DIFFERENTIATION OF SOME PENNSYLVANIAN UNDERCLAYS BY THEIR CLAY MINERAL COMPOSITION

NEAL R. O'BRIEN
Illinois State Geological Survey, Urbana

Ordinary field methods are of little value in local identification of some underclays of the Caseyville, Abbott, and Spoon Formations of Pennsylvanian age in Mercer, Henry and Rock Island Counties of northwestern Illinois. The lateral lithologic variation of some beds, the lenticular nature of others, and the thickness variations of the stratigraphic units make identification difficult.

Differences have been detected in the clay mineral content of some of the underclays. Where stratigraphic data are inconclusive, the differences in mineral composition could help

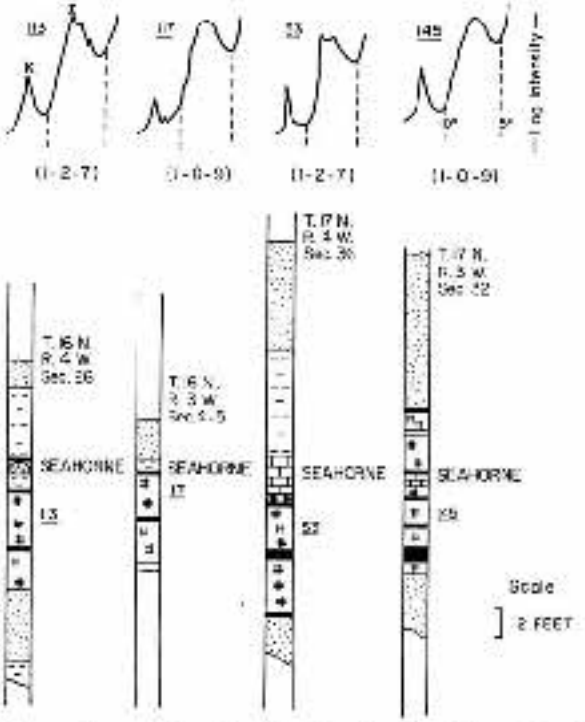

FIGURE 1.—X-ray traces (glycolated) of underclay below the Seahorne Limestone and columnar sections showing position of samples of underclay from Rock Island County.

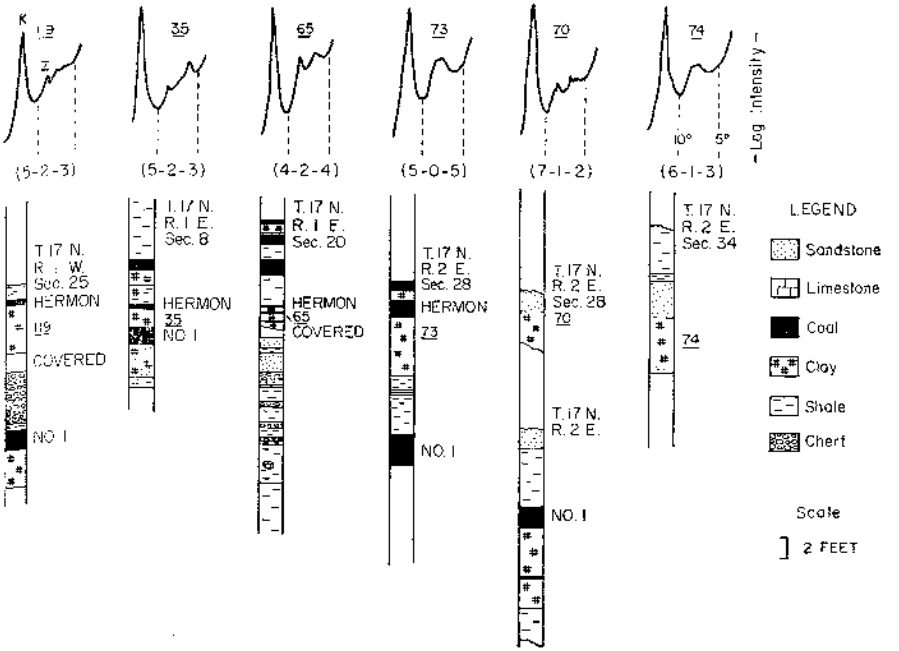

FIGURE 2.—X-ray traces (glycolated) of underclay below the Hermon Coal and columnar sections showing position of samples of underclay from Henry County.

