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POSTGLACIAL ALLUVIAL HISTORY IN THE UPPER WHITEWATER BASIN, SOUTHEASTERN INDIANA, AND POSSIBLE REGIONAL RELATIONSHIPS

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ABSTRACT. Alluvial geomorphology, soils, stratigraphy, and radiocarbon dates on a sub-alluvium organic horizon at one locality in the upper Whitewater basin, southeastern Indiana suggest two cycles of shallow postglacial valley entrenchment and alluviation. The first postglacial entrenchment, completed by 6800+ radiocarbon years B.P., established a stable valley bottom that persisted until 1000− radiocarbon years B.P., on which a mat of organic debris accumulated widespread. An episode of alluviation followed, burying the organic debris layer and producing a "high bottom" alluvial surface presently characterized by shallow soils with a very weak B horizon of clay accumulation. A second stream entrenchment occurred in historic time due, presumably, to increased run off and flood frequency from deforestation and cultivation, and deposition of alluvial silts with subsidence of floods has produced a slightly lower "first bottom" surface. Possible relationships of the postglacial and prehistoric events to postglacial vegetational and climatic changes inferred from pollen data are discussed.

Similar postglacial alluvial geomorphology, soils, and stratigraphies including a sub-alluvial organic debris layer occur throughout the Ohio River basin and in other upper Mississippi valley drainages.

INTRODUCTION

I mentioned in an earlier paper (Gooding, 1957, p. 45) the existence at several localities in the Whitewater basin of glacio-fluvial gravel covered by peaty vegetation debris and humus, mixed with mineral sediment, and buried in turn by fossiliferous, stratified, valley bottom alluvial silt and fine sand. This organic zone/alluvial silt and fine sand sequence, lying on coarse outwash gravels, till, or bedrock, has been observed at several other localities in valleys of the Whitewater basin and in part of the upper Miami basin in southwestern Ohio (Van Zant, ms). Radiocarbon dates from the organic zone beneath alluvial sediments at one locality establish a maximum age for certain weakly developed alluvial soils and provide a basis for interpreting the postglacial valley history in the area. Possible regional relationships are suggested on the basis of similar alluvial stratigraphies, radiocarbon dates, geomorphology, and soils elsewhere in the Ohio basin and upper Mississippi valleys.

VALLEY BOTTOM MORPHOLOGY

The valley bottoms of the Whitewater and Miami drainage systems and the Ohio River consist of the "first bottom", which is flooded seasonally, and a slightly higher surface, the "high bottom", which is subject to partial flooding along low areas only at intervals of several years during very high water stages.

In headwater and small side tributaries of the Whitewater and Miami basins, stream channels are generally incised 1 to 1½ m (4-5 ft) into the "high bottom" surface, and there is little or no "first bottom" development. Streams are eroding headward and have extended their valleys into uplands beyond the limit of the "high bottom" surface. Within relatively short distances down these headwater and side tributaries, however, narrow "first bottoms" exist 0.6 to 0.9 m (2-3 ft) below the "high bottom" surface. The difference in elevation between the "first bottom" and the "high bottom" surfaces gradually increases down stream to about 3 to 3.6 m (10-12 ft) along the Ohio River in southern Switzerland and Ohio Counties, Ind.

The "first bottoms" in the Ohio basin seem to be nearly stabilized, as their present topographic position below the "high bottom" surface has been mentioned in the soil survey literature for over 50 years. They are apparently being maintained at their present level by removal and redeposition of alluvium during seasonal floods.

ALLUVIAL STRATIGRAPHY

Many stream bank exposures in the Whitewater and upper Miami basins show that separate alluvial stratigraphic units underlie these two bottom land surfaces, as illustrated in figure 1. The "high bottom" alluvial sediments are 1 to 1.8 m (4-6 ft) thick in headwater and side tributary valleys and increase in thickness down valleys to a probable maximum of about 4.5 m (15 ft) along the lower parts of the Whitewater and Miami valleys. The "first bottom" alluvial unit is nearly of the same thickness at a given locality, but it lies in a narrower valley entrenched through the older "high bottom" alluvial unit. This situation accounts for the difference in level between the "first bottom" and the "high bottom" surfaces. Modern alluvium also occurs in channels scoured through the "high bottom" sediments during exceptionally high water stages (fig. 1).

