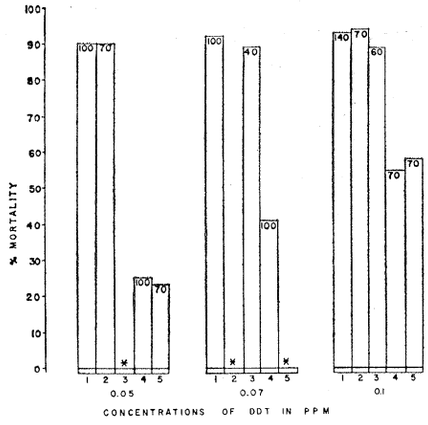

Fig. 1. Mortality of mosquito fish maintained 72 hours in three concentrations of DDT. Bars 1, 2, and 3 represent fish from untreated areas; bars 4 and 5 denote fish collected near treated cotton fields. Size of sample for each test is the number near the top of each bar. The asterisks indicate no specimens.

common among insects, was only recently demonstrated in vertebrates when Boyd, Vinson, and Ferguson (*3*) showed that two species of cricket frogs (*Acris*) were resistant. During that study, mosquito fish were occasionally found in pools and ditches completely surrounded by cotton fields that were heavily treated with chlorinated hydrocarbon insecticides, especially DDT. Insecticides were certain to have contaminated these places by intentional application, drift, drainage, or some combination of these methods of entry. Survival of mosquito fish in these adverse environments strongly suggested possible resistance to DDT.

In the present study, DDT susceptibility of fish from localities with a past history of exposure to DDT is compared with that of fish from previously untreated areas. Mosquito fish were collected from two treated sites, drained separately, near Sidon, Leflore County, Mississippi. Collections of fish from untreated areas were obtained from ponds near State College and 6 miles north of Starkville (Oktibbeha Co.), and near Aberdeen (Monroe Co.). After preliminary studies to establish the concentrations of DDT to be used, 1175 fish were tested; of these 185 were controls (110 from treated and 75 from untreated areas). The numbers of fish tested at each concentration are shown near the top of each bar in the graph (Fig. 1). Fish used in experiments ranged between 20 to 25 mm in length, and males outnumbered females three to one.

The DDT (*4*) was recrystallized from ethanol, weighed, and dissolved in acetone (reagent grade) to obtain a 0.1 percent solution. This was diluted in acetone to give 0.01, 0.007, and 0.005 percent solutions. One milliliter of each dilution was pipetted into a liter of water, so that the concentrations of the DDT in water were 0.1, 0.07, and 0.05 ppm. The liter of test solution was divided into 500-ml portions and placed in quart jars, and five fish from a single location were placed in each jar. An identical procedure with acetone only was followed for the control fish. All fish were maintained in the laboratory for 24 hours before they were tested. Mortality was recorded at 12-hour intervals for 72 hours. The room temperatures remained fairly constant throughout the experiments.

In Fig. 1 the percentage mortality is shown for each concentration of toxicant for all fish tested. The losses of fish for untreated areas (bars 1, 2, and 3) are strikingly higher than those of fish from the treated areas. Nearly identical mortalities occurred among populations that had similar past histories of exposure to insecticides. Thus, data on killing for the two treated collecting sites were similar, and those for the three untreated sites were also nearly identical.

The percentage mortality at each concentration for all treated and untreated areas was compared by means of chi-square tests at the level of 5 percent significance. All of the comparisons of differences in mortality between every possible combination of the treated with the untreated areas proved to be significant.

Differential mortality with respect to sex was not evident. The mortality among control animals was 10 percent from treated and 9.4 percent from untreated areas. The fact that fish were not fed during testing, the presence of acetone, or a change in environment may have produced these relatively high values.

The foregoing experiments indicate a resistance to DDT in mosquito fish bred in areas that have a long history of insecticide applications. The possible mechanism for development of resistance through selective pressure of insecticide and differential mortality in fish populations is implied in many field observations. For example, in a recent list of 75 cases of fish killed ostensibly because of agricultural poisons, there were only 12 cases where all fish present were killed (*5*). If surviving fish in the other 63 cases are assumed to have genotypes that conferred a resistance to the toxicant, one could easily imagine that a genetically resistant population might result from periodic applications of insecticide (*6*).