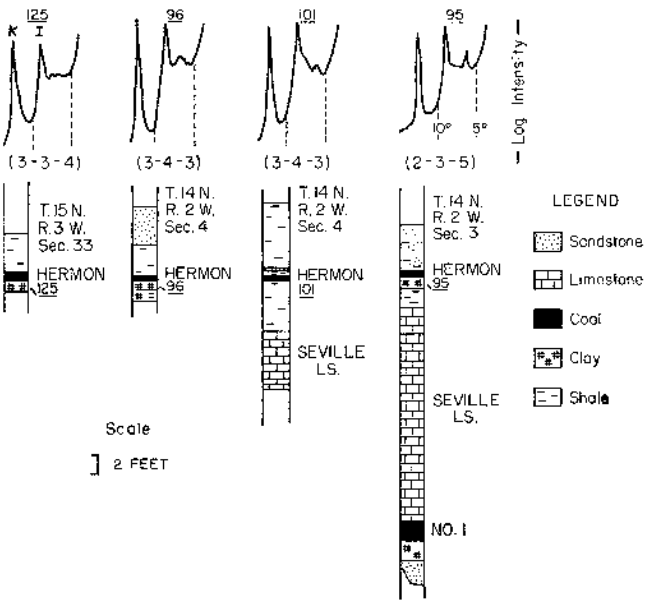

FIGURE 3.—X-ray traces (glycolated) of underclay below the Hermon Coal and columnar sections showing position of samples of underclay from Mercer County.

to identify the stratigraphic position of an underclay.

Method

Sampling in the three counties was limited to the upper third of the underclay outcrops, which range in thickness from a few inches to several feet.

The clay mineral composition of the underclay samples was determined by X-ray diffraction. The $< 2\ \mu$ clay fraction was prepared for analysis by oriented aggregate techniques and was saturated with ethylene glycol. X-ray diffraction patterns of saturated samples are shown in Figures 1 to 4.

The clay mineral composition of the underclays is given in terms of the abundance (parts in ten) of kaolinite, illite, and mixed-layer clay minerals, in that order. An under-

