George Hall

GUIDE TO THE TISAG EXCURSION

ON WEDNESDAY, SEPTEMBER 9, 1981

TO SOUTH CENTRAL OHIO TO SEE

THE GHOST OF GLACIERS PAST, AND INDIANS NOT-SO-LONG-GONE!

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OVERVIEW

Because there are no real glaciers in Ohio, we take you instead on a tour as far as Chillicothe, 80 km south of Columbus, which is the southern limit of the last (Wisconsin) glaciation. We shall "reconstruct" this last glaciation, both en route and at a number of selected stops. We shall concentrate on the glacial processes that have made these youngest deposits and surface features, but we should remember that there is also a long Quaternary (Pleistocene and Holocene) history, part of which is buried in the glacial layers here.

To summarize: the ice from the north expanded as far south as Columbus at least five times during the Pleistocene, with long "interglacials" when the ice retreated into upper Canada, or completely disappeared, as it has now. The periods of retreat were rather short and the periods of advance were long ($15{,}000^{+}$ years). In Central Ohio, where we are near the outer limits of the ice sheet, the time between burial under ice and re-emergence was at least 8,000 years. The next-to-last glaciation, 50,000 - 60,000 years ago (early Wisconsin-Altonian) reached only as far south as Columbus. Goodness knows how many more times during the cool periods in the previous two million years the ice advanced almost to Lake Erie, but not as far as mid-Ohio.

Age of climax approx. yrs. B.P.	Common U.S. names	Furthest south in Ohio-Kentucky	Nature of evidence
17,000-21,300	Wisconsin	39-1/4°N Chillicothe, Ohio	Shingle-like multi-layered tills
50,000-60,000	Middle Wisconsin	40°N Columbus, Ohio	Underlying till sheet in places
125,000-130,000	Illinoian	38-3/4°N Cincinnati, Ohio	Patches of till under Wisconsin continuous beyond Wisconsin
700,000+	"Kansan"	38-3/4°N Florence, Kentucky	Rare patches under Illinoian: exposed n Cincinnati airport
1,000,000+	"Nebraskan"?	38°N Lexington, Kentucky?	Scattered large "Cana boulders

All these ice invasions covered the spectacular earlier (Pliocene) valley system which was cut 70 to 150 m deep into dolostone and limestone (Silurian to Devonian) bedrock. Before the first stop we cross this main buried "Teays" Valley without being able to see it. The floor of the Teays Valley slopes northwestward and loops across northern Indiana to join the ancient Mississippi. Beyond the glacial borders, just after lunch, we'll see an exposed part of this old Teays Valley in the hills of shale and sandstone which constitute the Appalachian Low Plateau. There the valley is only partly filled with Illinoian glacial outwash. You will see that the slope of the present rivers in mid-Ohio is almost opposite to this Teays drainage; they now flow south.

It is remarkable that at least three times the ice sheet's southward expansion stopped very close to the same place, the topographic barrier formed by the 100 to 120 m broken escarpment of hills known as the Appalachian Low Plateau. The last Wisconsin-age ice built high hummocky moraine against these hills and forced 1 to 3 km-long "noses" of ice down broad old valleys. Illinoian ice had more "umph", inundating the outer hills and leaving till in valleys 3 to 17 km south or southeast of the escarpment. We'll follow it in the afternoon.

In the Columbus-Chillicothe area we are in the southeast part of the Scioto Lobe of the last glaciation (and also in the southeast part of the Cincinnati Lobe of the Illinoian glaciation) which suggests that the ice was deepest and flowed fastest down the broad depression of the Scioto River. Only on relatively flat terrain could the ice spread out in such a smooth lobe.

South of Columbus, however, the ice veered off to the southwest to reach 60 km west into Greene County, making a lopsided lobe. Apparently it was pushed aside (west) by the barrier of the escarpment hills. Seventy km north of the junction of lobes, there is a high area of bedrock, the "Bellefontaine outlier". With its capping of glacial drift this became the highest point in Ohio (458 m a.s.l.) and divided the lobes neatly. During the retreat of the Wisconsin Ice this interlobate area opened up first (18,000 B.P.) and subsequently some thin ice from the lobes flowed slowly into the interlobate area, leaving striae indicating southwestern movement of the ice.

The Wisconsin ice flowed into Ohio from two directions, from the northeast and from the north. Thousands of stone-counts, some sand-mineral counts and, more recently, strontium-rubidium isotopic ratio studies on feldspar, all show that the invading ice moved over Grenville- and Paleozoic-age rocks in eastern Canada, as well as the Huronian- and Paleozoic-age rocks due north of Lake Huron. These rocks, and the Ohio rocks picked up by the ice, get completely mixed within a kilometer of travel - the till is completely heterogeneous. How is this accomplished over flattish terrain like Ohio? Is it due to to turbulence in the bottom layers of the ice?

In the Scioto Lobe, the margin of the last ice sheet (and presumably those of earlier ones too) remained within 20 km or so of the extreme limit reached by the ice for at least 4,000 years (21,400 to

17,300 B.P.). Presumably the mass balance of large parts of the ice sheet showed only minor variations from equilibrium. In a few places, the oldest outer Wisconsin moraine and till ("Boston"), with logs 21,300 years old, extend beyond the younger tills ("Caesar"). In the Miami Lobe to the west, till of the same age as the Caesar, called Fayette Till, has datable wood and lies entirely under till from the still later small advances.

The principal advances came 20,200 years ago in the western (Miami) lobe and 18,200 years ago in this Scioto lobe. There was one later significant, but minor, readvance of the ice sheet edge to within 10 to 20 km of the outermost Wisconsin boundary. This "recessional moraine", called the Reesville Moraine in the Scioto lobe (at the edge of Darby till), lies on interstadial organic material 17,300 years old. The equivalent moraine in the Miami Lobe is the "Farmersville". Both of these moraine areas are identified by thousands of boulders at the surface and have long been called "boulder belts". 90 to 99% of the boulders are exclusively Canadian bedrock types. (Puzzle: why, at one special period of minor readvance, did the ice transport just boulders from hundreds of kilometers away, with little or none of the other components of till, namely sand, silt and clay?) In both lobes the known overriding of the dated organic material is limited to 40 km, so that the ice was still near its outer limit 17,000 years ago.

This history of the ice sheet is based on carbon-dating of wood buried in the lowest layer of Wisconsin-age till. The ice sheet edge advanced over the north shore of Lake Erie about 25,000 years ago; and then southward at about 100 m per year from Cleveland to Columbus and at about 60 m per year from Columbus to Chillicothe. Undoubtedly it had a very steep or cliffed margin, as <u>advancing</u> edges of the ice sheet do in Greenland today.