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27 November 1962

Illinoian and Wisconsin (Farmdale) Drifts Recently Exposed at Rockford, Illinois

Abstract. *New exposures in Rockford, Illinois, show fresh till overlying ferruginous gravel of marginal glacial origin. These, together with older sections, now slumped or no longer exposed, offer convincing evidence of two glaciations of the Rockford area, the first of Illinoian age and the second of early Wisconsin (Farmdale) age. The sections further suggest that the greater part of the drift fill in Ancient Rock River Valley is Illinoian, and that this is overlain by a relatively thin mantle of Farmdale drift.*

New exposures in the eastern part of Rockford, Illinois, show superposition of two glacial drifts of different ages, the lower one Illinoian in age, the upper one Wisconsin (Farmdale). They occur along the west and south sides of the Spartan Store (SW¼ NW¼ NW¼ section 29, township 44N, range 2E) (Fig. 1). The cuts are 500 feet south of U.S. route 20.

The two cuts afford a three-dimensional view. On the west side of the store the face is about 150 feet long and 25 feet high. As shown in Fig. 2, Farmdale till, grayish in color, overlies

Illinoian ferruginous gravels. At the northern (right) end the Farmdale till is thin, only 2½ to 4 feet thick, while the Illinoian gravels are exposed for 20 feet to the bottom of the cut. The till-gravel contact is sharp at this high point; from this point it slopes to the south (left) without change in surface contour, the till increasing in thickness to some 15 feet and the gravel becoming correspondingly thinner. The basal 1 foot of the thin till is calcareous, as are also the gravels, which contain limestones and dolomites throughout. This and the sharp contact make it obvious that most of the weathered zone of the old gravels was cut off by the overriding ice sheet.

The striking contrast in color of the ferruginous gravels and the gray till is visible from nearly a block away. The rusty brown color results from the coating of ferric oxide on the pebbles, the iron having originated from the development of a once existent weathered zone. That the iron oxide could not have come from the overlying Farmdale till is clear from its thinness, its gray color, and its freshness. The gravels also contain scattered segregations of manganese dioxide, which is also the product of the former weathering.

The percentage of pebbles and cobbles in the gravels is high, and there are some boulders nearly 2 feet in diameter (Fig. 3). Most of the constituents are angular-to-subangular, though some are waterworn. Of the latter, an occasional one is soled and striated, suggesting that the rounding took place at an earlier time. The gravels are unmistakably ice-marginal.

The sloping contact between the till and the gravel to the south may conceivably be a modified pre-Farmdale slope of erosion, for on the south side of the store the east-west cut shows a succession of grayish sands and gravels, 6 or 8 feet thick, and till 10 or 12 feet thick; both are Farmdale, lying above the ferruginous gravels.

Leverett and Hershey (*1*) held that there had been two glaciations, the first "probable" Illinoian, the second Iowan. At that time the Iowan was erroneously considered a separate glacial stage preceding the Wisconsin stage and separated from it by the Peorian Interglacial. Later, Alden (*2*) thought that there had been probably only one glaciation, the Illinoian. Leighton agreed with Alden until it became clear, in 1947 (*3*), that the Farmdale loess records an early glacial substage of the Wisconsin. In 1953 (*4*) he raised the question of the