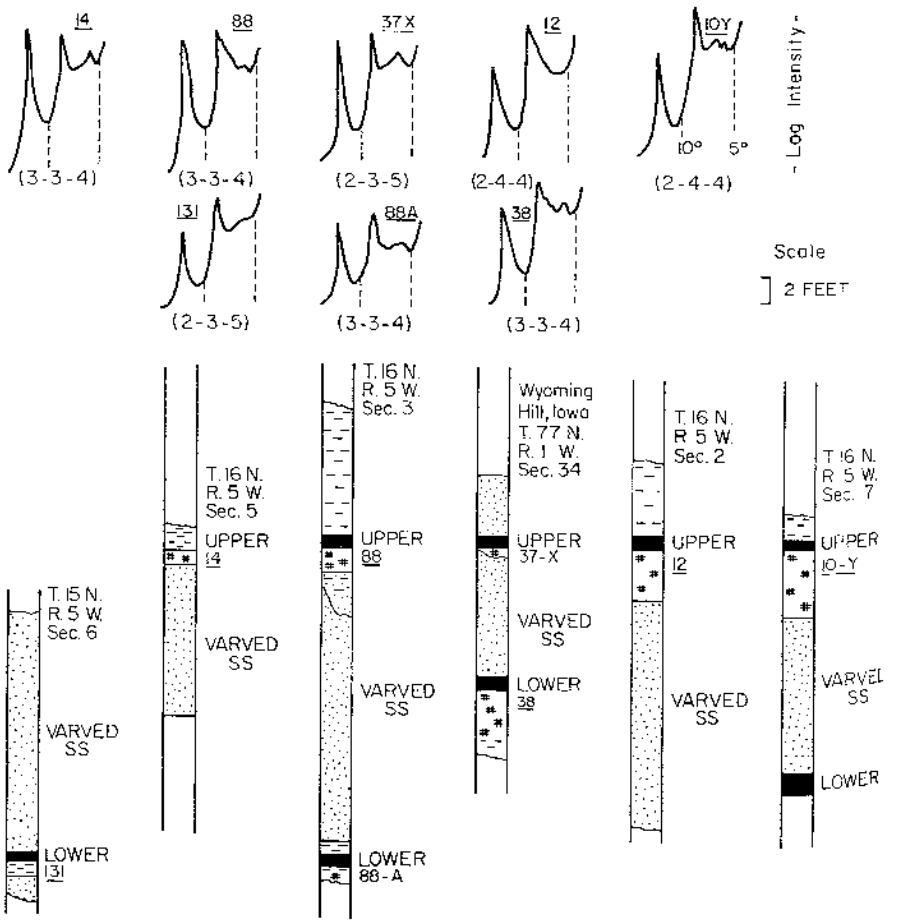

FIGURE 4.—X-ray traces (glycolated) of underclay below the Caseyville Coals and columnar sections showing position of samples of underclay from Rock Island County.

clay with a composition of 5-2-3, for instance, contains 5 parts kaolinite, 2 parts illite, and 3 parts mixed-layer minerals in 10 parts of $< 2\ \mu$ clay fraction. These values were determined by integrating the area under each first order diffraction peak (kaolinite, 12.4°2θ; illite, 8.8°2θ; mixed-layer material, 5-8.8°2θ) and dividing the first order peak value by the total area represented by all clay minerals present.

Discussion

If the clay mineral composition of any particular underclay varies greatly within a few square miles, it has little value in stratigraphic identification. However, if it can be demonstrated that the clay mineral composition is distinctive and consistent within that area, the composition may help to identify the underclay.

Identification is made in the following manner. The clay mineral compositions of a number of underclays of known stratigraphic positions in a small area are analyzed and particular note is taken of each underclay having a clay mineral composition that is distinct from all other underclays of different stratigraphic position. The rock sequences above and below the underclays are then observed so that both clay mineral and stratigraphic data can be used to characterize a particular underclay. If an underclay of unidentified stratigraphic position is then found in the same small area where underclays of identified position were sampled, and if the clay mineral composition and stratigraphic sequence above and below the unidentified underclay are similar to those of an identified underclay, then the unknown underclay can be identified.

Some of the underclays of the Caseyville, Abbott, and Spoon Formations were found to have distinctive clay mineral compositions. Three different groups of clay mineral assemblages were observed. The characteristic clay minerals, the abundance of kaolinite, illite, and mixed-layer material, and the stratigraphic position of each underclay group are as follows:

Group I—High kaolinite, low illite; low mixed-layer clay minerals; 5-2-3 ratio. *E.g.* underclay of Hermon Coal (Henry County).

Group II—Kaolinite; illite; mixed-layer clay minerals; 3-3-4 ratio. *E.g.* underclay of Hermon Coal (Mercer County). Underclay of coals in Caseyville Formation (Rock Island County).

Group III—Low kaolinite; low illite; high mixed-layer clay minerals; 1-1-8 ratio. *E.g.* underclay below Seahorne Limestone (Rock Island County).

Underclay Below the Seahorne Limestone (Rock Island County)

Underclays were sampled at two localities (Fig. 1, samples 53 and 145) in Rock Island County where the Seahorne Limestone indicates their stratigraphic position. They have a characteristic average clay mineral composition of 1-1-8 (Group

III), which is different from that of all other underclays in the area.

The presence of limestone nodules a few feet above underclay sample 113 (Fig. 1) suggests that this underclay also may lie under a thin coal below the Seahorne Limestone. The fact that sample 113 has a clay mineral composition of 1-2-7, which is similar to the composition of the underclays of known stratigraphic position mentioned above, corroborates the position of sample 113.

The stratigraphic position of sample 117 (Fig. 1) could not be identified positively in the field, although a position below the Seahorne Limestone is suggested by its occurrence slightly below the same elevation of nearby outcrops of flat-lying Seahorne Limestone. As sample 117 has a clay mineral composition of 1-0-9 (Group II, III), very much like the compositions of samples 53, 145, and 113, the possibility that it also may occupy a position under the coal below the Seahorne Limestone is strengthened.

Underclay of the Hermon Coal (Henry County)

The underclay of the Hermon Coal in Henry County has a distinctive clay mineral composition of 5-2-3, which was determined from samples 119 and 73 (Fig. 2). The striking feature of this underclay is its high kaolinite content. In no other underclay studied in this region was kaolinite so abundant.

