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ABSTRACT

One hundred and seventy-five samples of dark gray to black shale were taken from outcrops in 44 Illinois counties. The highest percent equivalent uranium, determined by radiometric assay, of any of the samples was .017. The uranium oxide ($U_3O_8$) of 15 of the shale samples having the higher percent equivalent uranium ranged between .001 and .014 percent. The uranium oxide averaged .002 percent lower than the percent equivalent uranium for these fifteen samples. Phosphatic nodules and bands found in relatively small quantities in some black shales gave a higher percent equivalent uranium than the shales in which they occur. The maximum uranium oxide content of the phosphatic materials investigated was .075 percent. None of the samples appears to meet the requirement for the minimum grade of ore on which the Atomic Energy Commission has published prices.

Numerous requests have been received by the Illinois State Geological Survey for information regarding the significance of Illinois black shales as possible sources of uranium. This report gives the results of a preliminary investigation to supply such data. It further serves as a basis for judging the importance of the shales in connection with possible future developments in the field of source materials of radioactive substances.

Other members of the Survey staff who have contributed to this report are J. A. Simon and J. E. Lamar. P. E. Potter, H. B. Stonehouse, J. C. Bradbury, and C. W. Spencer aided in the collection of samples.

## Geologic Age and Thickness

The black shales of Illinois are principally of Pennsylvanian, Mississippian, and Mississippian-Devonian age. Some Ordovician gray shales were also investigated. The names of the individual units or formations sampled and the identifying numbers are given in table 1.

The Pennsylvanian shales occur most commonly above coal beds. They rarely exceed 10 feet in thickness, are usually less than 5 feet thick, and crop out at many places throughout the State except in the northern fifth, portions of western Illinois, and extreme southern Illinois. One hundred and twenty samples of Pennsylvanian shales were included in this investigation.

Outcrops of shales of the Chester series (Upper Mississippian) occur in extreme southern and southwestern Illinois. Most of these shales are dark gray

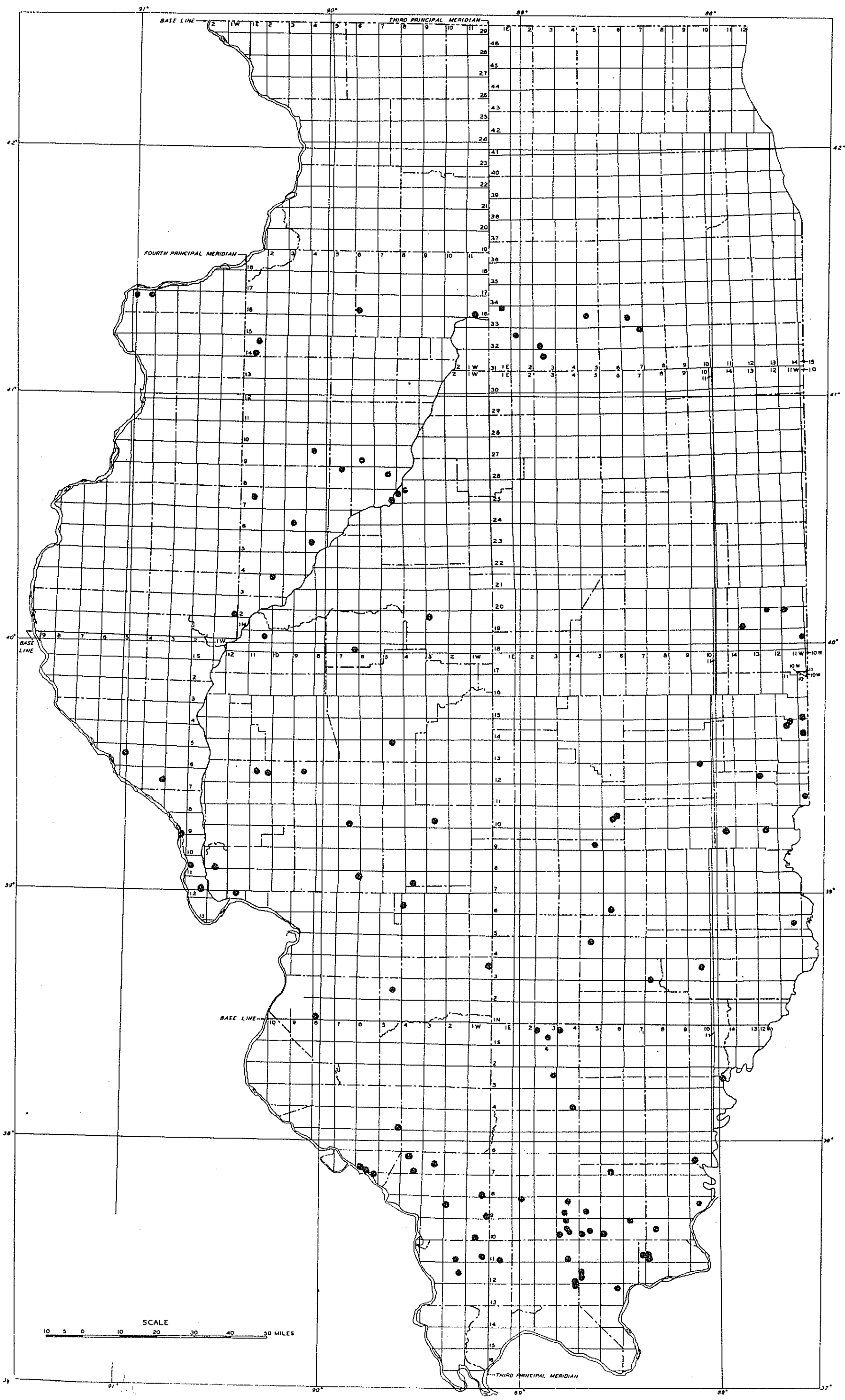


Fig. 1. - Locations of shales sampled.

