

THE ANTRIM-ELLSWORTH-COLDWATER SHALE
FORMATIONS IN MICHIGAN¹

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Figure 1.— An east-west cross-section between the points A and B, in Allegan and Bay Co., respectively.

Figure 2.— A north-south cross-section between the points D and C, in Antrim and Allegan Co., respectively.

The lenticular reconstruction and correlations are mostly imaginative but represent what the writer believes to be the most logical interpretation.

Figure 3.— A composite correlation diagram of the cross-sections shown in Fig. 1 and 2. The arrow of the index map indicates the position in which the observer is viewing the diagram. The index map of Michigan shows the location of the wells studied and charted in the cross-sections.

ABSTRACT

The shale sequences between the overlying Marshall sandstone and the underlying Traverse limestone group were investigated along two sections, one approximately east-west across the central part of the basin, and the other, north-south along the western side. Samples from wells spaced about ten miles apart were the basis for the study.

Three major shale units exist, namely, the black or dark brown Antrim, the grey or grey-green Ellsworth, and the grey or blue-grey Coldwater.

Evidence was found for the following conclusions. First, the Antrim thins out noticeably from east to west and the upper two-thirds interfingers with the lower half of the Ellsworth. Second, the Ellsworth is confined to the western counties and is almost uniform in thickness. Third, a wedgelike extension of the "Berea" sandstone occurs on the eastern side of the basin. It is thickest along the line of the section at Saginaw Bay and dies out before the middle of the state is reached. A thin grey shale lens of Coldwater type, in the upper Antrim, has been called the Bedford. The Sunbury, a thin black shale bed, of Antrim type, resting directly upon the "Berea", is

a mapable unit in the eastern counties only.

The conception of tabular formations of wide extent with simple sequent stratigraphic relations must be altered to one in which several type lithologies are found in thousands of interfingering and separate lenses. Altogether the lenses build up a shale series of uniform thickness (ca. 1500 feet thick) but the separate units, each dominantly of an individual lithology, have interfingering lateral relations to each other.

INTRODUCTION

The extent and relationship of the three major shale formations which lie between the top of the Traverse limestone and the bottom of the Marshall sandstone were studied from the cutting of twenty two typical wells. These three formations are the black or dark brown Antrim, the green or gray-green Ellsworth and the gray or blue-gray Coldwater. A wedge of sandstone within the shale section in the eastern side of the basin has been called the Berea.

The cuttings were studied microscopically for their lithology alone, strip logs were prepared and transferred to two diagrams, and strata were joined together in what appeared to be the most probable relationship. In view of the lenticular and inter-fingered nature of the entire sequence, many of the jagged lines, showing interfingering are merely expressive of the writer's conception of the deposit. In general, however, the relations are evident and may be accepted without fossil records.

ANTRIM SHALE

Type locality

The black shales of Michigan which bear the name to-day of Antrim, were first cited in a report by

Douglass³ in 1841, to occur on Sulphur Island in

³ Douglass, C. C., "Report." Fourth Ann. Rep. State Geol. Mich., Senate No. 16 (1841)p. 105.

Lake Huron, on the shore of the mainland south of this island, on the north shore of Pine (Charlevoix) Lake, in Charlevoix Co. and along the coast of Grand Traverse Bay, Lake Michigan. He did not name them but considered them "equivalent to the shales of western New York" which are known to be of Upper Devonian age.

In 1861, Winchell⁴ included the same black shales,

⁴Winchell, Alexander, "Geology, Zoology & Botany of the Lower Peninsula." First Bien. Rep. Progr. Geol. Surv. Mich. Pt. 1, (1861)pp. 71-80.

an overlying green shale, and a fine-grained, somewhat argillaceous sandstone and gritstone in his Huron group. He correlated this group with the Portage group of New York.

However, Rominger⁵, in 1876, believed that the name

⁵Rominger, Carl. Geology of Lower Peninsula. Geol. Surv. Mich., Vol. III, Pt. 1, (1876)pp. 64-65.

Huron should be applied only to the basal black shale in Winchell's Huron group because the strata overlying these shales contain fossils present in the Cuyahoga shale of Ohio, regarded as being of Mississippian age by Ohio geologists and Winchell. He correlated the shales with the Genesee of New York since he thought the shales in Michigan rested directly on the beds of the Hamilton group.