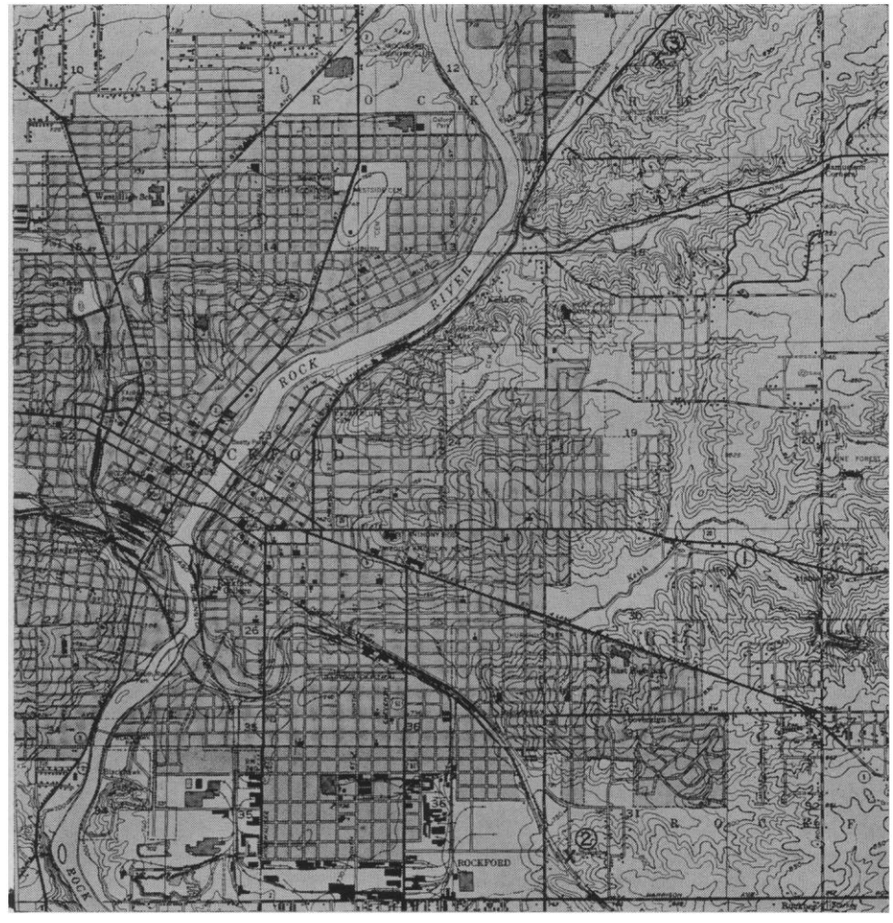


Fig. 1. Portion of topographic map of Rockford, Illinois. (1) Station 1, location of the new exposure; (2) station 2, location of Bretz's ferruginous gravels; (3) station 3, location of Leighton's tilted ledge of ferruginous conglomerate surrounded by Farmdale till.

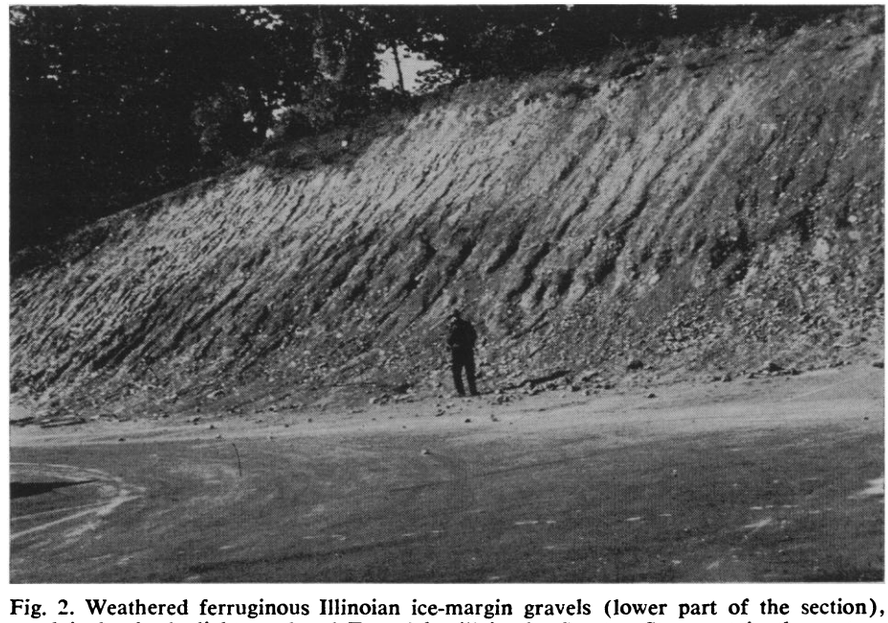
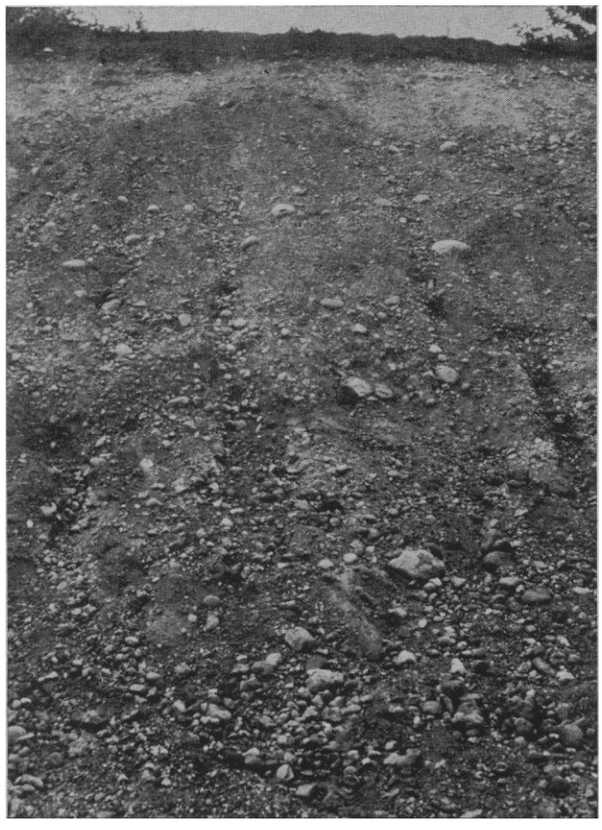