Between the outermost moraine complex and Lake Erie there are at least ten more "recessional" moraines. The first Stop of our tour is on the Bloomingburg Moraine. Only two moraines are associated with significant readvances, the Powell Moraine and the Wabash Moraine. By the time they were formed, 14,000 years ago, the ice sheet comprised a lobe (the Erie Lobe) moving down Lake Erie and a second separate lobe advancing from Lake Huron. Because all the moraines are large and lobate in form, we deduce that the surface ice velocities remained high even as the ice edge was retreating northward and that the edge of the ice sheet was probably quite steep during these retreat phases and quite thick even close to the edge. We have calculated that there were at least 800 m of ice over Columbus.

In other parts of the retreating Laurentide Ice Sheet, the edge behaved differently. For example, in Manitoba-Saskatchewan-Alberta the ice stagnated over immense flat areas and readvances of the ice sheet covered part of the already decaying, honeycombed ice. In New England, as the ice sheet thinned the mountains stopped its general movement, so that lens-like masses of ice were left in each basin where they slowly decayed. Each of these modes of deglaciation has its own suite of quite different deposits.

By 13,000 B.P. all of the ice sheet had retreated from Ohio. Thus, between 17,000 and 13,000 B.P., 48,000 km^3 of ice melted. It is probable that at least 10 km^3 of meltwater, on average, was added to the annual precipitation of that time (which probably was as heavy as today, about 1 m), more than doubling the runoff. In addition, it all drained off in only three or four months of the melt season, giving stream flow and annual floods six times that of today. In front of the ice, the south-draining valleys, which had been cut into the lowest parts of the surface of the till plain, filled from wall to wall with sandy gravel.

Much of the gravel fill originated under the retreating ice sheet. This happens in south Greenland or Iceland today. In the 13,000 to 17,000 years since the ice left, most of this late-glacial outwash has been removed; what is left forms accordant terrace systems. Today we shall ride on four different terraces, each associated with a distinct terminal position of the receding ice.

START

At 09:00, with breakfast inside us, we start from the parking area outside Drackett Tower and head left (S) on old river road.

Immediately we are on the most northerly but lowest outwash terrace system ("Worthington", on Fig. 1). Between us and the College of Agriculture, right (W), is one of the channels, probably 15,000 years old. To the left (E) is the present flood plain, on which the Ohio Stadium and the Battelle Memorial Institute are built. Buried logs tell us that more than 6,000 years ago the Olentangy River had trenched the Worthington outwash, leaving a terrace here and constructing a lower floodplain of silt and fine sand.

We follow Route 315 (elevated at first), join I-71 and pass under I-70 west of the city center (assuming I-71 is open). Occasional views of city center skyline are on the left (E). The TV tower (right) is on the same lowest gravel outwash terrace; south of Greenlawn exit and cemetery the terrace has been widely excavated.

12 mi. (16 km) Exit right, from I-71, circle onto Frank Road (E), under I-71, and right again (stop) onto Route 104 heading south. In the big pit, left (E) at truck entrance, the section once showed a 25 m thickness of gravel overlying 2 m of till on striated limestone. If our measurements in Alaska of the rate-of-accumulation of similar grade gravels are

applicable to the seasonally-flooding glacial stream of Ohio, some of this bottom gravel may relate to an earlier (mid-Wisconsin) phase of gravel deposition. Similar early-deposited gravel is seen (in passing) in the pit on the right (W). It underlies late Wisconsin till that forms the plain seen rising to the right as we cross the I-270 overpass and is found under us after we cross Route 316 at 27 mi. (43 km).

32 mi. (51 km) Three to four miles (5-6 km) before reaching Fox Village we pass over that ancient pre-glacial Teays Valley. Under the plains west of us it is a regular canyon, 100 m deep, filled to the brim with early glacial deposits. At the surface we are also passing over the first channel of Darby Creek; immediately after the last ice had disappeared the streams hardly "knew" which way to go. In general these streams are parallel and flow south; the youngest till plain slopes south from an elevation of 1000 feet (300 m) just west of Columbus to 850 feet (260 m) as it nears Ross County. However the streams diverged and joined wherever the slope was indeterminate.

South of Fox Village we drop to Darby Creek's broad, present-day flood plain with fine scarps, scrolls, and meanders. We rise onto the low terraces of late Wisconsin (Worthington) outwash again for 2 miles (3 km) past the flashing light (Ohio Route 56). Only those streams which extend north as far as the Powell moraine carry this outwash; we conclude that this outwash fill was completed when the ice was at the position of the Powell moraine.

36 mi. (58 km) At the crossing of Route 22, we rise sharply off the outwash onto moraine. We proceed a mile past kettles (hollows) resulting from the melting of stranded ice in the trees and high bumps (house left, E) to a roadside stop at the crest of Bloomingburg moraine.

STOP 1

37 mi. (60 km) Stevenson Farms at the Circleville end of Bloomingburg moraine. Top of highest knoll, left (E) of Ohio Route 104. This should be just before 10:00 am. (we hope). (35 min. here)

In Ohio the moraines that record positions of the Wisconsin ice margin during halts or readvances are usually belts, 1 to 3 km wide, of slightly higher (10 to 20 m) hummocky ground. The till they contain is very little, if at all, different from that in the "Darby" till plains north of them. Some moraines do mark the southern limit of one till sheet, however, so that their till is different from that in the till plains to the south. The moraines are most remarkable for their continuity; some extend for hundreds of kilometers in broad sweeping lobate forms. At this stop, we are at the southeast curve of the lobe, due to the blocking effect of the hills showing up ahead south of us.

Large streams like the Scioto River cut through these moraines, and did so even as the moraine was being made, as they do around the Iceland ice-caps today. Small streams, on the other hand, tend to flow parallel to the moraine edges. There are also abandoned dry channels and eskers continuing through moraines. Across the Scioto River is the segmented Circleville esker, extending 25 km from south Columbus and ending just NE of us against the moraine. It is a big feature (and gravel resource!), 5 to 20 m high. West of us, through the trees, is a smaller esker, only 5-10 m high. Clearly these were water-escape routes in ice tubes under a steep, active, but frequently receding ice edge.