Both alluvial units consist mainly of stratified fine sand and silt, with occasional coarser sand and "pea" gravel at some horizons in shallow cut-and-fill structures. The "first bottom" alluvium is thinly to massively bedded and is generally gray to nearly black with contained humus, especially in headwater valleys. The "high bottom" sediment is thinly bedded and gray to shades of brown, often as a mottled pattern,

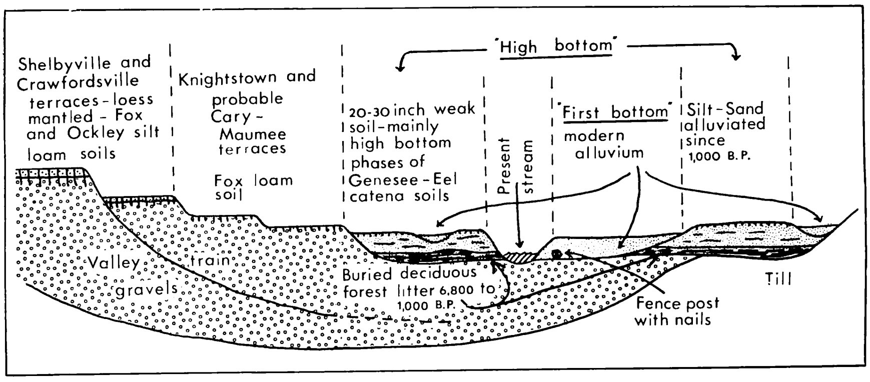

Fig. 1. Generalized cross section showing geomorphic, stratigraphic, and soils characteristics of postglacial alluvial units in valleys of the Whitewater and upper Miami basins, southeastern Indiana and southwestern Ohio.

and humus is generally confined to thin layers at various horizons. Coarser, shallow channel-fill layers may be oxidized to bright yellows and browns.

Wood fragments and mollusks are common in both alluvial units; mollusks occurring to the surface in "first bottom" alluvium and to within 0.5 to 0.7 m (20-30 in.) of the surface in "high bottom" alluvium. At some localities the "high bottom" alluvium is non-calcareous throughout or at certain horizons, in which case mollusks are not present.

At an exposure of "high bottom" alluvium along the West Fork of the Whitewater River south of Connersville, Ind., which shows numerous cut-and-fill structures and coarse sand and "pea" gravel layers, mollusks were collected from five zones through 4 m (13 ft) of the alluvium. The mollusks were found to be mixed aquatic and terrestrial forms common in the area today, with pulmonate gastropods most abundant in the silt and fine sand layers. The pulmonate gastropods are largely forms that live in wet places along rivers and creeks among rotting leaves and decaying logs. The aquatic mollusks, both gastropods and pelecypods, are forms that live in small creeks and ponds with muddy to sandy bottoms, with water generally quiet to stagnant and less than 2 m in depth (Foster, ms). The aquatic mollusks at this locality may be in part autochthonous in each sampled unit, while the pulmonate gastropods are probably largely allochthonous. The contacts between the sampled layers of alluvium at this site are sharp, and the base of each truncates underlying units, suggesting that each unit was probably deposited during a given flood episode in newly-formed and temporary small flood water channels. The scattered wood fragments throughout the alluvium, along with the pulmonate gastropods, were probably derived from the flood-stage channeling of vegetated flood plains.

SOILS

As illustrated in figure 1, the "high bottom" alluvium commonly lies on an organic accumulation that is a few inches to 0.6 m (2 ft) thick. This organic layer is a mat of logs, branches, twigs, and nuts of deciduous trees, with varying proportions of mineral sediment. Stumps of trees have been observed in their position of growth. Shells of mollusks, mostly gastropods, may occur in the upper part of the plant debris, but the admixed mineral sediment in the organic unit is commonly non-calcareous. The organic litter in all exposures lies with a sharp contact on glacio-fluvial gravels, or scoured till, or bedrock.

The slight entrenchment of present streams has exposed the organic litter at the base of the "high bottom" alluvium, where streams are cutting laterally into the older deposits. Although occasional logs and scattered wood fragments are found in both alluvial units, a concentration of organic debris has not been found at the base of the younger alluvium.

As has been mentioned, the "high bottom" alluvial unit may be weakly calcareous throughout, or it may be neutral to slightly acid throughout or in certain layers. The sediment was probably only weakly calcareous on deposition, having been derived largely from already weathered soil in the drainage basin, perhaps largely at times of exceptionally heavy spring rains, or times of rapidly melting snow in years when winter frost remained late in the ground. The characteristic thin stratification and frequent humus streaks common to this alluvial unit indicate slow accretion, which might also have permitted some *in situ* leaching of sediments and mollusks during accumulation. No zonal soil development has been found within the "high bottom" alluvial unit. Accretion seems to have been fairly regular but at intervals probably greater than the normal seasonal flood cycle.