Wright⁶, in notes edited by Lane in 1895, applied

⁶Wright, C. E., "The Geology of Lower Michigan". Geol. Surv. Mich., Vol. V. Pt. II, (1895)p. 21.

the name St. Clair to the black shale and higher strata which were identified with the Ohio, Erie, Cleveland and Bedford shales.

Lane⁷, in 1901, proposed to substitute the name Antrim for the name St. Clair because the latter name

⁷Lane, A. C., Michigan Miner. Vol. 30, No. 10, (1901)p. 9.

was preoccupied. He did not specify any definite type locality for the Antrim shale but stated "that on account of the exposures of shale which occur ... along the coast of Grand Traverse Bay, T. 32 N., as

described in the 1841 report, (footnote ³) I have suggested Antrim, the name of the county in which the exposures last mentioned occur.''

Morse⁸ suggests that the place which exhibits

⁸Morse, M., unpublished manuscript

the exposures noted by Lane, is located about 1 mile south of Norwood, Charlevoix Co., along the southwest boundary of Sec. 2, T. 32 N., R. 9 W., Antrim Co.

Lithology

Newcombe⁹ describes the Antrim as essentially

⁹Newcombe, R. B., Oil & Gas Fields of Michigan, Mich. Geol. Surv. Pub. 38, Geol. Ser. 32. (1933)p. 47.

brown to black to dark gray bituminous shale with many concretions concentrated in a zone near the base. The writer's observations agree with these, and the following details may be added. The beds near the bottom are black shale with occasional lenses of light grey shale or limestone. The beds are uniformly black in the middle of the formation, becoming lighter towards the top.

Devonian fossils have been found in the upper part.¹⁰

¹⁰Morse, M. unpublished manuscript.

Relation to the Traverse group.

The Antrim black shale is separated from the true Traverse formation by a transitional zone consisting of lenses of limestone, dolomite and black, red and green shale. There is a distinctive brown dolomite layer which varies in thickness from 5 to 10 feet, in the transitional zone. As it was found in each well studied by the writer, it was indicated on Figures 1 and 2 as a continuous layer. As typical Antrim black shale does not occur below this dolomite layer, it is suggested that this may mark the break between the Traverse and Antrim formations.

Horizontal and vertical distribution

The thickness of the formation varies from 100 to 450 feet with the greatest thickness occurring on the eastern side of the state. Figure 1 shows that the Antrim thins out to the west (wells 5 and 6) and interfingers with the green or grey Ellsworth shale. The thickness of the formation from Saginaw Bay southwestward for 50 miles is about 400 feet but only the lower 150 feet continue to the western part of the

the state. Along the western side and towards the southwestern corner of the state the much thinned black shale is under the Ellsworth except for minor transitional lenses. The color becomes more uniformly black to the east.

ELLSWORTH SHALE

Type locality

The blue and light gray shales above the Antrim were first described, in 1855, by Douglass¹¹ from an

¹¹Douglass, C. C. , Rocks of Michigan. Trans. of State Agri. Soc. Vol. VI, (1855) p. 299.

outcrop on Grand Traverse Bay, in T. 31 N.

Later, in 1861, Winchell ¹² described similar beds

¹²Winchell, op. cit. p. 72.

on the east shore of Grand Traverse Bay, nearly opposite the north end of Torch Light Lake. This description was made at the same outcrop as Douglass found.

In 1933, Newcombe¹³ proposed the name Ellsworth

¹³Newcombe, op. cit. p. 49.

for these shales and named the exposure one and one-half miles south of Ellsworth, in the Petoskey Portland Cement Company quarry, where there is a ledge of 30 to 40 feet of greenish grey shale, as the type section. This location is in Sec. 26, T. 32 N., R. 8 W., Banks Township, Antrim County. According to Newcombe, the Ellsworth is probably of upper Devonian age, nearly equivalent to the Bedford shale of Ohio. Both Ehlers¹⁴ and Bishop¹⁵ believe that the major break

¹⁴Ehlers, G. M. oral communication.

¹⁵Bishop, M. S. "Isopachous Studies in Michigan" A.A.P.G. Bul. Vol. 24, No. 12. (1940)p.2153.

between the Devonian and Mississippian did not occur within this shale series. A correlation of this partial section with the entire section in the log of the first well to the south has been indicated on Figure 2, Location 23, and on the Index Map of Michigan, Figure 3.