to grayish black. The maximum thickness sampled from an outcrop was 25 feet. Twenty-two samples were taken.

The Hannibal and Maple Mill shales of the Kinderhook series (Lower Mississippian) crop out in Jersey, Pike, and Calhoun counties in western Illinois. Five samples were taken in Jersey County, two in Calhoun, and two in Pike. The shales are gray to dark gray.

Mississippian-Devonian black shale crops out in Hardin County, where it is known as the New Albany shale, and in Union County, where it is known as the Mountain Glen shale. It has a maximum thickness of 50 feet in Union County and possibly as much as 400 feet in Hardin County. However, in Hardin County only about 25 feet of relatively unweathered shale suitable for sampling was found. Nineteen samples of southern Illinois shale were obtained.

Another shale of Mississippian-Devonian age, the Grassy Creek shale, occurs in Pike County. It is about 50 feet thick and dark gray to black. Two five-foot samples were taken.

The Ordovician (Maquoketa) shale is ordinarily gray. Three samples were included in this study because the formation is comparatively thick and is commonly exposed in parts of Calhoun County and in northwestern Illinois.

## Phosphatic Materials

Some of the Pennsylvanian black shales contain small pebble-like nodules and lenticular bands or irregular masses of brownish-gray phosphatic material, which are generally more radioactive than the shale in which they occur. Samples D6c, D9a, D9b, D77a, and D103 contain phosphatic materials.

The basal few feet of the Maquoketa shale in Jo Daviess County also includes scattered phosphatic nodules. Sample M9 contains such nodules.

## Character of Black Shales

The dark gray to black color of Illinois shales is caused primarily by carbonaceous material. The shales are believed to have been deposited in seas that covered large portions of the State. Many of the black, or almost black, hard, brittle shales that break into thin layers are known popularly as "black slates," but they are not true slates.

Some black shales, especially the hard black shales above coals, contain iron sulfide in the form of the brassy yellow minerals pyrite and marcasite, which weather to yellow sulfur or to yellow, brown, or red minerals composed of iron oxides.

## Sampling and Preparation for Testing

Samples were taken in strip mines, road cuts, and stream cuts where reasonably unweathered material could be obtained. Samples were collected to give a wide distribution throughout the State (fig. 1) and to represent the majority of the outcropping shale units and formations (table 1). Most samples were taken by cutting channels in the face of exposed rock. The greatest thickness of shale represented by one sample was eight feet; the sample weighed about 20 pounds. Samples were crushed to a maximum diameter of about 1/10 of an inch for radiometric and chemical analyses. A particle-size analysis of a crushed sample follows.

| Mesh size | Percent |
|---|---|
| +8 | 1.6 |
| -8+16 | 31.6 |
| -16+35 | 27.2 |
| -35+65 | 11.7 |
| -65+100 | 13.3 |
| -100+150 | 2.5 |
| -150 | 12.1 |

Radiometric assays were made with a laboratory model Geiger counter, which was standardized against samples furnished by the Atomic Energy Commission. The assays indicate roughly the total amount of radioactive materials in a sample, including thorium and other radioactive substances as well as uranium, expressed in terms of the percentage of uranium oxide that would show an equivalent amount of radioactivity. Such a value is known as the percent equivalent uranium and is not necessarily a true measure of the uranium oxide content.

Chemical analyses for uranium oxide content were made according to procedures recommended by the Atomic Energy Commission in their booklet, "Manual of Analytical Methods for the Determination of Uranium and Thorium in Their Ores." Color measurements were made with a Beckman Model DU spectrophotometer with 10 cm. Corex cells standarized against samples supplied by the Atomic Energy Commission.

Seventeen shale samples and two samples containing phosphatic material were analyzed chemically. They were selected to represent shales of wide geographic distribution from a number of rock units and formations. Most of them had an equivalent uranium value of more than .01 percent (1/100 of one percent).

## Results of Tests

Results of equivalent uranium assays on 175 samples of shale are given in table 2. Determinations of uranium oxide for 15 shales are shown in table 3. Data on five samples of phosphatic material from shales appear in table 4.

## Conclusions

All the shale samples tested gave uranium oxide or equivalent uranium values below .02 percent (2/100 of one percent). The lowest grade of ore on which the Atomic Energy Commission has quoted prices contains .1 percent (1/10 of one percent) uranium oxide. Thus none of the shales tested appears to be of commercial importance at the present time.

