaolinite percentage reported here should indicate Mahaska County is probably a near shore deposit at its edge. Schultz (1968) reports a red clay as the lateral equivalent of an underclay in his Zone 7; this investigator did not find the red clay or the high illite and low kaolinite percentage in the underclays reported by Schultz. The percentages reported in this investigation are much more in agreement with Schultz's Zones 3, 4, or 5 than Zone 6 or 7 of the Marmathon. This is

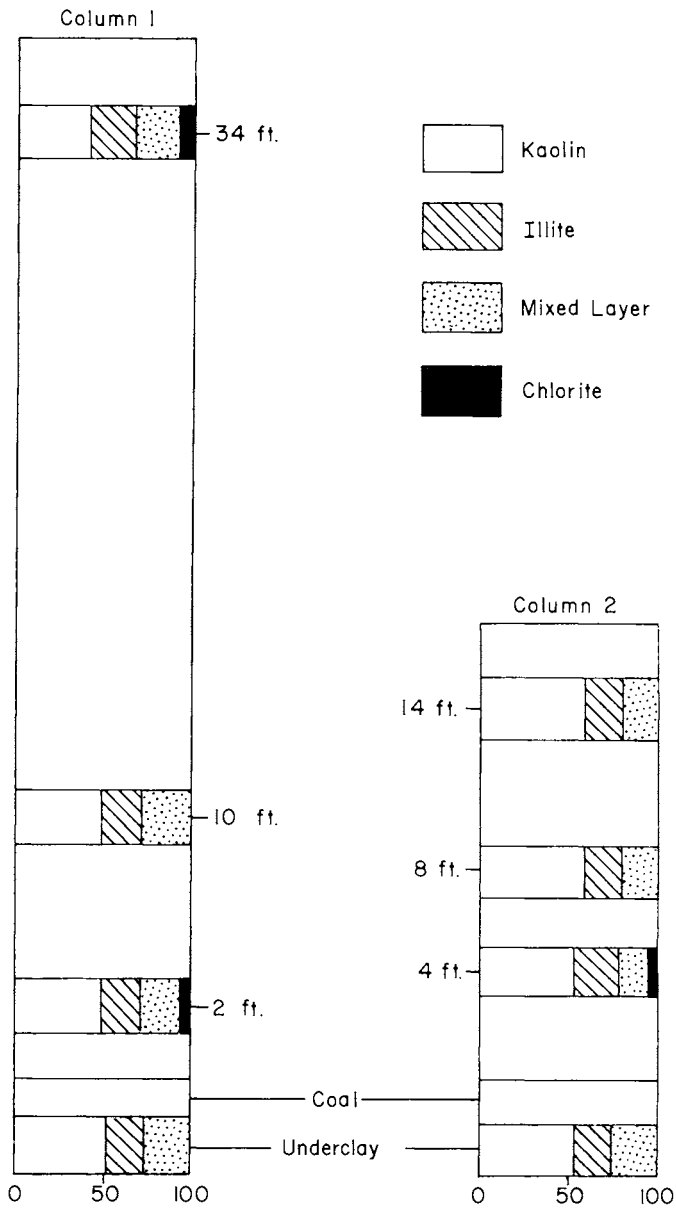

Figure 3. Art Hieser Mine.

also in better agreement with Landis and Van Eck. Thus based on the findings of this investigation, it appears the Pennsylvanian rocks of Mahaska County are best placed in the Cherokee Group as part of the Ford coal stratigraphy, since no differentiation of the coals has been made.

The percentages of kaolinite and illite of this study are very similar to those reported by Odom and Parhan (1968) for the Illinois Basin; hence, the deposits possibly would be suitable for the same uses as the clays of the Illinois Basin. These uses include building bricks, sewer pipe, refractory bricks and stoneware. The high firing temperature of the kaolin, the physical size of the deposits, and the iron content will be the determining factors of its economic value.

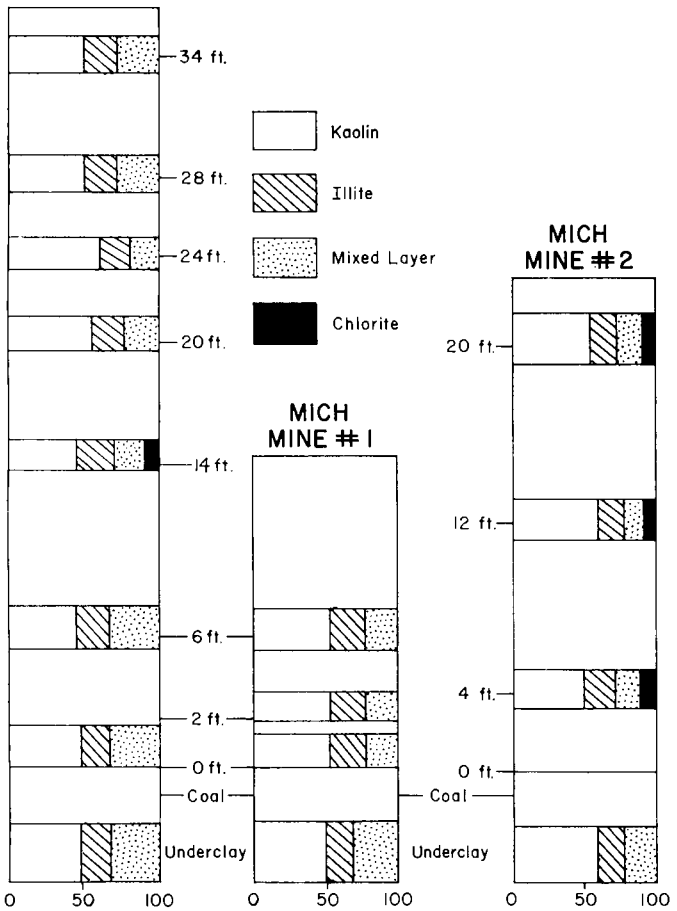

Figure 4. Lost Creek Mine #1.

ACKNOWLEDGMENTS

The author wishes to express his appreciation to Dr. George R. McCormick, University of Iowa geology professor, for the many hours of guidance and consultation concerning the geology, the X-ray analyses, and supervision of the actual work.

The author also wishes to express his appreciation to the Iowa Academy of Science for the grant to help defray the expenses of this investigation.

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