Samples 35, 65, 70, and 74 (Fig. 2) were of unidentified stratigraphic position. Sample 35 was taken at the head of a small stream, at the mouth of which the Rock Island (No. 1) Coal crops out. As the clay of sample 35 lies slightly higher in the stratigraphic section than the Rock Island Coal, it possibly occurs below the Hermon Coal. In this case, however, stratigraphic information alone was not quite sufficient for identification. The x-ray traces of the unidentified clay were compared with those of underclays already known to occur below the Hermon Coal and were found to belong to the same group. Although the clay mineral composition alone was not definite evidence of position, in cases such as this it adds weight to the evidence provided by stratigraphic data.

Parham (1962) observed that the clay mineral composition of a particular underclay may vary from place to place, in some instances changing from Group I to Group III within a short distance. The use of clay mineral composition for identification, therefore, is valid only in small areas where the variation is known to be minor. For example, the underclay of the Hermon Coal varies only slightly in a distance of seven miles from the position of sample 119 to the position of sample 73, and underclays with abundant kaolinite within this area probably can be considered to lie under the Hermon Coal. The clay below the Seahorne Limestone also varies very little in a distance of about four miles (from the location of sample 145 to the location of sample 117), making it probable that clays with a composition approximately 1-1-8 in this small area lie below the coal under the Seahorne Limestone.

Underclays of the Hermon Coal (Mercer County) and Two Underclays in the Caseyville Formation (Rock Island County)

Although a distinctive clay mineral composition may be useful in identifying a particular underclay, underclays of two different stratigraphic positions may have similar clay mineral compositions different from those of all other underclays in the area. Clay mineral composition is still useful in identification in such cases for confirming available stratigraphic data.

The underclay of the Hermon Coal in Mercer County (Fig. 3) and the underclays of two unnamed coals (Fig. 4) all have a composition of approximately 3-3-4 (Group II). Robert M. Kosanke (personal communication, 1961) has found spores from these unnamed coals that are similar to spores from coals in the Caseyville Formation of southern Illinois, and the coals, therefore, are presumed to be from the Caseyville Formation. The two coals are separated by approximately 10 feet of varved, tan sandstone, which is a good marker bed. As no stratigraphic names have yet been applied to these coals, they will be referred to here as the coal above the sandstone (upper coal) and the coal below the sandstone (lower coal).

The underclays of the Hermon Coal in Mercer County lie above a marker bed — the Seville Limestone. The Hermon Coal lies approximately 100 feet above the two coals in the Caseyville Formation. Although the clay mineral composition of the three underclays is similar, the compositions are still valuable in distinguishing among them when sufficient stratigraphic information is not available. For example, samples 125 and 96 (Fig. 3) were taken from two outcrops where no distinctive marker bed was present. The composition of these samples was approximately 3-3-4 (Group II), which indicates that they are definitely below either the Hermon Coal in Mercer County or the Caseyville coals. Numerous outcrops of known stratigraphic position of the flat-lying Hermon Coal occur near and at the same elevation as samples 125 and 96, whereas in this area coals in the Caseyville Formation lie 100 feet below the Hermon Coal. Thus, it is reasonable to assume that samples 125 and 96 are from the underclay of the Hermon Coal. Here the clay mineral data furnished a clue to the stratigraphic position of the underclay and the stratigraphic information substantiated this position. Used separately, neither set of data offers sufficient evidence for identification; used together, they offer a reasonably certain stratigraphic identification.

Summary

Clay mineral composition, determined by X-ray diffraction, may be a useful supplement to stratigraphic data in identification of underclays.

The characteristic clay mineral composition of an underclay of known stratigraphic position must first be identified. If the clay composition of the identified underclay remains reasonably consistent in a

small area, it may then be compared with the clay composition of an underclay of unidentified stratigraphic position within that same area. If the clay mineral compositions of the underclays are similar and there is reasonable similarity in their stratigraphic position, the underclays ca be assumed to be the same unit.

Literature Cited

Parham, W. E. 1962. Clay mineral facies of certain Pennsylvanian underclays. Unpublished Ph.D. thesis, University of Illinois.

Manuscript received March 2, 1963.