Lithology

The Ellsworth shale is a grey-green or grey shale with many red shale, limestone and dolomite lenses, which make up, however, a small part of the formation.

It is soft to medium hard and somewhat claylike.

Vertical and horizontal distribution

The total thickness of the strata has been estimated by Newcombe¹⁶ to be between 500 and 600

¹⁶Ibid., ad loc.

feet in the western part of the state. In the wells studied by the writer, the thickness ranged from 400 to 500 feet. The formation as shown in Figures 1 and 3 is, in the lower part, equivalent to the upper part of the Antrim, and in the upper part equivalent to the lower part of the Coldwater. The term equivalent is used here to indicate thickness of sedimentation not to indicate time intervals. Lenses of "Ellsworth type" occur commonly throughout the Antrim and Coldwater shales.

"BEREA" SANDSTONE

Type locality

The Berea sandstone has never been observed in outcrop in Michigan but a sandstone of "Berea type" has been traced in well-cuttings along the eastern side of the state. It has been correlated with outcrops in Ohio, West Virginia and Pennsylvania.

The type locality is Berea, Cuyahoga County, Ohio. It was formerly called, in Michigan, the Richmondville sandstone as it was said by Wright¹⁷ to outcrop at

¹⁷Wright. op. cit. p. 21.

Richmondville, on Lake Huron. Rominger¹⁸ first

¹⁸Ibid., p. 23.

identified 92 feet of the "Berea" in a well dug at the Ann Arbor Courthouse in 1871. Lane¹⁹ interpreted

¹⁹Russell, I. C., and Leverett, F., "Ann Arbor Folio, Michigan". U. S. G. S. (1907)p. 4.

120 feet in a well dug on the campus of the University of Michigan in 1899, as "Berea", although only 15 feet of this was actually sandstone.

Lithology

The "Berea" is a fine-grained, micaceous sandstone. The color is either grey or yellow or brown depending on the amount of disseminated pyrite grains in it and the amount of weathering. The quartz grains

are angular and uniform in size. Grey shale often separates the sandstone layers. The "'Berea'" formed the third salt horizon in early geologic reports of the state.²⁰ The salt wells of Tawas, Oscoda and

²⁰A. C. Lane as reported by M. E. Wadsworth, Mich. Geol. Surv. Rept. Vol. V. , part 2.(1881-93)p. 20.

Huron obtained their salt from it.

Relation to Antrim, Bedford and Sunbury formations

In the area where the "'Berea'" is found, it lies upon the Antrim shale. A thin grey shale underlying the "'Berea'" has been called the Bedford shale by some geologists but by most has been included in the Antrim formation. A black or dark grey, pyritiferous shale that rests directly upon the "'Berea'" has been called the Sunbury and in the eastern counties forms a mapable unit. In western Michigan, it occurs merely as a lens within the Ellsworth. Correlation of these shales with the type formations after which they have been provisionally named has not been confirmed by paleontologic study.

Horizontal and vertical distribution

The "'Berea'" has been found only in the eastern counties, especially in the Thumb region. It thins

out rapidly to the west and disappears in Gratiot County, (Figure 1). It ranges in thickness from 10 to 150 feet.

COLDWATER SHALE

Type locality

The Coldwater shale was named in 1893 by Lane²¹

²¹Ibid., p. 19.

for outcrops in Branch County, along the Coldwater River. Outcrops are also found in Hillsdale County.

Lithology

Lane stated that the Coldwater shale "consisted of light colored, greenish or bluish, sometimes darker, shales, growing sandier toward the top and gradually passing into the Marshall ...may have occasional bands of limestone". More recent studies have noted the existence of several distinctive layers or lenses. The "Redrock" or red shale of the formation, in the western part of the state is found at or near the base. This bed is extremely limy and changes in some localities into a shaly limestone.²² Hale²³ describes this layer

²²Newcombe., op. cit., p. 54.

²³Hale, L., Abstract. "A Study of the Sedimentation and Stratigraphy of the Lower Mississippian in Western Michigan." Program A.A.P.G. Chicago, 1940.

as being "a fossiliferous limestone rather than a shale; several very fossiliferous zones rich in crinoids, ostracods and bryozoans with some brachiopods, gastropods, cephalopods, and pelecypods appear quite consistently." In Kent and Ottawa Counties, the "Redrock" is underlain by a thin layer of limestone that contains oolites. Lenses of limestone, dolomite, red and green shale are common throughout the Coldwater formation. On the east side of the state, there are several lenses of sandstone of the same texture and color as that of the "Berea" formation below.