Chemical determinations of the percentage of uranium oxide (table 3) in 15 representative shale samples showed a maximum uranium oxide content of .014 percent. The percent equivalent uranium was higher than the percent uranium oxide in nine samples. It was lower by an average of .003 percent for five samples and equal for one sample.

The ranges in percent equivalent uranium for shales of the four geologic ages represented were: Pennsylvanian, .000 to .017; Mississippian, .000 to .009; Devonian-Mississippian, .001 to .014; and Ordovician, .001 to .002. Chemical analyses of certain samples gave ranges in uranium oxide of .001 to .014 percent for the Pennsylvanian shales and .006 to .013 percent for the Mississippian-Devonian shales. Determination of uranium oxide content was not made on the Mississippian or Ordovician samples because the radiometric assays were low.

No obvious regional variations in the equivalent uranium values of the shales were noted. The highest value, .017 percent equivalent uranium, was recorded from a Gallatin County sample. The counties that yielded one or more samples having equivalent uranium values in excess of .01 percent and the higher value in each county, in order of decreasing radioactivity, were Gallatin, .017; Saline, .016; Hardin and Sangamon, .014; Union, .013; Clinton, Johnson, and Williamson, .012; and Fulton, Jefferson, Schuyler, and Vermilion, .011.

There is considerable variation in the equivalent uranium values of samples taken at different places from the same shale unit or formation. The values also vary vertically within the same formation or unit. The geologic units represented by two or more samples having the highest average equivalent uranium values were the Stonefort and Davis shales with averages of .008 percent, and the New Albany, Liverpool, Macoupin, Shoal Creek, and Cohn shales with a .007 percent average.

Variations in percent equivalent uranium within geologic systems ranged from an average of .002 for the Ordovician to .007 for the Devonian-Missisippian. The Mississippian and Pennsylvanian averaged .004 and .004+, respectively.

Black shales appear to have slightly higher equivalent uranium values than gray or dark-gray shales. The maximum equivalent uranium value for the black shales was .017 percent, for the gray and dark-gray shales, .013. The average equivalent uranium value for 92 black shale samples was .005, for 73 gray and dark-gray shales, .004 percent.

Phosphatic bands and nodules in the black shales had greater radioactivity than the associated shales. The two phosphatic samples tested chemically had uranium oxide percentages equal to, or greater than, the equivalent uranium values. Bands of phosphatic material occurring between layers of shale represented by sample D77 gave a reading of .065 percent equivalent uranium as compared with a .003 percent equivalent uranium for the shale and phosphatic material together.

Table 1. - Sequence of Shale Beds and Geologic Units Sampled

| Beds sampled | Geologic unit | Sample numbers |
|---|---|---|
| | Pennsylvanian (Coal Measures)* McLeansboro group | |
| Shales above Upper McLeansboro coals | Position uncertain | D15, D16, D20 |
| Shale above Shumway coal | Shumway | D14, D96 |
| Shale above Trowbridge coal | Shelby | D13 |
| Shale about 10 ft. below Trowbridge coal | Shelby | D12 |
| Shale about 25 ft. above Omega limestone | Unnamed | D97 |
| Shale above Upper Bogota coal | Bogota | D47, D49U, D49L, D50 |
| Shale above Cohn coal | Cohn | D9, D9a, D9b |
| Shale above coal that crops out near town of Divide | Unnamed | D17, D18, D19, D90, D94, D95 |
| Shale below limestone | LaSalle and Livingston | D57, D86 |
| Shale about 50 ft. above Shoal Creek limestone | Unnamed | D78 |
| Shale about 30 ft. below Livingston limestone | Unnamed | D2, D87, D93 |
| Shale below Shoal Creek limestone | Shoal Creek | D10, D11, D21, D70, D72, D92, D99 |
| Shale above Macoupin coal | Macoupin | D44, D71, D73, D77, D77a, D88, D89, D91, D98 |
| Shale above Brouillett coal | Brouillett | D85 |
| Shale above Exline limestone | Gimlet | D63 |
| Shale below Lonsdale limestone | Gimlet | D10Z |
| Shale above lower Scottville coal | Gimlet | D74 |
| Shale above Cutler Rider II coal | Unnamed | D30 |
| Shale above No. 7 coal | Sparland | D5, D5a, D5b, D59, D60, D65, D69, D100 |
| | Carbondale group | |
| Shale above Jamestown limestone | Jamestown | D81 |
| Shale above Herrin limestone | Brereton | D80U, D80L |
| Shale above No. 6 coal | Brereton | D4, D6a, D6b, D6c, D31, D46, D51, D79, D82 |

*Most of the units in the Pennsylvanian system are called cyclothems.