Fig. 2. Weathered ferruginous Illinoian ice-margin gravels (lower part of the section), overlain by fresh, lighter-colored Farmdale till in the Spartan Store cut in the eastern part of Rockford, Illinois.



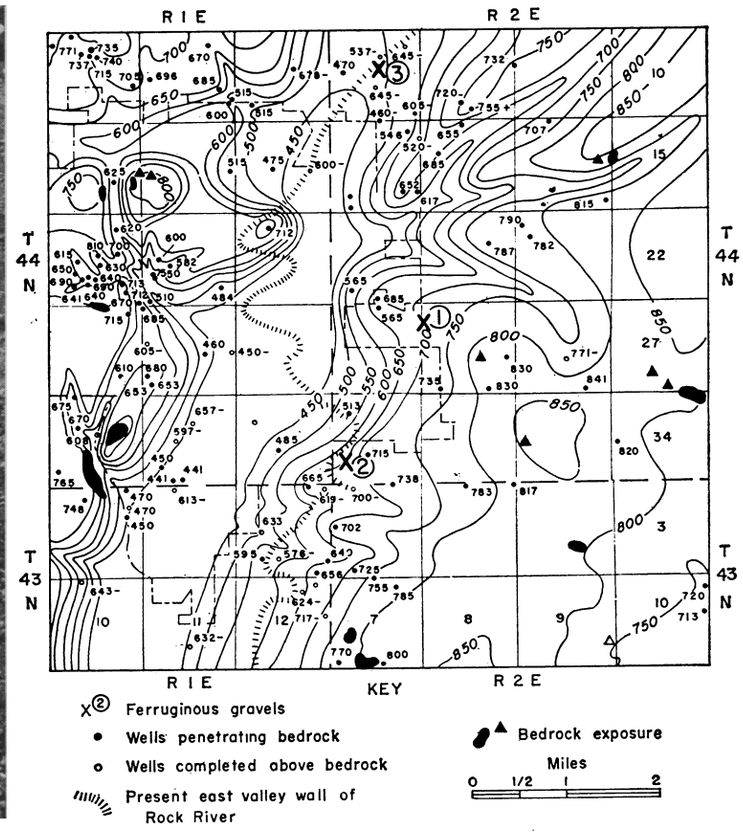


Fig. 3 (left). Close-up view of the bouldery Illinoian gravel and the thin overlying Farmdale till. (Fig. 4 (right). Topography of bedrock surface in the vicinity of Rockford, Illinois, showing Ancient Rock River. [After Hackett (*8*)]

Farmdale age of the surface drift in Boone and Winnebago counties. Paul R. Shaffer pursued the study, and in 1954 (*5*) he reported clear evidence of Farmdale drift. In his report of 1956 (*6*) he assigned all of the drift as far west as the Driftless Area to the Farmdale Substage. In the latter report (*6*, p. 11) he stated, "there is no established evidence, from exposures, of Illinoian till in northern Illinois within 45 miles of Wisconsin." We have taken exception to this view (*7*), holding that both the Farmdale drift and the Illinoian drift are present in the Pecatonica lobe discussed by Leverett (*1*, plate 12). The new exposure confirms our view.