Lane, upon naming the Coldwater formation, placed it in Winchell's Huron group, which Winchell, in 1861, placed in the Mississippian and designated all strata lying between the top of the Traverse limestone and the bottom of the Marshall sandstone as belonging to it.

Relation to underlying formations

The bottom of the Coldwater rests on the black Sunbury shale, if present, and on the "Berea" (well 9) sandstone in the eastern counties, and mostly upon the Ellsworth shale in the western counties.

Horizontal and vertical distribution

According to Lane²⁴ the vertical limits of the

²⁴Lane., op. cit., p. 20.

Coldwater shale were set at the top, by the brine-bearing sandstone, the Marshall, and at the bottom, by the brine-bearing sandstone of Port Arthur and Oscoda, the "'Berea'". The horizontal distribution is state-wide. It ranges in thickness from approximately 400 feet in Allegan County to 1000 feet in the center of the basin.

CORRELATIONS

In Figure 3, the composite correlation diagram, an attempt has been made to show, in three dimensions, the position of the wells studied and the relation of the strata to each other. The conception of tabular formations of wide extent with simple sequent stratigraphic relations must be altered to one in which several type lithologies are found in thousands of interfingering and separate lenses. Altogether the lenses build up a shale series of uniform thickness (ca. 1500 feet thick) but the separate units, each dominantly of an individual lithology, have interfingering lateral relations to each other. The great mass of grey shales, dominantly of Coldwater type, is entirely younger than the Antrim but the Ellsworth must be considered in part equivalent to the lower part of the Coldwater of the eastern counties, and in part equivalent to the upper part of the Antrim, also

of the eastern counties. A large body of grey shale of "Coldwater type" in Kent County, is equivalent to the upper part of the Antrim and is actually below some Ellsworth type beds, but equivalent to other parts of the Ellsworth.

The problem of source, sedimentary environment, and type and growth of deposits are too speculative to be discussed profitably by the writer, with the information at hand.