The "high bottom" alluvium does have developed at its present surface soils that are slightly acid to depths of 0.5 to 0.7 m (20-30 in.) and with very weakly developed subsoil B horizons of illuviated clay accumulation from about 0.4 to 0.7 m (15-30 in.) in depth (Bushnell, Ulrich, and Kunkel, 1930, p. 35-40; Alfred and others, 1960, p. 37 and 43). There are several categories of the "high bottom" weakly developed alluvial soils, relating to textural variations in alluvial sediments, and whether or not the subsoil alluvium is calcareous. Fine sand and silt is the dominant texture of the alluvial material, however, with coarser sand and occasional "pea" gravel materials being confined to former, narrow, shallow, channel belts over the alluvial surface. In the upper Whitewater and Miami basins these weakly developed soils are mainly "high bottom" phases of the Genesee Soil Series.

AGE OF "HIGH BOTTOM" ALLUVIAL UNIT AND ITS INCIPIENT SOILS

Radiocarbon dates have been obtained from the organic litter at the base of the "high bottom" alluvium at one site that is typical of many in the upper Whitewater and Miami basins.

Berry Farm site.—On the Greenville Treaty Line Road at the northwest corner, sec. 8, T. 15 N., R. 1. W., Fountain City, Indiana Quadrangle:

Unit	Thickness	Description
4	1 m (4 ft)	Fine sand, silt, and clay. Upper 0.6 m brown, non-calcareous, with weak B horizon clay accumulation in lower 0.3 to 0.35 m (12-14 in.); lower 0.6 m (2 ft) buff colored, weakly calcareous, and contains gastropods.
3	0.15 to 0.3 m (0.5-1.0 ft)	Fine to medium sand, gray, weakly calcareous; contains a few gastropods.
2	0.09 to 0.6 m (0.3-2.0 ft)	Vegetation, peaty, in mineral sediment; many limbs beaver-chewed (oak, birch, black walnut trees identified). Butternuts, walnuts, hickory nuts, hazel nuts, buckeyes, and acorns abundant; gastropods at top of organic unit. Main part of unit non-calcareous.

1	10.6 m (35 ft)	Glacio-fluvial gravel, penetrated by drag line. Gravel well-sorted. Sizes up to about 0.07 m (3 in.) with an occasional boulder up to 0.2 m (8 in.) in diameter.

Berry Farm radiocarbon dates.—(Olson and Broecker, 1961, p. 162):
1000 ± 150 (L-480D)—walnuts collected from organic unit 2.
2350 ± 100 (L-480E)—gastropods collected from organic unit 2.
6800 ± 100 (L-480F)—oak (?) log collected from unit 2.

The above radiocarbon dated samples were not collected stratigraphically within organic unit 2. However, it is likely that the sample dates are near the maximum and minimum age limits of the organic layer. These dates indicate a period of valley bottom exposure and vegetation accumulation on the order of 5800 ± 250 radiocarbon years, during which the mineral sediment of unit 2 was somewhat weathered and leached of its carbonates. Although weathered drift beneath the organic horizon has not been observed in the upper Whitewater and Miami basins, similar alluvial stratigraphies in other southern Indiana basins (to be discussed later), which are probably genetic and age correlatives of those in the Whitewater and Miami basins, do have a shallow zone of weathered drift beneath the sub-alluvium organic layer.

The non-calcareous nature of the "high bottom" alluvium through much of its thickness at some localities may give the impression that post-depositional soil development extends to depths of several meters and that the "high bottom" geomorphic surface therefore is of considerable age. The slightly acid condition to depths of 0.5 to 0.7 m (20-30 in.) and the accumulation of a very little B-horizon illuviated clay at depths of approximately 0.48 to 0.7 m (15-30 in.) mark the actual depth of post-depositional soil formation, however, and indicate that the "high bottom" geomorphic surface is not very old.

The Berry Farm radiocarbon dates indicate that the "high bottom" alluvial unit in the upper Whitewater basin is less than 1000 radiocarbon years in age. Its suggested mode of accumulation in thin increments, with some *in situ* weathering in places during accretion, would have required most of this period of time for its accumulation. The surficial incipient soil development to shallow depths must therefore be very young indeed and probably began when a change in the regimen of streams initiated slight entrenchment and formation of the lower, younger alluvial unit, thus essentially terminating "high bottom" alluvial accretion.

As present stream channels are generally below the base of the "high bottom" alluvial unit, the water table in the "high bottom" alluvium has been lowered slightly. This has promoted better drainage and aeration, permitting oxidation and other weathering processes, and the beginning of clay illuviation in the upper 0.5 to 0.7 m (20-30 in.) of the "high bottom" sediments. The generally brown and gray mottled character of the lower part of the incipient "high bottom" alluvial soils indicates that the water table now fluctuates seasonally through the weak soil profile.