Another feature in this moraine is an increase in the number of big boulders, mostly 20 cm to 1 m diameter, at and near the surface. These boulders are rolled off fields or broken up by farmers. Now they are found in creeks, under barns, and in gateposts. Further west, near

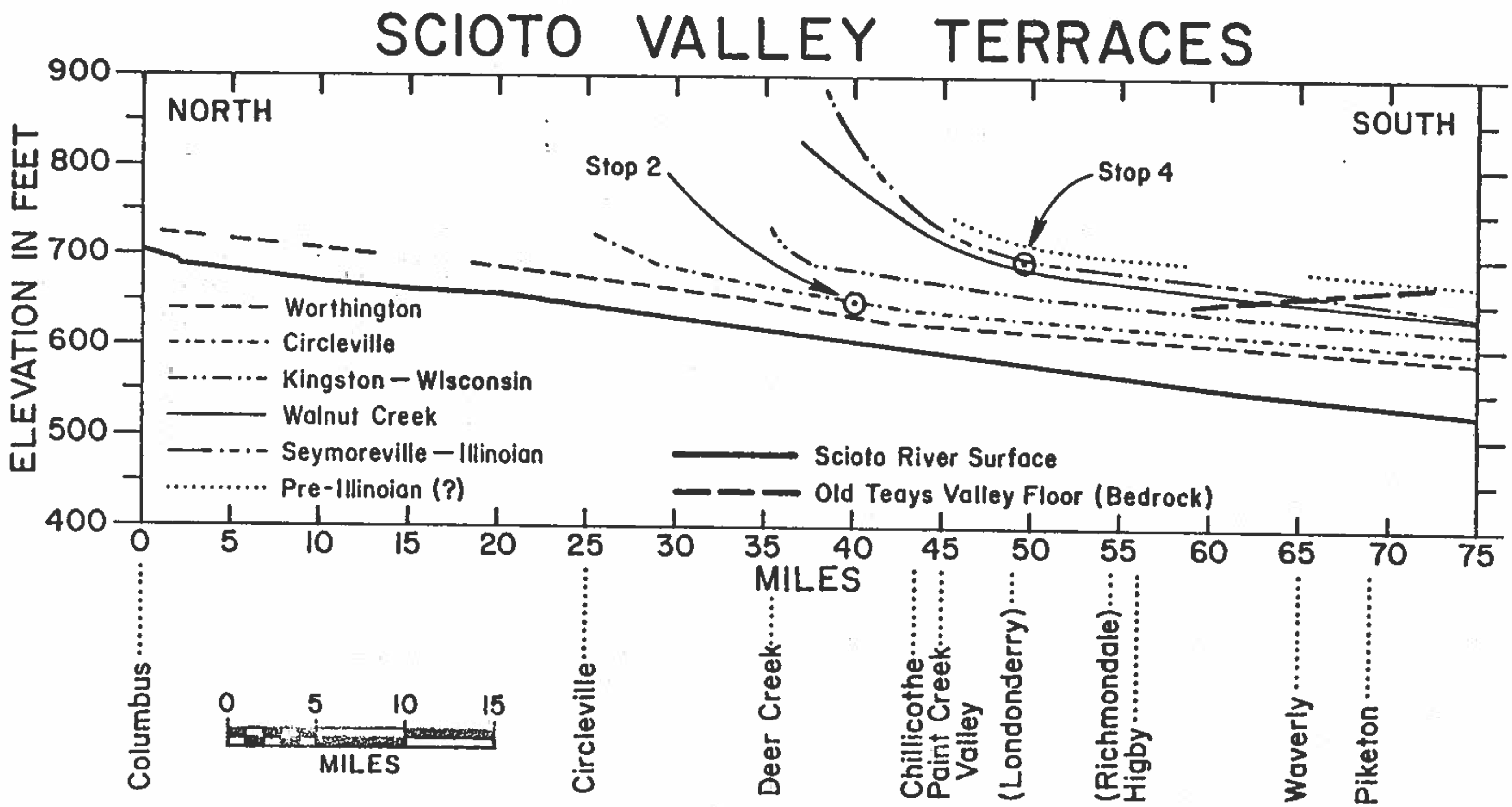

Fig. 1A. Longitudinal profiles of the glacial outwash terraces down the Scioto River Valley.

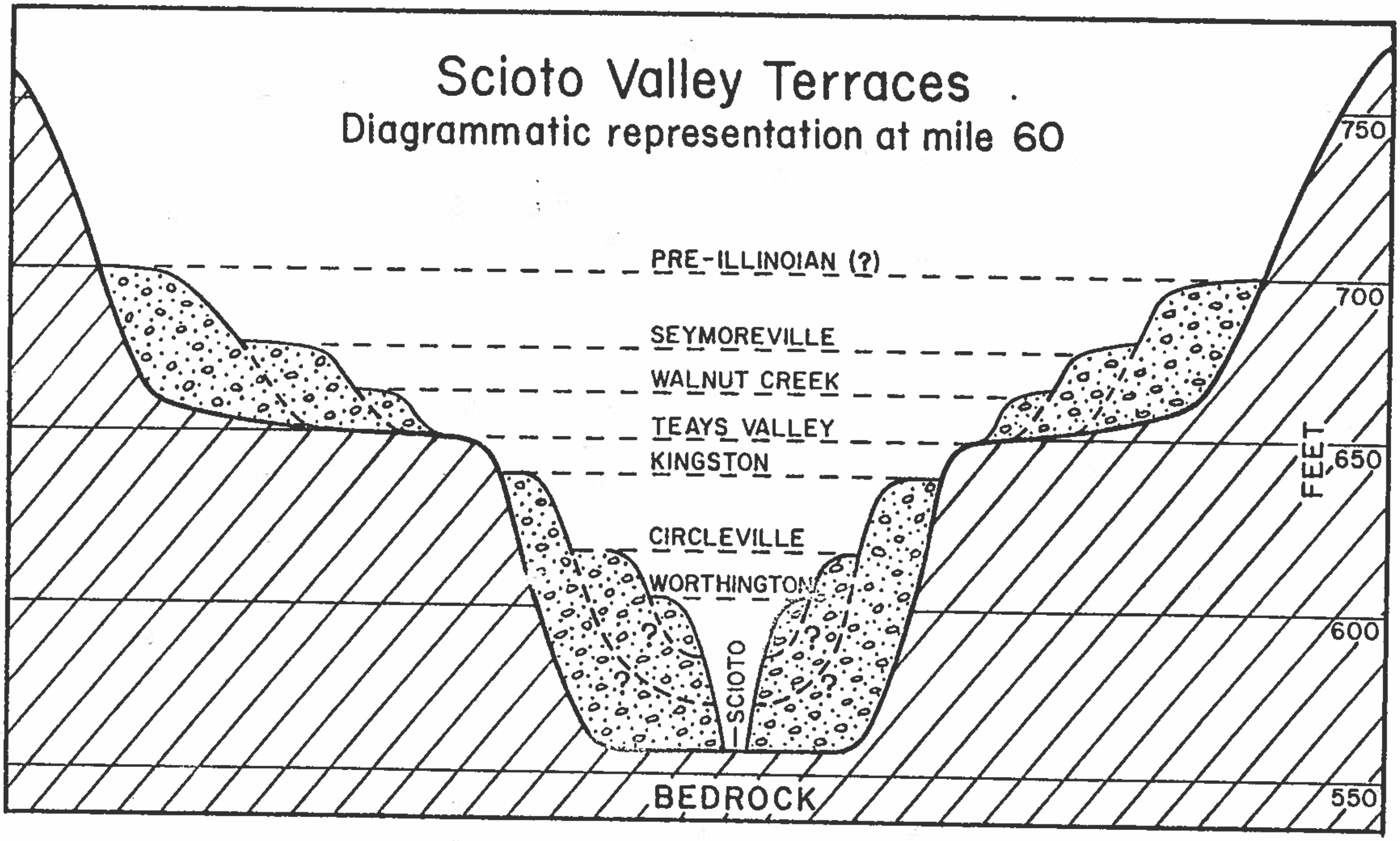

Fig. 1B. Diagrammatic cross section of the Scioto Valley at mile 60 to show the arrangement of bedrock and river terraces.