Table 1. (continued)

| Beds sampled | Geologic unit | Sample numbers |
|---|---|---|
| Shale above No. 5 coal | St. David | D1, D37U, D37L, D53, D54, D55, D64, D66, D67, D103 |
| Shale above No. 4 coal | Summum | D3, D3a, D3b, D33, D38, D52, D76 |
| Shale above No. 2 coal | Liverpool | D22U, D22L, D42, D56, D58, D68, D75, D101 |
| | Tradewater group | |
| Shale above Dekoven coal | Dekoven | D26, D34 |
| Shale above Davis coal | Davis | D24, D25, D32 |
| Shale above Campbell Hill coal | Unnamed | D83 |
| Shale below Seahorne limestone | Seahorne | D43 |
| Shale above Stonefort limestone | Stonefort | D23, D27, D35 |
| Shale below Stonefort limestone | Stonefort | D28 |
| Shale above limestone (D61a and D62a at base of exposures) | Seville | D61a-f, D62a-d |
| Shale below limestone | Seville and Curlew | D29, D45, D48 |
| Shale above Murphysboro coal | Unnamed | D7, D39U, D39L |
| "Ava" shale | "Ava" | D8 |
| Shale above Willis coal | Grindstaff | D84 |
| | Caseyville group | |
| Shale at position of Reynoldsburg coal | Pounds | D36 |
| Shale at position of Battery Rock coal | Battery Rock | D40 |
| Shale below Battery Rock coal | Battery Rock | D41 |
| | Mississippian Chester series | |
| Shale | Formation uncertain | A20 |
| Shale | Clore formation | A21-A24, A27, A32 |
| Shale about 25 ft. above base of formation | Clore formation | A5 |
| Shale at base of formation | Clore formation | A6 |
| Shale 25 ft. below top of formation | Clore formation | A7 |
| Shale 27 1/2 ft. below top of formation | Clore formation | A8 |
| Shale from top of formation | Clore formation | A25 |
| Shale from base of formation | Clore formation | A26 |
| Shale at contact of formations | Clore and Palestine formations | A30 |

Table 1. (continued)

| Beds sampled | Geologic unit | Sample numbers |
|---|---|---|
| Shale below A30 | Palestine formation | A31 |
| Shale | Menard formation | A28 |
| Shale below A28 | Menard formation | A29 |
| Shale at contact of formations | Menard-Waltersburg formations | A1 |
| Shale; samples in ascending order A2, A3, and A4 | Waltersburg formation | A2-A4 |
| Shale | Tar Springs | A33 |
| | Kinderhook series | |
| Shale near top of formation | Hannibal formation | A34 |
| Shale at base of outcrop | Hannibal formation | A42 |
| Shale, 0-3 and 5-7 ft. above A42 | Hannibal formation | A43 |
| Shale at top of formation | Hannibal formation | A46 |
| Shale | Maple Mill member (black-shale facies) | A37 |
| Shale, above A37 | Maple Mill member (black-shale facies) | A38 |
| Shale from base of formation; in ascending order A39, A40, A41 | Maple Mill member (black-shale facies) | A39-A41 |
| | Devonian-Mississippian | |
| Shale, A45 above A44 | Grassy Creek formation† | A44, A45 |
| Shale, 35 ft. above creek | Mountain Glen formation† | A9 |
| Shale, at base of formation | Mountain Glen formation† | A10 |
| Shale 10 to 30 ft. above base of formation; samples in ascending order | Mountain Glen formation† | A11-A14 |
| Upper 25 ft. of formation; samples in descending order | Mountain Glen formation† | A15-A19 |
| Shale, position in formation not known; samples in descending order | New Albany formation† | M1-M5 |
| Shale, position in formation not known; M6 above M7 | New Albany formation† | M6, M7 |
| Shale, position in formation not known | New Albany formation† | M8 |
| | Ordovician | |
| Shale below 6 in. red zone in basal part of formation | Maquoketa formation | A35 |

Table 1. (continued)

| Beds sampled | Geologic unit | Sample numbers |
|---|---|---|
| Shale above 6 in. red zone in basal part of formation | Maquoketa formation | A36 |
| Shale from "Depauperate zone" near base of formation | Maquoketa formation | M9 |

†These formations are roughly the same geologic age.