AGE OF "FIRST BOTTOM" ALLUVIUM

In Fayette County, Ind., a rotted log was found exposed near the base of about 1.5 m (5 ft) of "first bottom" alluvium in a small tributary valley to the Whitewater River. On excavation, initially for purposes of obtaining a sample for radiocarbon dating, it was found to contain old rusty nails. Thus, at this locality, the young alluvium is historical in age. Its similarities throughout the Whitewater and upper Miami basins as to topographic and stratigraphic relations to the older "high bottom" alluvium and its generally high content of humus and lack of surficial soil development suggest that the young alluvial unit beneath the "first bottoms" everywhere in Whitewater and Miami valleys may date within historic times. I suggest that as settlement, deforestation, and land cultivation proceeded through the Ohio basin, increased slope wash and general run-off initiated accelerated erosion of humus-rich top soil from higher slopes and uplands and that floods increased in frequency and volume. During these larger and more frequent floods, stream channels were cut deeper than previously in the older "high bottom" alluvial surface, and large volumes of humus-rich top soil silt and fine sand were deposited in these slightly incised channels as floods receded. The apparent historical age of the "first bottom" alluvial unit, its relatively rapid rate of accumulation as indicated by some massive beds, and the fact that its surface is regularly modified by seasonal floods explain the absence of weathering horizons and soil development within it.

SUMMARY OF POSTGLACIAL VALLEY HISTORY IN THE WHITEWATER BASIN

The data and interpretations previously discussed suggest two cycles of postglacial entrenchment and alluviation in valleys of the Whitewater basin (see fig. 2). The first postglacial entrenchment produced by 6800+ radiocarbon years B.P. a broad stable valley bottom that persisted until 1000– radiocarbon years B.P., on which a mat of organic debris accumulated widespread. Alluviation then occurred, burying the organic debris layer and forming a "high bottom" alluvial surface presently characterized by shallow soils with a very weak B horizon of clay accumulation. A second stream entrenchment occurred in historic time, and deposition of modern silts with subsidence of floods has produced a slightly lower "first bottom" surface.

REGIONAL IMPLICATIONS FOR THE OHIO BASIN

Reference has been made to the uniform and continuous topographic relationship between the "first bottom" and "high bottom" surfaces down the Whitewater and Miami drainage ways and in the Ohio River valley in Switzerland and Ohio Counties, Ind. This relationship is believed to persist down the length of the Ohio River valley and in the tributary Wabash and White River basins, although in some stream

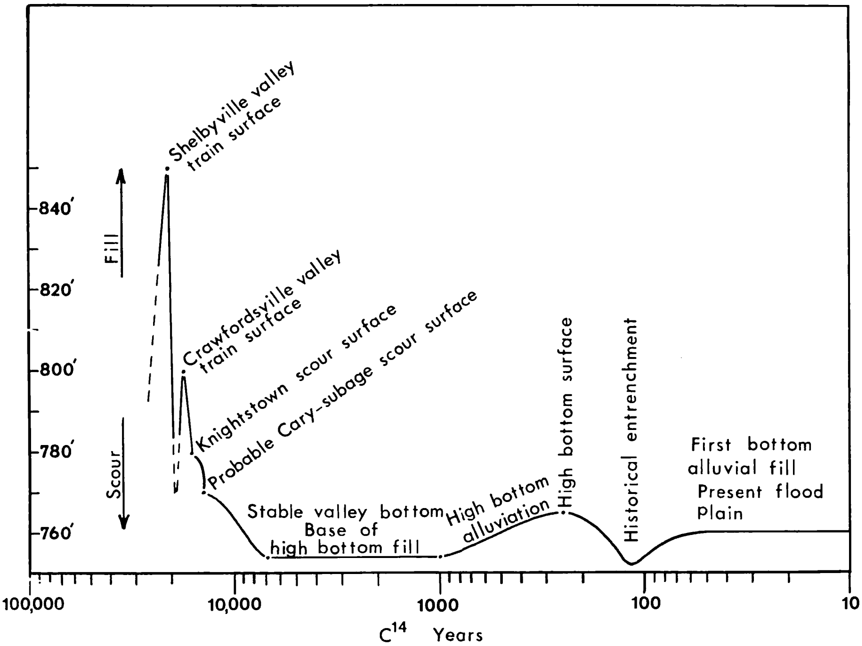

Fig. 2. Four cycle semi-logarithmic time plot of late and postglacial scour and fill episodes interpreted in the Whitewater basin, Ind. Approximate relative elevations of geomorphic surfaces in southern Fayette County, Ind. are shown. Data on the Shelbyville through Cary events are from Gooding, 1957.