Bloomingburg, there were initially as many as 100 boulders per hectare (Fig. 2).

Between 92% and 99% of these boulders are "crystallines", from the Canadian (Pre-Cambrian) Shield, no less than 600 km away. Very few of the boulders are of local bedrock types, and those that are could be from Southern Ontario as well as Ohio. On the other hand, 75% to 95% of the pebbles are of local bedrock type. What ice dynamic regime preferentially gathered the far-away boulders and transported them here, without adding many local ones? Why did this occur only during two particular readvances of the ice sheet? Several hypotheses exist: (1) Did selective weathering occur along wide-spaced joints in granitic rocks of some Canadian source area, such as is known to produce big round core boulders in places like Georgia or Arkansas? (2) Could there have been winnowing away of the fine sand-silt-clay by wind or rain, after deposition here? - Neither of these hypotheses stand reasonable tests. We are left with the hypothesis that ice gathered these boulders from coarsely jointed and weathered outcrops far north, then overrode lower ice layers as it advanced over Ohio to the terminal area, where the boulders became the ablation load. (Presumably the bulk of the terminal moraine is basal load and contains all the fines.)

Our final consideration at this stop is outwash. We rode here partly on terrace remnants of a low outwash, which once filled the valley from side to side and which stemmed from a moraine north of Columbus. Beginning here at the Bloomingburg moraine, and visible over a wide area southeast of us, is a higher terrace. From here south (Fig. 1) we have two sets of terraces: the more northerly, "Worthington" low terrace is inset into a trough cut in the higher, "Circleville" terrace; in other words the Circleville terrace was trenched and refilled or regraded, when the ice receded and stood just north of Columbus. At that time the glacier lobe was active but receding, and at each major stop or readvance it generated a new lower level of outwash. With terraces, "oldest is highest".

From STOP 1 we follow Ohio Route 104 south. Within 0.6 miles (1 km) the road drops from the moraine onto the higher Circleville outwash and continues past a coutry school. Just beyond the school we pass a stream where we see (to the west) pits in the south end of the small esker mentioned earlier.

45 mi. (72 km) Cross Deer Creek and its broad floodplain. The "airport" road, right, goes onto a bedrock outlier (Mississippian shale and sandstone) of the low plateau escarpment, which had little effect in holding back the advancing Wisconsin ice lobe.

47 mi. (75 km) Where we rise onto outwash (the Worthington low terrace again) we see (left) bushes overgrowing the old Ohio-Erie Canal. Built for commerce and using horse-drawn barges, the Canal followed terraces and its water was replenished from small crossing creeks. It switches over to our right side in 2 miles (3 km). The last barge went through the canal in 1920!

50 mi. (80 km) Our route is joined by Ohio Route 207 and we rise onto the higher Circleville outwash. Airphotos show some of the old (17,000 B.P.) anastomosing channels.

52 mi. (84 km) We turn left (E) through gates at the sign to Mound City Monument. It should be before 11:00 am.

STOP 2

Mound City Group is a U.S. National Park Service historic monument (1 hour). Its significance will be explained to us and we will be guided by Superintendent Kenneth Apschnikat or one of his Rangers. Mound City was the area of a small Indian village and burial site along Scioto River during the first two centuries A.D. Hopewell Indians populated this part of America, thinly by our standards, and frequented but did not live year-round in the village. Note that the Indians utilized the prominent terraces, especially the open high ones. Many of the pipes, masks, beads and tools in these burial mounds may have been made at other sites like Siep Mound "work shop", 25 km or so to the south on U.S. Route 50.

[Alternate route, if after 12:30. Otherwise skip this paragraph. If we should be too late leaving here we will continue left (S) on Ohio Route 104 for 1-1/2 mi. (2-1/2 km) to Camp Sherman Memorial Park on the right (W) for LUNCH (45 min.). This was a large World War I encampment.]

We continue south on Ohio Route 104 a half mile (1 km) past the Federal Penitentiary, (on the left) and turn right (W) on the first blacktop road before the first wooden house; continue through fields which dip slightly at the main, old, now dry, outwash channel.

53 mi. (85 km) At the Stop sign, we turn right (NW) toward a school but bear left (SSW) up old Route 35, along a ravine and under a bridge, through Pleasant Valley. The outer limit of the Wisconsin till has been located (by soil auger) as being halfway across the hill to the left. This is part of Adena, the farm home of Ohio's first governor, Thomas Worthington. Chillicothe was Ohio's first capital and the Ohio State Seal is the view across Scioto Valley to the escarpment. The bumps ahead and to the left are part of the Wisconsin end-moraine, built 18,000 years ago.

We travel all the way through Pleasant Valley and across Biers Run, noting the Waverly Shale of Mississippian age in the outlier on the right (N).

57 mi. (92 km) We turn right (N) on Biers Run Road, cross Route 35 on an overpass and keep left at Cattail Road. We park left, just off Biers Run Road if possible, at about noon.

STOP 3

Biers Run cuts. Peecher & Smith farm. We reach here by 12:30 if before lunch; otherwise 13:45 (30 min. here). Before Route 35 was re-located, this was a long fine high exposure described in the "Wisconsin Age Forests" reprint. Over 200 logs, none rooted in place, have stuck out of the till bank of the stream at one time or another. Numerous C^{14} dates average 18,050 years B.P.; some of these were the first good wood dates from "solid carbon" in the 1950's. With the terminal moraine nearby to the south, this dates the outermost Wisconsin till. Traced westward it is oft-times the outer moraine, called "Cuba", and outer till, "Caesar Creek".

Studying these trees Dr. Burns and I came to several conclusions which may interest you:

(1) The ice rode over a young forest; few of the trees have more than 100 annual rings.