Table 2. - Location and Percent Equivalent Uranium of Shale Samples

| County | Sample | Location 1/4 | 1/4 | 1/4 | sec. | T. | R. | Thickness inches | % eU* | Sample source† |
|---|---|---|---|---|---|---|---|---|---|---|
| Bond | D78 | SW | NE | SE | 19 | 6N | 4W | 10 | .000 | Stream cut |
| Bureau | D46 | SW | NE | NE | 29 | 16N | 6E | | .006 | Strip-mine dump |
| " | D57 | NE | SW | NW | 33 | 16N | 11E | 7 | .000 | Stream cut |
| Calhoun | A34 | | NW | NE | 35 | 9S | 3W | 60 | .007 | Weathered bluff** |
| " | A36 | SE | NE | SW | 17 | 11S | 2W | 60 | .001 | Valley wall** |
| " | A35 | SE | NE | SW | 17 | 11S | 2W | 60 | .002 | Valley wall** |
| " | A46 | C | SW | NE | 23 | 12S | 2W | 72 | .005 | Quarry** |
| Cass | D101 | SW | SW | NE | 11 | 18N | 11W | 26 | .001 | Bluff |
| Clark | D90 | SE | SW | NW | 4 | 9N | 12W | 22 | .004 | Stream cut |
| " | D91 | SE | NE | SE | 3 | 9N | 12W | 31 | .004 | Stream cut |
| " | D92 | SE | NW | SE | 3 | 9N | 12W | 10 | .004 | Stream cut |
| " | D93 | SW | NW | SE | 3 | 9N | 12W | 32 | .001 | Stream cut** |
| " | D89 | NE | NW | NW | 20 | 11N | 10W | 33 | .009 | Road cut |
| " | D94 | SE | NE | SE | 30 | 12N | 12W | 12 | .004 | Road cut |
| Clay | D50 | SW | SE | SW | 32 | 3N | 8E | | .004 | Stream cut |
| " | D97 | SW | SW | SW | 10 | 4N | 5E | 72 | .006 | Valley wall |
| Clinton | D99 | SW | SE | SE | 22 | 2N | 5W | 26 | .012 | Stream cut |
| " | D98 | NE | SW | NE | 13 | 3N | 1W | 12 | .000 | Stream cut |
| Coles | D95 | SW | SW | SE | 3 | 12N | 10E | 10 | .002 | Stream cut |
| Crawford | D47 | SE | SW | NW | 14 | 5N | 11W | 32 | .002 | Stream cut |
| Edgar | D88 | SW | NE | SW | 29 | 14N | 10W | 16 | .009 | Stream cut |
| " | D87 | | C | SW | 2 | 14N | 11W | 15 | .000 | Stream cut** |
| " | D86 | SE | SE | SE | 10 | 14N | 11W | 24 | .006 | Stream cut |
| " | D85 | NW | SE | NW | 32 | 15N | 10W | 14 | .002 | Road cut |
| Effingham | D96 | SE | NE | NW | 28 | 6N | 6E | 31 | .003 | Stream cut |
| " | D14 | SE | SE | SW | 26 | 9N | 5E | 34 | .001 | Stream cut |
| Fulton | D67 | | N | NE | 3 | 3N | 2E | 15 | .007 | Strip mine |
| " | D42 | NE | NW | NW | 17 | 5N | 4E | 24 | .006 | Stream cut |
| " | D66 | NW | SW | SW | 28 | 6N | 3E | 20 | .002 | Strip mine |
| " | D43 | SW | SE | NW | 14 | 7N | 1E | 15 | .002 | Stream cut |
| Gallatin | D44 | SE | NE | NW | 16 | 9S | 10E | 30 | .017 | Stream cut |
| " | D1 | | C | NW | 16 | 10S | 8E | 36 | .004 | Strip mine |
| Greene | D76 | NW | SE | NW | 21 | 12N | 11W | 30 | .003 | Strip mine** |
| " | D75 | SW | SW | SW | 24 | 12N | 11W | 30 | .009 | Strip mine |
| Grundy | D54 | NW | SE | NE | 1 | 32N | 7E | 18 | .002 | Stream cut |
| " | D53 | SE | NW | NW | 20 | 33N | 7E | 22 | .004 | Stream cut |

*eU = equivalent uranium.
**Gray, dark gray, or grayish black.
†All samples are black except those double-starred.

Table 2. (continued)