We believe that Rock River Valley has had a more complex history than that recently set forth by Hackett (*8*). As shown in his Fig. 7 and on pages 31 and 33 of his text, Hackett believed that the great fill in the valley of the Ancient Rock, which lies in large part east of the present Rock River Valley (Fig. 4), is predominantly Farmdale gravel and till. But it appears now that the fill is largely Illinoian, because of the high elevation of the Illinoian gravels at station 1, nearly 800 feet above tide, and at station 2, 780 feet. The ferruginous gravels at station 1 are nearly 100 feet above the old bedrock valley slope (Fig. 4), fully three-fourths of the way up to the old upland. The overlying Farmdale till here is at most only 15 feet thick.

At station 2 there are partially cemented ferruginous gravels, described by Bretz (*9*), which lie more than halfway up the old valley wall, and the intervening fill is 140 feet thick. Here the Farmdale till may be somewhat thicker than 15 feet. If the high level of the dissected Illinoian surface is maintained for three-fourths of a mile northwest of station 1 to a point where the Farmdale surface is at an elevation of 810 to 820 feet, the Farmdale unit can scarcely exceed 25 feet.

This thinness is consistent with other evidence that records the brevity of the Farmdale glacial substage. Logs of wells northwest of station 1, where the valley fill is thicker, show that the fill is composed partly of till and partly of gravel.

It is likely that it was the Illinoian fill in the Ancient Rock that diverted the drainage to the westward beyond the old valley, onto high bedrock, where the new Rock became superimposed on bedrock 250 feet or more above the old floor. Such a diversion would match in time the striking diversion, by the Illinoian glacier, of Rock River downstream for many miles below Stillman Valley. During the long Sangamon Interglacial there was much weathering of the fill, but dissection of the fill was limited by the relatively high position of the stream on rock which it eroded to about 650 feet above tide. In view of the situation at both stations 1 and 2, it seems probable that the summit of the Illinoian gravel originally approached 800 feet before it was lowered by Sangamon weathering and erosion and later by the Farmdale glacier. The apparent lack of weathering zones in well records may be due to Farmdale glacial and glaciofluvial erosion. It is upon this surface, then, that the Farmdale drift lies as a relatively thin mantle.

Bretz (*9*) first called attention to the occurrence of old ferruginous glacial gravels, beneath fresh till, in a large abandoned gravel pit, east of the tracks of the Chicago and Northwestern Railway (NW¼ SW¼ SW¼ sec. 31, T. 44N, R. 2E). At that time the overlying till was regarded as Illinoian, but it is now known to be Farmdale. This location is less than 2 miles south by south-

west of the new exposure at station No. 1, and the gravel-till contact is estimated, from the large-scale topographic map, to be about 780 feet above tide. This is about 130 feet above the stream bed of Sangamon times—a fact which explains the well-drained profile that is so colorful.

In 1920 one of us (M.M.L.) observed and described in notes a nearly vertical ledge of ferruginous glacial conglomerate in an abandoned gravel pit in the east valley wall of the present Rock River (SE¼ NW¼ NW¼ sec. 7, T. 44N, R. 2E) about 4½ miles north of the pit described by Bretz. As exposed, this ledge was 10 feet high and 7 to 8 feet thick, the lower part being surrounded by fresh Farmdale till. One 3-foot bed was so firmly cemented that when it was struck with the hammer the fracture went through the pebbles rather than around them. Clearly the cementation took place prior to the Farmdale glacial invasion, with cement that resulted from the weathering of the gravel. The elevation of the ledge is estimated roughly at 750 feet.