(2) The forest was a monotonous stand of Picea (spruce), with very few Larix (tamerack).

(3) The climate was cool, like north-central boreal Ontario-Quebec today.

(4) Judging from the width of the annual rings, it seems that the summers became much colder about 60 years before the site was overrun by the ice sheet.

(5) Many branches were bent sharply without breaking and the bark

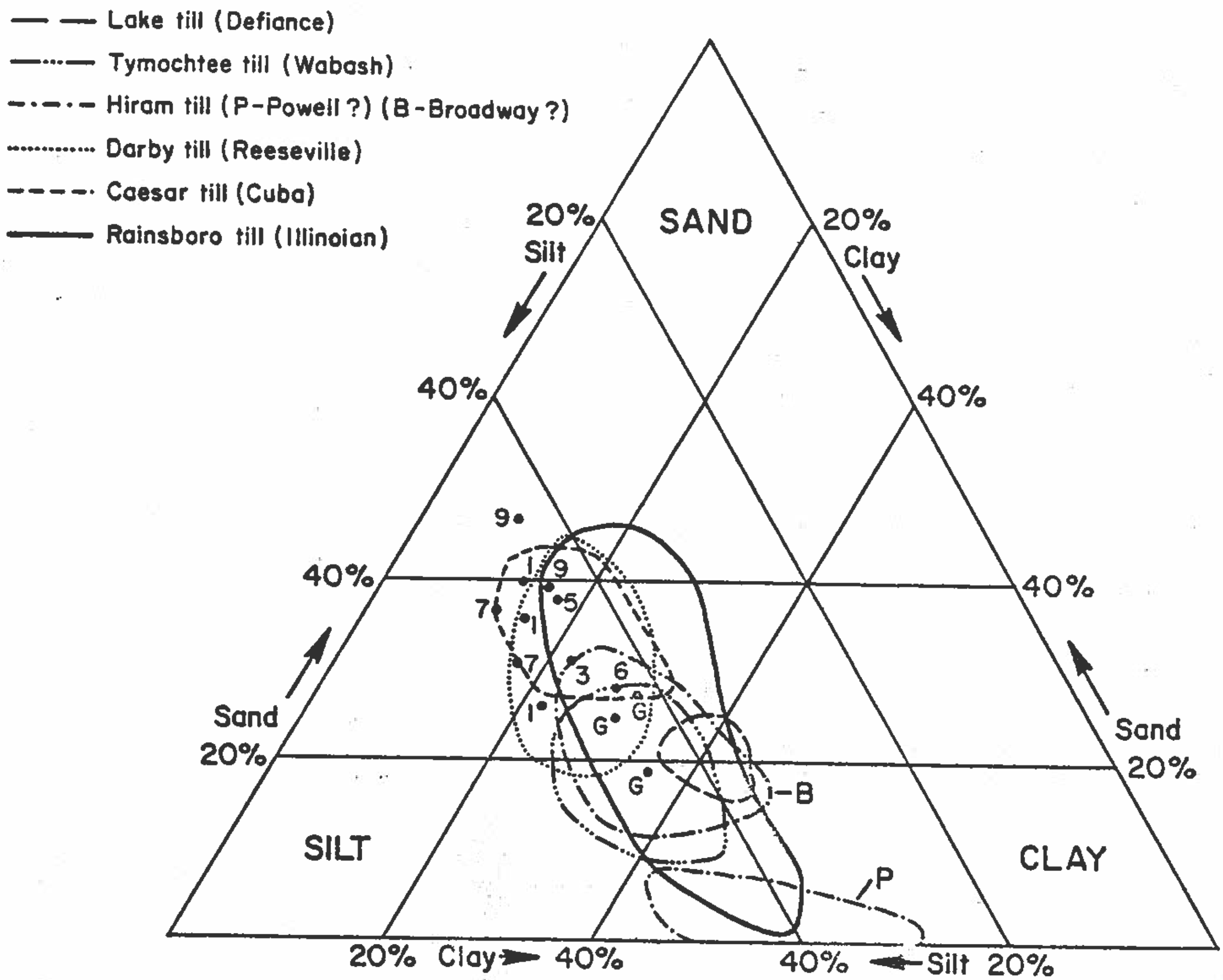

Fig. 3. Sand-silt-clay triangular diagram for the tills of Ohio.