| County | Sample | Location 1/4 | 1/4 | 1/4 | sec. | T. | R. | Thickness inches | % eU* | Sample source† |
|---|---|---|---|---|---|---|---|---|---|---|
| Hardin | M1 | SW | NW | SE | 25 | 11S | 7E | 36 | .003 | Stream cut** |
| " | M2 | SW | NW | SE | 25 | 11S | 7E | 60 | .003 | Stream cut |
| " | M3 | SW | NW | SE | 25 | 11S | 7E | 60 | .003 | Stream cut |
| " | M4 | SW | NW | SE | 25 | 11S | 7E | 60 | .014 | Stream cut |
| " | M5 | SW | NW | SE | 25 | 11S | 7E | 60 | .009 | Stream cut |
| " | M8 | SW | SE | SE | 30 | 11S | 8E | 48 | .003 | Road cut |
| " | M6 | SE | NE | NE | 31 | 11S | 8E | 60 | .001 | Road cut |
| " | M7 | SE | NE | NE | 31 | 11S | 8E | 60 | .006 | Road cut |
| Henry | D48 | SE | NW | SE | 11 | 14N | 1E | | .006 | Mine dump |
| " | D45 | NE | NE | NE | 33 | 14N | 1E | | .004 | Mine dump |
| Jackson | D7 | NW | NE | SW | 22 | 7S | 3W | 30 | .000 | Strip mine |
| " | D83 | NW | SE | NE | 4 | 7S | 4W | 30 | .003 | Stream cut |
| " | D8 | SE | SE | NE | 35 | 7S | 4W | 48 | .003 | Stream cut** |
| " | D38 | SE | NW | NW | 35 | 8S | 1W | 36 | .008 | Mine entry |
| " | D39U | NE | SW | NE | 36 | 9S | 1W | 30 | .001 | Strip mine |
| " | D39L | NE | SW | NE | 36 | 9S | 1W | 60 | .003 | Strip mine** |
| " | D84 | SW | SE | NE | 19 | 9S | 2W | 24 | .003 | Stream cut** |
| " | D40 | SW | NW | NW | 33 | 10S | 1W | 22 | .000 | Stream cut |
| " | D41 | SW | NW | NW | 33 | 10S | 1W | 18 | .001 | Stream cut** |
| Jefferson | D15 | SE | SW | SE | 7 | 1S | 3E | 18 | .005 | Stream cut |
| " | D16 | NW | SW | SW | 22 | 1S | 3E | 15 | .011 | Road cut |
| " | D17 | NW | SW | SW | 7 | 1S | 4E | 15 | .003 | Road cut |
| " | D18 | SE | SE | SE | 13 | 3S | 3E | 38 | .003 | Stream cut** |
| " | D19 | SE | SE | SE | 13 | 3S | 3E | 12 | .000 | Stream cut |
| " | D20 | NE | NE | SE | 35 | 4S | 4E | 40 | .001 | Stream cut |
| Jersey | A38 | | NE | SE | 4 | 6N | 12W | 60 | .007 | Stream cut** |
| " | A37 | | NE | SE | 4 | 6N | 12W | 60 | .008 | Stream cut** |
| " | A41 | SW | SE | NW | 34 | 8N | 13W | 60 | .000 | Valley wall** |
| " | A40 | SW | SE | NW | 34 | 8N | 13W | 60 | .004 | Valley wall** |
| " | A39 | SW | SE | NW | 34 | 8N | 13W | 60 | .004 | Valley wall** |
| Jo Daviess | M9 | NE | SE | SW | 26 | 29N | 2E | 12 | .002 | Railroad cut** |
| Johnson | D36 | SE | NE | SE | 33 | 11S | 4E | 27 | .012 | Stream cut |
| " | A28 | NE | SW | NE | 36 | 12S | 4E | 72 | .003 | Railroad cut** |
| " | A29 | SE | SE | NW | 1 | 13S | 4E | 48 | .001 | Railroad cut** |
| Knox | D64 | | | S | 8 | 9N | 4E | 22 | .008 | Strip mine |
| LaSalle | D51 | SE | SE | SE | 9 | 31N | 3E | 24 | .000 | Road cut |
| " | D56 | | SE | SW | 8 | 32N | 2E | 22 | .008 | Stream cut |
| " | D52 | | SW | SE | 32 | 32N | 3E | 29 | .007 | Stream cut |
| " | D58 | NE | NE | NE | 3 | 33N | 1E | 14 | .002 | Stream cut |
| " | D55 | SW | SE | NE | 21 | 33N | 5E | 14 | .004 | Stream cut |
| Logan | D102 | SW | NE | NE | 7 | 19N | 3W | | .000 | Blocks from quarry floor** |

Table 2. (continued)

| County | Sam-ple | Location 1/4 | 1/4 | 1/4 | sec. | T. | R. | Thickness inches | % eU* | Sample source† |
|---|---|---|---|---|---|---|---|---|---|---|
| Macoupin | D77 | SW | NE | NE | 12 | 7N | 7W | 24 | .003 | Stream cut |
| " | D73 | SE | SE | SW | 35 | 10N | 7W | 24 | .006 | Stream cut |
| " | D72 | SW | SW | SE | 35 | 10N | 7W | 36 | .004 | Stream cut |
| " | D74 | NW | SW | NW | 16 | 12N | 9W | 18 | .006 | Stream cut |
| Menard | D100 | C | NW | NW | 36 | 18N | 7W | 12 | .005 | Stream cut |
| Montgomery | D11 | SW | SW | SE | 21 | 7N | 4W | 18 | .009 | Stream cut |
| " | D71 | NE | SE | NW | 28 | 10N | 3W | 26 | .004 | Stream cut |
| Peoria | D59 | | C | SE | 23 | 7N | 7E | 7 | .002 | Road cut |
| " | D63 | | C | NE | 3 | 8N | 5E | 4 | .003 | Stream cut |
| " | D69 | NE | NE | SW | 11 | 8N | 7E | 14 | .006 | Road cut |
| " | D65 | | NE | SW | 28 | 9N | 6E | 10 | .002 | Road cut |
| Pike | A45 | | NE | SW | 17 | 6S | 5W | 60 | .008 | Stream cut** |
| " | A44 | | NE | SW | 17 | 6S | 5W | 60 | .003 | Stream cut** |
| " | A43 | C | NW | NE | 24 | 7S | 4W | 60 | .003 | Road cut** |
| " | A42 | C | NW | NE | 24 | 7S | 4W | 60 | .003 | Road cut** |
| Pope | A25 | SW | NW | SE | 19 | 12S | 5E | 48 | .002 | Railroad cut |
| " | A21 | SE | SE | SW | 19 | 12S | 5E | 36 | .006 | Railroad cut |
| " | A22 | SE | SE | SW | 19 | 12S | 5E | 48 | .000 | Railroad cut** |
| " | A23 | SE | SE | SW | 19 | 12S | 5E | 24 | .000 | Railroad cut |
| " | A24 | NW | SW | SE | 19 | 12S | 5E | 42 | .000 | Railroad cut |
| " | A27 | SW | NW | SE | 19 | 12S | 5E | 72 | .002 | Railroad cut |
| " | A26 | SW | NW | SE | 19 | 12S | 5E | 48 | .003 | Railroad cut |
| " | A30 | NW | SW | SW | 30 | 12S | 5E | 60 | .008 | Railroad cut |
| " | A31 | NW | SW | SW | 30 | 12S | 5E | 60 | .006 | Railroad cut |
| " | A33 | SE | SE | SE | 11 | 13S | 6E | 90 | .001 | Road cut |
| Randolph | D81 | NE | SW | NE | 36 | 5S | 5W | 33 | .001 | Strip mine |
| " | D80U | NE | SW | NE | 36 | 5S | 5W | 60 | .000 | Strip mine |
| " | D80L | NE | SW | NE | 36 | 5S | 5W | 60 | .000 | Strip mine |
| " | D82 | NW | SW | NE | 36 | 5S | 5W | 34 | .002 | Strip mine |
| " | A1 | NW | NW | NE | 32 | 7S | 6W | 60 | .006 | Stream cut |
| " | A2 | NW | NW | NE | 32 | 7S | 6W | 60 | .007 | Stream cut |
| " | A3 | NW | NW | NE | 32 | 7S | 6W | 60 | .005 | Stream cut |
| " | A4 | NW | NW | NE | 32 | 7S | 6W | 36 | .001 | Stream cut |
| " | A5 | SW | NE | SE | 33 | 7S | 6W | 30 | .004 | Stream cut |
| " | A6 | SW | NE | SE | 33 | 7S | 6W | 48 | .003 | Stream cut |
| " | A7 | SW | SE | SE | 2 | 8S | 6W | 24 | .002 | Quarry |
| " | A8 | SW | SE | SE | 2 | 8S | 6W | 30 | .009 | Quarry |
| Richland | D49U | SW | SW | SE | 15 | 3N | 10E | 36 | .006 | Stream cut |
| " | D49L | SW | SW | SE | 15 | 3N | 10E | 36 | .000 | Stream cut |
| Rock Island | D61a | NE | NE | SW | 1 | 16N | 5W | 60 | .007 | Stream cut |
| " | D61b | NE | NE | SW | 1 | 16N | 5W | 60 | .004 | Stream cut |
| " | D61c | NE | NE | SW | 1 | 16N | 5W | 60 | .002 | Stream cut |