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10-3N-15W
1

5-5N-14W
2

27-7N-13W
3

10-9N-11W
4

29-9N-10W
5

31-10N-7W
6

29-10N-6W
7

2-10N-5W
8

2-10N-5W
9

17-11N-2W
10

1-12N-1W
11

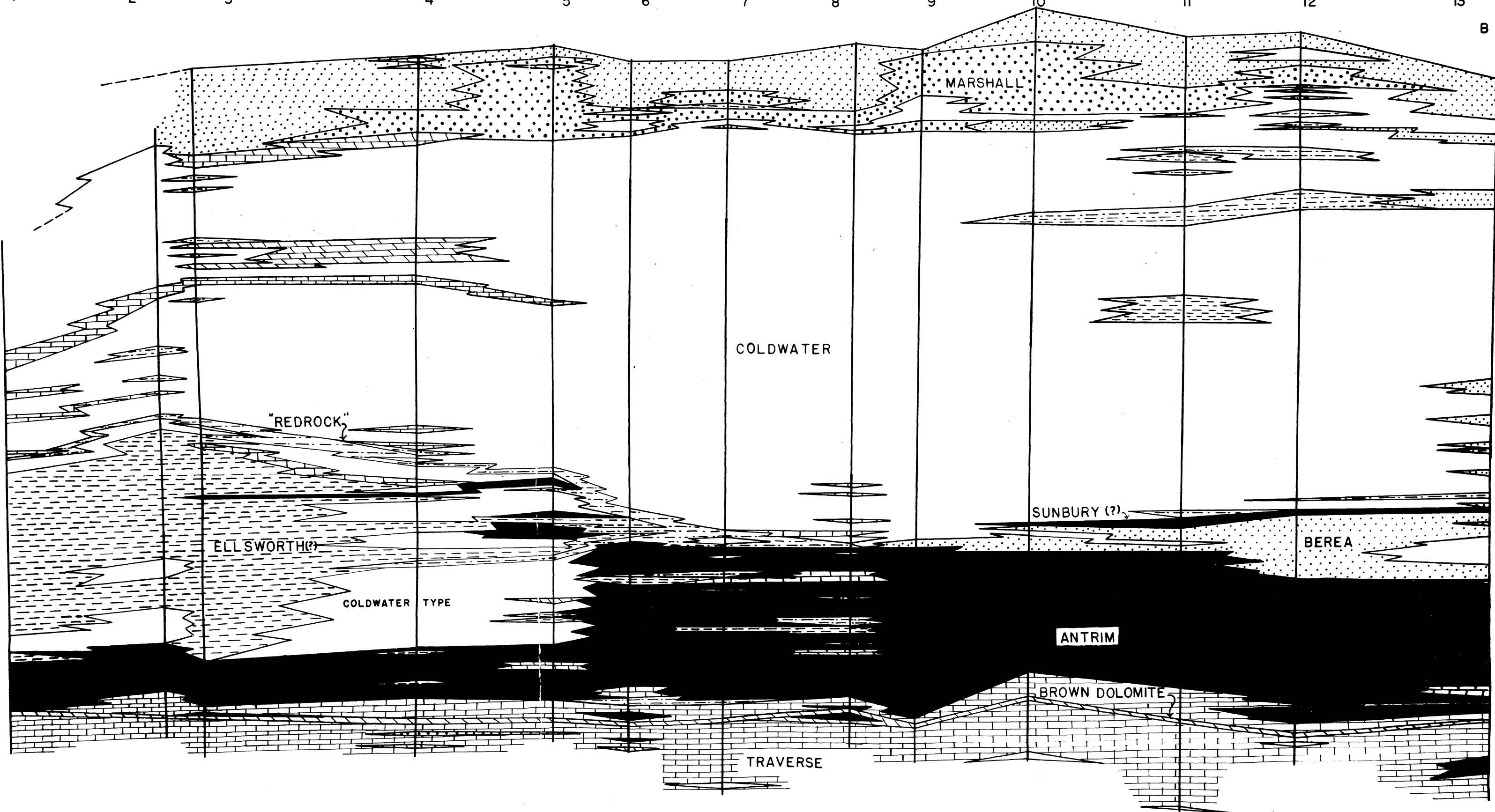
9-13N-2E
12

1-14N-4E
13

A

B

HUNDREDS OF FEET THICK



-  SHALE, RED
-  SHALE, GREEN
-  SHALE, GRAY
-  SHALE, BLACK
-  LIMESTONE
-  DOLOMITE
-  SANDSTONE, RED
-  SANDSTONE, GRAY
-  GYPSUM