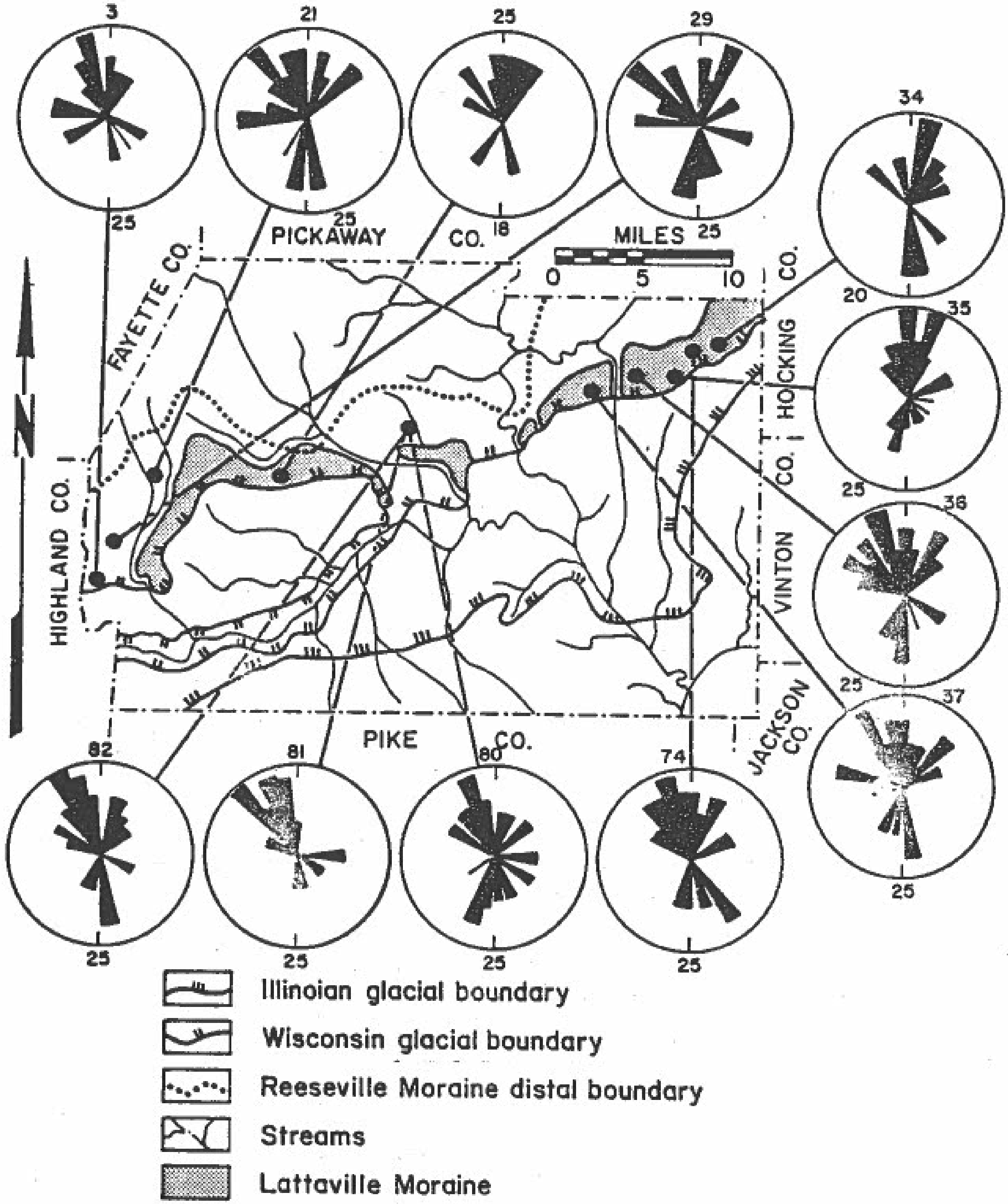

Fig. 4. Map of the glacial geology of Ross County, Ohio, with rose diagrams of till fabric of the Caesar till.

is intact: the trees were green when they were incorporated in the till.

(6) The forest was interstadial, growing between the 21,500-year advance and the 18,000-year advance; it does not represent interglacial (Sangamon) forest which had oak (*Quercus*), beech (*Fagus*) and maple (*Acer*).

(7) There were other forests like this near the Wisconsin ice margin. The most famous are the stumps rooted in place under till near Wilmington, 70 km to the west.

(8) The forest which was the source of the logs probably was nearby, not more than 10 to 20 km to the north.

A second main feature at STOP 3 is the till itself. Tills do differ in mechanical composition - although not by very much in western Ohio (Fig. 3). Normally we consider only the proportions of sand, silt and clay in the matrix, even though some tills are stony or bouldery, as at STOP 1. Tills are very well mixed, even one km down-glacier from a bedrock outcrop. The till composition varies with the direction of movement and the nature of the exposed bedrock up glacier and it changes from layer to layer in superimposed till. Chips of the local rock, here shale, are seen streaming off into the lowest till at any one site, but, obviously, upper till layers come from further away and have less shale. A long traverse by the ice sheet over shales incorporates more clay-size particles whereas extensive movement over sandstones introduces more sand and pebbles. "Boston till", the 21,000 year old till found under this till in the next county west, has only half as much calcium carbonate as this till at STOP 3, illustrating a chemical means of separating tills. The mineral content of sand-silt also determines the color, making small distinctions in the yellow-brown-red range, which can be used empirically to identify some tills.

As well as till composition, another clue to direction of ice motion at this site comes from the "fabric" of the till, the preferred orientation of the elongate pebbles, or the sand grains or even the logs. The plot of the orientations of components of the till at this locality looks like Figure 4. Generally the preferred orientation, to the NNW, accords with that of the striae on bedrock nearby and with the ice directions inferred from the lithology of the pebbles. The fabric of a till, when strong and uniform can be used to identify basal or lodgement till. We still have not proven whether the till particle orientation is due to (a) their orientation within the active ice, or (b) motion, including rolling, as the till is emplaced, or (c) flow in the juicy supersaturated till immediately before or after the ice disappears. As we argue the possibilities, remember that we often step off a glacier into knee-deep grey till.

In the bus we retrace our tracks to Pleasant Valley.

59 mi. (95 km) After 1-1/2 miles (2 km) we swing left (NE) onto new U.S. Route 35, east and south, back across old Ohio Route 104, for 4-1/2 miles (7 km), and across Scioto River twice as we swing around Chillicothe.

[Alternate route IF LUNCH was not had earlier. Turn right off U.S. 35 back onto Ohio 104, going now left (N) at traffic light for less than a half mile (1 km) to Camp Sherman Park, left (W). LUNCH at the shelter (45 min.). Afterwards return to U.S. Route 35 and left (E) at traffic light onto it. Return to full routing if before 14:30, OR continue more alternate routing below at 70 mi. log if near or after 15:00.

In 1.3 mi. (2 km), after crossing Scioto River once only, swing right (S) and full circle underneath "35" to go north on Bridge St., U.S. Route 23 (Business). In two miles (3 km) pass under railroad and U.S. 23 north, through Hopetown. In four miles (6-1/2 km) the complex moraine which we think is Reesville (17,000 years B.P.) rises on our left (W) but the huge gravel pit on our right (E) is all that is left of a 180-foot-high (58 m) discontinuous esker ridge in the 18,000-year-old terminal ("Cuba") moraine belt. This was all the under-ice meltwater drainage at maximum stand here.

67 mi. (108 km) At Kinnikinick, just beyond, turn right (E) on Ohio Route 180. For 7-1/2 miles (12 km) we rise through till hummocks of this massive Wisconsin-age end moraine stacked against bedrock hills of the Appalachian Plateaus right (S). The wooded hills are bedrock and rise above the Wisconsin terminal "Cuba" moraine which is all fields, plowed or grazed.

75 mi. (120 km) At Hallsville join the regular route log (below) at 93 miles (150 km). We have skipped 18 miles (30 km) and STOP 4.]

63 mi. (101 km) Note on the left (NE), after passing over old U.S. Route 23, the high terrace, beyond the woods and railraod. This is the oldest and highest of the three Wisconsin-age terraces in the Scioto River Valley (Figures 1 and 5). It once extended from hill wall (E) to hill wall (W) in front of the ice. As the first-formed of the 3 outwashes, it extends only from the Wisconsin end-moraine (18,000 years old) to Kingston. Inset into it are both the younger outwashes, the "Circleville" and the "Worthington". As with the other two outwashes, the head end of the "Kingston" is "kettled". However, the Kingston terrace differs from the others by having a cover of loess. Elsewhere in Ohio, in Champaign County, the loess deposits are shown to be the result of storms carrying dust from outwash, and the loess deposition ended about 17,000 years ago. Thus, the presence of loess allows us to correlate the early Wisconsin terraces across western Ohio.