Table 2. (continued)

| County | Sam-ple | Location 1/4 | 1/4 | 1/4 | sec. | T. | R. | Thickness inches | % eU* | Sample source† |
|---|---|---|---|---|---|---|---|---|---|---|
| Rock Island | D61d | NE | NE | SW | 1 | 16N | 5W | 60 | .004 | Stream cut |
| " | D61e | NE | NE | SW | 1 | 16N | 5W | 60 | .006 | Stream cut |
| " | D61f | NE | NE | SW | 1 | 16N | 5W | 60 | .001 | Stream cut |
| " | D62a | SE | SE | SW | 6 | 16N | 5W | 60 | .000 | Road cut |
| " | D62b | SE | SE | SW | 6 | 16N | 5W | 60 | .004 | Road cut |
| " | D62c | SE | SE | SW | 6 | 16N | 5W | 60 | .000 | Road cut |
| " | D62d | SE | SE | SW | 6 | 16N | 5W | 60 | .002 | Road cut |
| St. Clair | D79 | SE | SE | NW | 31 | 1N | 8W | 31 | .003 | Strip mine |
| Saline | D21 | NE | NE | SW | 33 | 7S | 6E | 10 | .007 | Stream cut |
| " | D31 | SW | NE | SW | 29 | 9S | 5E | 23 | .008 | Strip mine |
| " | D26 | | NE | NW | 21 | 10S | 5E | 30 | .002 | Strip mine |
| " | D25 | | NE | NW | 21 | 10S | 5E | 22 | .007 | Strip mine |
| " | D27 | NW | NE | NE | 30 | 10S | 5E | 35 | .013 | Railroad cut |
| " | D28 | NW | NE | NE | 30 | 10S | 5E | 20 | .001 | Railroad cut |
| " | D24 | NE | SE | NE | 30 | 10S | 6E | 10 | .016 | Stream cut |
| " | D23 | NE | SE | NE | 30 | 10S | 6E | 17 | .004 | Stream cut |
| " | D22U | C | SW | NW | 5 | 10S | 7E | 15 | .007 | Stream cut |
| " | D22L | C | SW | NW | 5 | 10S | 7E | 18 | .008 | Stream cut |
| Sangamon | D70 | NW | NE | SW | 3 | 13N | 5W | 17 | .014 | Stream cut |
| Schuyler | D68 | cen. sec. | | | 36 | 2N | 1W | 38 | .011 | Stream cut |
| Shelby | D13 | NW | NW | NE | 14 | 10N | 6E | | .002 | Mine dump |
| " | D12 | NW | NE | SW | 22 | 10N | 6E | 30 | .003 | Road ditch |
| Tazewell | D60 | NE | NE | NW | 18 | 25N | 4W | 5 | .004 | Stream cut |
| Union | A32 | SE | SW | SE | 33 | 11S | 1E | 72 | .000 | Stream cut** |
| " | A20 | NW | SE | SW | 26 | 11S | 1W | 36 | .006 | Road cut |
| " | A14 | | C | NE | 34 | 11S | 2W | 60 | .008 | Stream cut** |
| " | A13 | | C | NE | 34 | 11S | 2W | 60 | .007 | Stream cut** |
| " | A12 | | C | NE | 34 | 11S | 2W | 60 | .011 | Stream cut** |
| " | A11 | | C | NE | 34 | 11S | 2W | 60 | .013 | Stream cut** |
| " | A9 | SE | NE | NE | 34 | 11S | 2W | 60 | .007 | Stream cut** |
| " | A10 | SE | NE | NE | 34 | 11S | 2W | 24 | .008 | Cut bank** |
| " | A15 | SW | NW | SE | 14 | 12S | 2W | 60 | .005 | Valley wall** |
| " | A16 | SW | NW | SE | 14 | 12S | 2W | 60 | .008 | Valley wall** |
| " | A17 | SW | NW | SE | 14 | 12S | 2W | 60 | .008 | Valley wall** |
| " | A18 | SW | NW | SE | 14 | 12S | 2W | 60 | .008 | Valley wall** |
| " | A19 | SW | NW | SE | 14 | 12S | 2W | 60 | .004 | Valley wall** |
| Vermilion | D3 | SW | NW | NW | 13 | 18N | 11W | 14 | .011 | Stream cut |
| " | D3a | SW | NW | NW | 13 | 18N | 11W | 5 | .002 | Stream cut** |
| " | D3b | SW | NW | NW | 13 | 18N | 11W | 4 | .003 | Stream cut** |
| " | D4 | SE | SE | SE | 6 | 19N | 11W | 23 | .007 | Stream cut |
| " | D5 | | | SE | 4 | 19N | 12W | 17 | .002 | Strip mine** |
| " | D5a | | | SE | 4 | 19N | 12W | 3 | .004 | Strip mine, top 3 in. of A5** |