29-IN-13W
14

22-4N-12W
15

6-5N-12W
16

27-7N-13W
3

32-8N-13W
17

5-12N-12W
18

7-16N-11W
19

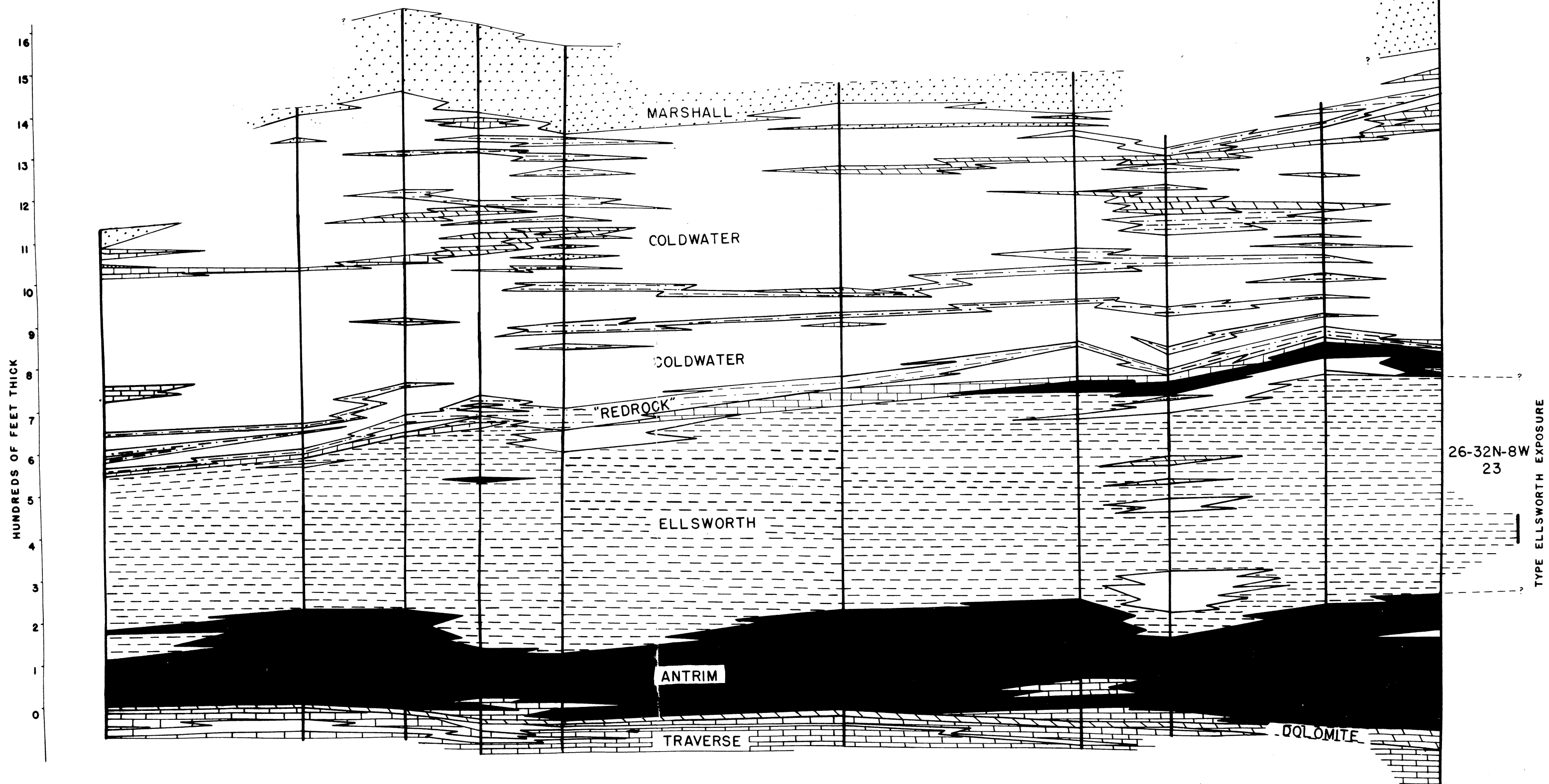
25-18N-12W
20

11-20N-11W
21

17-22N-9W
22

C

D



-  SHALE, RED
-  SHALE, GREEN