Also in 1920, in a new western addition to Rockford, a basement excavation for a house and a nearby open cistern were observed which showed 1 to 1½ feet of reddish sand and gravel beneath 2½ to 3¾ feet of partly weathered till and 4½ feet of weathered loess. The till, now known to be Farmdale, contained a 3-inch lens of the older reddish sand. The driller of a well 12 feet away had just struck rock at 23½ feet; he reported that the red sand and gravel is 4 feet thick and that a "grayish pebbly hardpan" lies beneath; this might well be Illinoian till.

Almost equally significant was the finding of fragments of ferruginous glacial conglomerate on the surface of an esker 3½ miles west of Rock River in the north half of section 21, township 45N, range 1E, and on a knoll at the center of the east line of section 32, township 45N, range 1E.

These phenomena, each striking in itself, show conclusively that the Rockford area was glaciated twice, once by the Illinoian and later by the Farmdale. We have already shown (*7*) that the Farmdale drift sheet extends west to Freeport and that the Illinoian drift extends to the Driftless Area.

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18 JANUARY 1963

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23 November 1962

Ependymal Cilia: Distribution and Activity in the Adult Human Brain

Abstract. *Examination of 150 to 200 samples of the ependymal lining of the ventricles of nine adult human brains obtained 2½ to 6 hours post-mortem revealed cilia in at least 20 separate sites in the four ventricular cavities. In seven of the brains ciliary motion was evident, and in two of these it was widespread and rapid. It seems likely that the adult human ventricular ependyma is ciliated throughout. Currents having distinct patterns are induced in the ventricles of animal brains by ciliary motion, and such currents probably exist in man. A local mechanism for the rapid movement of cerebrospinal fluid is therefore present.*

Little consideration has been given to the ciliated ependymal cells in man in recent years although the literature before 1900 contains numerous references to them (*1*). Most of the earlier accounts refer only to ciliated ependymal cells in human embryos, although the first description of them by Valentin (*1*) describes them in the adult. Modern textbooks generally refer only to "patches" of cilia in the adult human (if they are mentioned at all) but recognize a fully ciliated ependyma in the human embryo. Crosby, Humphrey, and Lauer (*2*) do acknowledge that "it is not rare" to find such patches at various stages after birth. It is, however, implicit in the brevity of these modern accounts that the matter is of little consequence.

Since experience in our laboratory and the accounts of Stoklasa (*3*), Chu (*4*), and others indicated to us that there is a widespread occurrence of cilia in the ventricular systems of many species, a fundamental difference in primates, including man, seemed unlikely. An investigation of the distribution of ciliated cells in the ependyma of man was therefore undertaken. Nine adult human brains were obtained at autopsy and examined from 2½ to 6 hours after death. They were immersed in mammalian Ringer's solution as soon as practicable after removal. Small pieces of ependyma were removed by curved corneal scissors held parallel to the ependymal surface in order to obtain a specimen with a thin edge; these specimens were then examined in the fresh state with water immersion lenses.

In the nine brains examined within this time period cilia were found in numerous places in each of the four ventricular cavities and were always present in any given area selected for examination. In seven of the brains, cilia which were still beating were found at one or more sites, and in the two best specimens of the series cilia which were still beating with a rapid and uniform motion were found in at least 10 separate areas in each brain. (Motion pictures of ciliary movement in the human brain were taken.)

Correlations between quality of preparation on the one hand and elapsed time after death or cause of death on the other are difficult to make in this short series. However, the two brains in which ciliary motion was uniform, widespread, and rapid were from cases of sudden, accidental death in individuals without known disease. They were examined 2½ and 3 hours after death. Moreover, the ependymal cilia from a patient with hepatic cirrhosis showed no movement when examined 3½ hours after death. With the exception of one case of drowning, the remaining cases were from patients with chronic systemic disease. These observations suggest that severe systemic disease may be a more important factor in disturbing ciliary activity in supravital preparations of human ependymal cilia than elapsed time after death. However, we have no experience with long periods of elapsed time after death in cases of sudden accident in healthy individuals.

Cilia have been found in the following sites in one or more of the brains examined, and in most instances, in all of them: floor of the rhomboid fossa in several different places, obex, ven-