70 mi. (113 km) We leave U.S. Route 23, cross the Scioto River a last time and leave U.S. Route 35 south. We follow U.S. Route 50 ESE over the steps from the middle-Wisconsin "Circleville" outwash terrace to high Wisconsin "Kingston" terraces, at the first houses and 2 mi. (3 km) east of the Scioto River, onto an Illinoian terrace which is still higher. We are only 4 km from the limit of that Illinoian glaciation, which is marked by till against the wooded hills south of us.

Illinoian outwash (about 125,000 years old) filled the rather deep valley ahead; it is the old Teays Valley (Pliocene) in which the river flowed towards the west. The bedrock floor is high (it is visible, with difficulty from a few places along the road) so the Scioto River never flowed here. A few kettle holes are still faintly visible in the next mile. Here is a chance to see the holes in ice, gone these 125,000 years.

After a road corner we climb for a mile over an isolated hill and then descend again onto the old outwash and, through deep roadcuts, across Walnut Creek. Here lake beds under the Illinoian outwash used to be exposed. Now they are grassed over. (They caused problems with road-building, due to slumping.) This might be an Illinoian ice-dammed lake but is is more likely that it was part of the "Kansan"-age Lake Tight, which flooded the whole of the Teays Valley system. Paleomagnetic measurements show that the lake sediment is reversely magnetized, the north magnetic pole is to the south. This has not happened since 700,000 B.P. so this lake is at least that old.

76 mi. (122 km) We turn right (S) as U.S. Route 50 enters Londonderry. We go one-third mile (0.6 km) down Hanna Lane to a parking area on the left, at David Stanley's drive; it should be just about 14:30.

STOP 4

Hanna Lane road cut in front of David Stanley's house. (30 min.) This is an exercise in unravelling the problem of periglacial and inter-

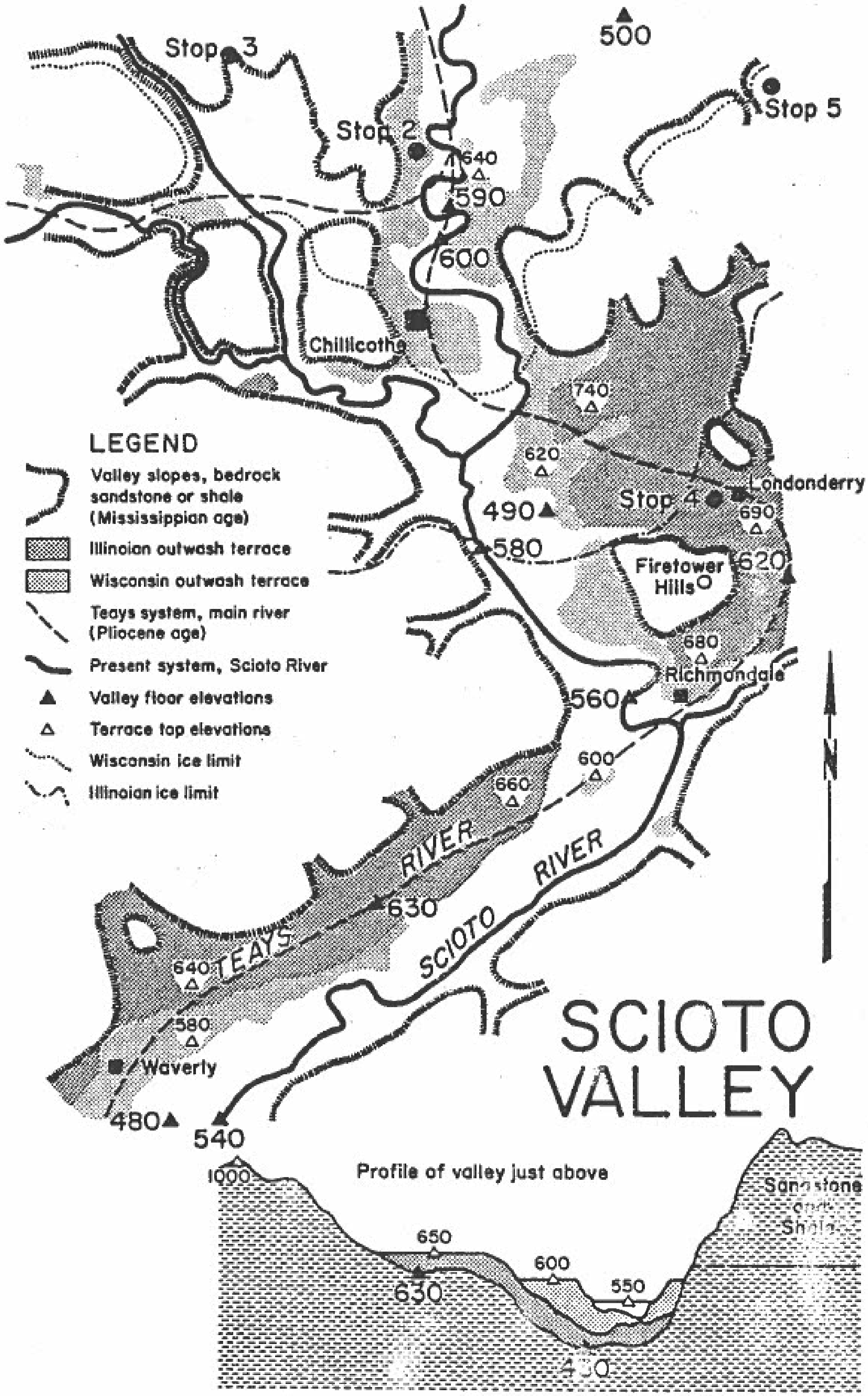

Fig. 5. Map of the Scioto River Valley in the Chillicothe region showing stop locations (•).

glacial environments, exposed in one simple road cut. Here we are at the limit of the Illinoian glaciation, 125,000 years old; that ice sheet left its southernmost till further south along this road and on the slopes of the nearest hills. That ice sheet did extend over the first line of Appalachian hills.

The bedrock floor of the abandoned Teays Valley is 21 m beneath us. The valley here is filled with 10 to 20 m of lake sediments, which are believed to be of "Kansan" age, 700,000 years old, because they show reversed remanent magnetization. The Illinoian ice sheet eroded some of the lacustrine clays north of the central hills. For some reason the Illinoian meltwater is not recorded down this portion of Scioto Valley. Instead it coated this long-way-around with outwash (Fig. 5).

Two soil profiles are present here. The present-day, surficial soil shows A and B layers that are 35 and 123 cm thick respectively. The B layer is a concentration of weathered clay products and has yellow-brown colors. The second soil, about 158 cm below the surface, is a paleosol, or "old soil". It also shows A and B zones, 43 and 305 cm thick at least. This buried soil is of Sangamon-age and represents weathering that occurred during the warm interglacial between the Illinoian and Wisconsin glaciations. It is developed in the sand of the earlier, Illinoian, outwash plain.