Table 2. (continued)

| County | Sam-ple | Location 1/4 | 1/4 | 1/4 | sec. | T. | R. | Thickness inches | % eU* | Sample source† |
|---|---|---|---|---|---|---|---|---|---|---|
| Vermilion | D5b | | | SE | 4 | 19N | 12W | 1 | .002 | Strip mine, bottom 1 in. of A5** |
| " | D2 | NW | NW | SW | 31 | 19N | 13W | | .004 | Stream cut |
| White | D9 | | SW | SW | 21 | 3S | 14W | 12 | .007 | Stream cut |
| " | D10 | SE | SW | SE | 17 | 7S | 10E | 12 | .005 | Stream cut |
| Williamson | D37U | | NE | SW | 4 | 9S | 2E | 36 | .001 | Strip mine |
| " | D37L | | NE | SW | 4 | 9S | 2E | 36 | .006 | Strip mine |
| " | D30 | SE | SW | NW | 10 | 9S | 4E | 41 | .001 | Stream cut |
| " | D6a | | NE | NE | 28 | 9S | 4E | 9 | .011 | Strip mine, bottom 9 in. |
| " | D6b | | NE | NE | 28 | 9S | 4E | 21 | .006 | Strip mine, upper 21 in. |
| " | D33 | NW | SE | NW | 4 | 10S | 4E | 36 | .001 | Stream cut |
| " | D34 | NW | SW | NW | 16 | 10S | 4E | 24 | .006 | Valley wall |
| " | D32 | NE | SE | NE | 16 | 10S | 4E | 33 | .001 | Stream cut |
| " | D35 | SW | SW | NW | 22 | 10S | 4E | | .012 | Road cut |
| " | D29 | NW | NE | SW | 30 | 10S | 4E | 18 | .002 | Road cut |

Table 3. - Percent Uranium Oxide ($U_3O_8$) of Shale Samples

| Sample | % $U_3O_8$ | Sample | % $U_3O_8$ | Sample | % $U_3O_8$ |
|---|---|---|---|---|---|
| D3 | .014 | D35 | .013 | D70 | .010 |
| D6A | .006 | D36 | .001 | D89 | .014 |
| D16 | .012 | D44 | .014 | D99 | .013 |
| D27 | .008 | D56 | .003 | A11 | .013 |
| D24 | .009 | D68 | .008 | M+ | .006 |

Table 4. - Analyses of Phosphatic Materials

| County | Sample | Location 1/4 | 1/4 | 1/4 | sec. | T. | R. | % eU | % $U_3O_8$ | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| Macoupin | D77a | SW | NE | NE | 12 | 7N | 7W | .065 | .075 | Phosphatic bands from sample D77 |
| Tazewell | D103 | NW | NE | SE | 24 | 25N | 5W | .013 | | Mine dump; phosphatic bands and nodules |
| White | D9a | | SW | SW | 21 | 3S | 14W | .019 | | Phosphatic siltstone above Cohn coal |
| White | D9b | | SW | SW | 21 | 3S | 14W | .019 | .019 | Phosphatic nodules from sample D9 |
| Williamson | D6c | | NE | NE | 28 | 9S | 4E | .011 | | Strip mine; random blocks of black shale containing phosphatic nodules and bands |

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# ILLINOIS STATE GEOLOGICAL SURVEY

URBANA