-  SHALE, GRAY
-  SHALE, BLACK
-  LIMESTONE
-  DOLOMITE
-  SANDSTONE, GRAY

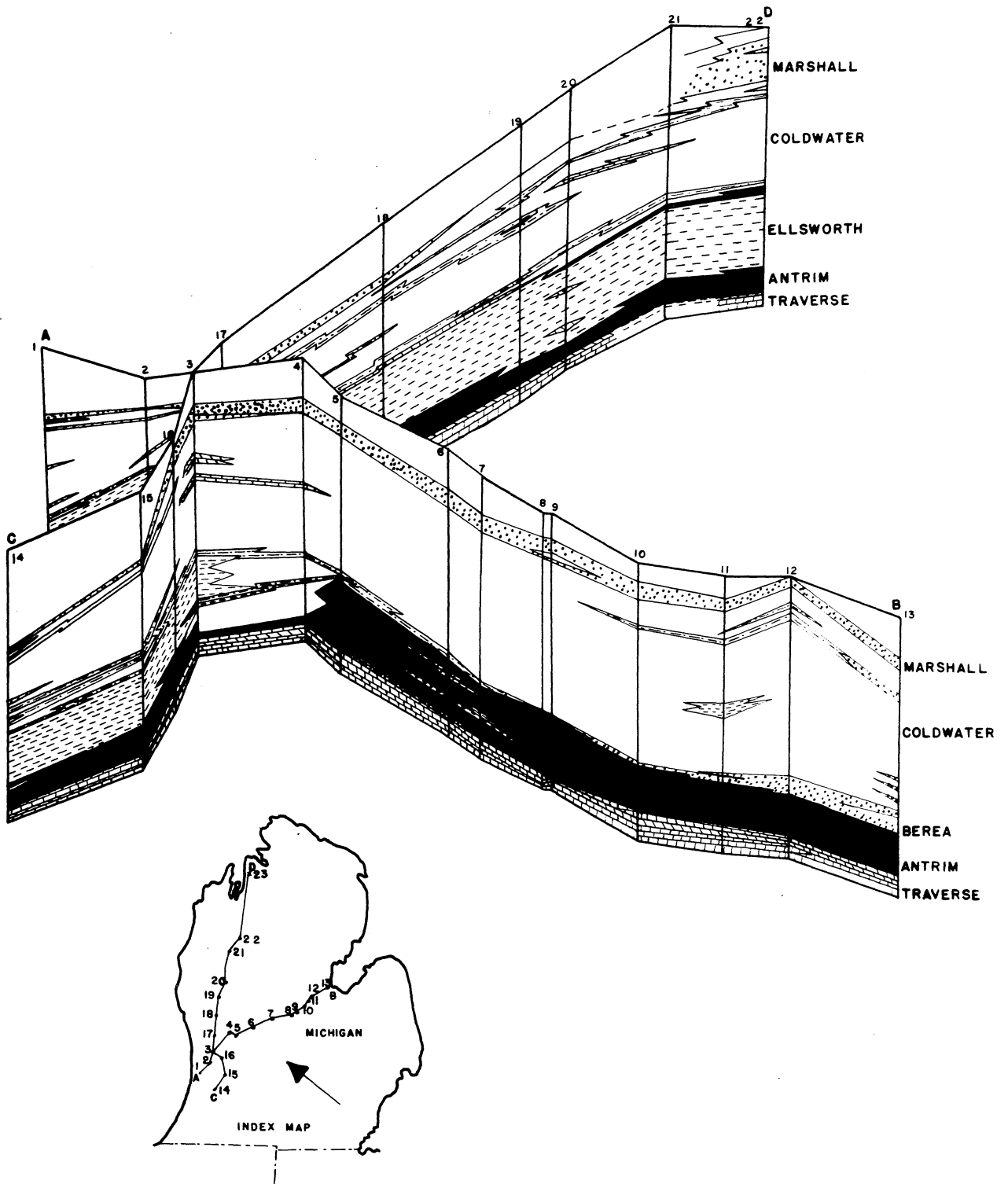
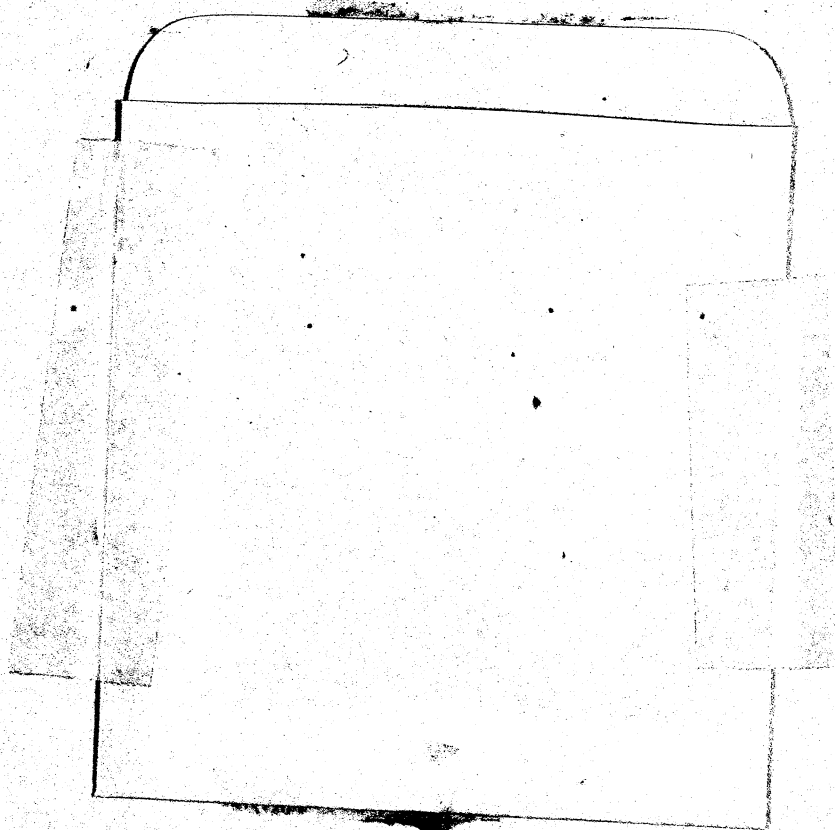


Figure 3.

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