The upper soil, however, blankets the entire area and is composed of 2% to 8% very fine sand, 64% to 72% silt, and 24% to 33% clay, with no coarser sand and very rare pebbles. Eight hundred soil samples from the southwest quarter of the state of Ohio show:

1. a great contrast exists between the grain sizes in the soils and those in the sandy-pebbly material below;
2. the soil makes a mantle on both high and low topography (it may be washed off, down-slope);

3. soils thicken to 1 to 2 meters; just east of the outwashes in some valleys, for example, of the White, Little Miami, Paint Creek, and Scioto Rivers but not in others, for example, the Miami River Valley;

4. an increase in minerals, (e.g. hornblende) appropriate to certain outwash systems (down Little Miami River); and

5. no depositional layering, that is, sorting by grain sizes.

All of this evidence, when compared to the present-day situations in Greenland, Alaska, and New Zealand, indicates that the material is loess, blown from outwash plains in the autumn of each year. Because no significant amount of loess is found on surfaces younger than 17,300 B.P. we conclude that the great dust storms must have ended by then.

Leaving STOP 4, we retrace the route up Hanna Lane and left (W) on U.S. 50 for 2 mi. (3 km).

78 mi. (126 km) We turn right (N) on Sugar Run Road (Ross County Road 221), jog left (W) along a stream, and right (N) on Possum Hollow Road (County Road 231). Note the high end of the Illinoian outwash terrace above on the left; we follow the outer limit of the Illinoian ice, to the southeast.

82 mi. (132 km) Enter Mooresville. At the Stop sign, we turn right (E) on County Road 222, Charleston Pike, and continue straight for 2-1/2 mi. (4 km) through Tucson.

86 mi. (138 km) Charleston. In 0.6 mi. (1 km) we turn left (W) on Hough Road. This crosses the highest and most northerly remnant of Illinoian-age outwash. Here we leave the Illinoian glaciation limit, marked on ridges only by scattered boulders from Canada. The valley is narrowing to a gorge through the northern-most hills of the Appalachians. We turn right (N) on Walnut Creek Road, County Road 233, for 2-1/2 miles (4 km). From a gorge at the former head of Walnut Creek, a tributary of the Teays during the Pliocene, we travel over the clays on the floor of a lake trapped

behind the Wisconsin end-moraine which lies ahead.

91 mi. (146 km) We turn right (E) on Marietta Road (County Road 235) onto high hummocky moraine and then left (N) to Hallsville. Here a spruce log found in the moraine till was dated at just under 18,000 B.P. as it should be; this is the outermost but not the oldest, Wisconsin drift. (The oldest was 21,300 years B.P. to the west.)

93 mi. (150 km) We turn right (E) on Ohio Route 180 at Hallsville for two miles. Note the sharp hummocky moraine topography. Note also the gravel pits in the kames along the moraine. Many of the high bumps consist of washed material. We go right (S) one mile on Charleston Pike, for a side-trip to Colerain Church.

STOP 5

96 mi. (154 km) View from Colerain Church at about 15:30. (20 min. here)

Imagine ice at your feet and the ice sheet surface rising steeply to the north, partly covered by ablation moraine. The ice was active: it delivered 5 to 50 m of hummocky dirt here. Most of the area covered by the dirt is now cleared fields; the unglaciated bedrock area is mostly wooded. Most of the till is compact and has a fabric, so we conclude it was emplaced by basal ice. The looser ablation till usually forms hummocks, and is only a small part of the whole.

Many reversals of stream-flow direction took place along this ice margin wherever a north-flowing stream was blocked by the ice sheet. Here, due to ponding, reversals were short. To the east, at Laurelville, is a major reversal of Salt Creek.

We return north a half mile (1 km) to Ohio Route 180, and continue right (E) along the moraine for two miles (3 km) to enter Adelphi. This route turns left (N) for a half mile to join Ohio Route 156, which is just off the moraine.

100 mi. (161 km) We cross Salt Creek on Ohio Route 156, into Laurelville and turn left (N), following Ohio Route 180, swinging northeast again. Note the high Illinoian kames above Laurelville. The Salt Creek valley we follow narrows in the normal fashion of headwaters of dendritic systems, but the continuation of the valley southeast along Ohio Route 56 goes up an ever-narrowing valley to a gorge to the south. This is shown on the 15-minute quadrangle maps, which will be passed around. For 2 mi. (3 km) north and east of Laurelville, we see kames and then leave glaciated country at South Perry.

107 mi. (172 km) We turn right (S) on Ohio Route 374 to Rockhouse (State park), which is reached in two miles (by 16:30). We climb up 94 m, past cliffs of Blackhand Sandstone. This coarse sandstone, of Mississippian age, is part of an ancient marine delta deposit which now forms the hilltops and has defended them from erosion ever since Pliocene time, 2 to 5 million years ago.

STOP 6

The sandstone cliffs at Rockhouse weather away along the joints by dissolution of the cement holding the grains of sand together. Thus the hillsides are dotted with shelter caves, formed by erosion along joints, which slowly undermines the slopes. We follow the trails down (NE) to see the caves. Dr. Carman estimated that if 1 teaspoon of loosened sand grains were blown or washed out each day this cave could have been formed in a million years.

If we had time to climb the firetower we would see the same scene as from the bus travelling along the ridge. The hills make a uniform skyline - one accordant level. Many different bedrock types are exposed in this area, implying that the accordant level represents a rather extensive erosion surface, formed before Pliocene time, before the Teays System of valleys were eroded, say 10 million years ago. Such a surface used to be called a "peneplain", but how flat was this erosion surface, really?

109 mi. (175 km) We return to Ohio Route 374 and turn left (S) to Gibisonville. This is a twisting road along the crest dividing the drainages on either side. The topography is "mature" and well-eroded; on both sides of the crest, stream heads, called "coves", occur in semicircular basins formed by slow erosion. Turn left (N) in two miles (3 km) onto Ohio Route 678, through Gibisonville and another mile to join Ohio Route 180.

115 mi. (185 km) We follow Ohio Route 180 northeast for four miles (6 km) to U.S. Route 33. We turn left (NW) across the flat loess-covered top of an Illinoian-age outwash terrace which filled the whole Hocking Valley 130,000 years ago, and which, in section, shows a typical deep yellow-red soil profile.

121 mi. (195 km) We pass through Rockbridge. Two miles (3 km) further north we turn left (W) off U.S. Route 33 at the sign to Camp Wyandot and continue along a very rough dirt road by the side of Clear Creek for almost six miles (10 km) to a dirt road diagonally right, up a steep hill to Barnebey Center where, with luck, there will be food!

130 mi. (210 km) Happy Ox Roast!!