stretches the "first bottom" is very narrow to absent. Throughout all these basins, the "high bottom" surface has developed on it weak soils with an incipient B horizon of clay accumulation at shallow depths. These weak soils have been classified into several alluvial soil series based on slight differences in the mineralogical character of the parent silt and fine sand alluvium due, presumably, to differences in the bedrock and drift sources down the Ohio River valley. The degree of soil profile development, however, is similarly weak everywhere in the Ohio basin in all of the "high bottom" alluvial soils with the same drainage conditions. Representative "high bottom" soil series, generally in order from headwater and side basins on down the Ohio River valley, are: high bottom phases of Genesee and Huntington, Worthen, Calhoun, Ross, and Emma (see the following and other Indiana County Soil Survey Reports: Wayne, Fayette, Union, Franklin, Switzerland, Ohio, Vanderberg, Gibson).

As the postglacial climatic conditions producing these soils would have been much the same over the area of the Ohio basin, I suggest that the postglacial alluvial history outlined previously may apply to the entire Ohio basin. A few radiocarbon dated alluvial stratigraphies elsewhere in the Ohio basin support the regional geomorphic and soils evidence for a common postglacial alluvial history in the entire Ohio drainage basin.

Wabash Valley

4040 ± 250 (W-666) Farmersburg, Ind.—Wood from the bank of Prairie Creek, 8 km northwest of Farmersburg, Vigo County, Ind. (middle stretch of the Wabash valley). Wood was embedded at 1.5 m (5 ft) depth in sediments lying beneath the flood plain of Prairie Creek. Non-calcareous gravel underlies the wood-bearing silt zone; clayey silt overlies the organic zone (Rubin and Alexander, 1960, p. 141).

7030 ± 260 (W-832) Posey County, Ind.—Wood from blue-gray lacustrine silt in creek bed in Haubstadt Quadrangle, Posey County, Ind. (along lower Wabash valley). Alluvial section: 2.4 to 3.6 m (8-12 ft) gray, fine sandy silt, non-calcareous; 0.3 m (1 ft) silt, oxidized, topped with small pebbles and sand, cemented; 0.6 m (2 ft) blue-gray non-calcareous silt containing wood—bottom not exposed (Rubin and Alexander, 1960, p. 142).

White River Valley

5000 ± 250 (LJ-290) Lake Eminence, Ind.—Wood from log in bank of east fork of Mill Creek southwest of Clayton, Hendricks County, Ind. (headwaters of White River). Alluvial section: 2.0 m silt, sand, yellowish brown, laminated to massive, non-calcareous; 1.0 m sand and gravel, light yellowish brown, calcareous; 0.3 m silt, medium gray, calcareous, abundant plant remains and gastropods, base not exposed. Wood sample from top of this unit, among many large logs (Hubbs, Bien, and Suess, 1963, p. 257).

The above listed radiocarbon dates are from beneath alluvial sediments in the Wabash and White River systems, which grade to the Ohio River. Descriptions with each of the above radiocarbon dated samples refer to a wood-bearing layer of mineral sediment at the base of the alluvium. None of the above dates is necessarily a maximum date for the organic layer, as the wood samples were not collected from the base of the organic unit. The dates are all within the time period from about 7000 to 1000 radiocarbon years B.P., which I suggest was a period of stable valley bottoms in the Ohio basin. The non-calcareous nature of the mineral sediments in the organic zone at one of the above localities (W-832) and of non-calcareous gravel beneath the organic zone at another locality (W-666) imply a significant period of valley bottom exposure to weathering processes, as is postulated.

Ohio River Valley

9140 ± 400 (W-1040) Switzerland County, Ind.—Wood from a creek bank along the Ohio River in Switzerland County, Ind. Sample collected from near creek level under 4 m (14 ft) of compact, non-calcareous, oxidized alluvial silty clay. L. L. Ray comments that the sample dates the beginning of alluviation in the Ohio valley. Other radiocarbon dates from similar sites in the Ohio River valley are 9400 ± 250 (W-418) and 9250 ± 300 (I-420) (Ives and others, 1964, p. 43).

One would expect the postglacial valley profile of equilibrium and the stable valley bottom conditions to have been attained first in the lower valley reaches, in this case the Ohio River valley to which the Whitewater, Miami, Wabash, and White Rivers and others are graded, and to have proceeded headward up these tributary drainage systems. The first organic litter to have accumulated on the graded, stable valley bottom in the Ohio River valley would thus be expected to radiocarbon date somewhat earlier than these deposits in the side tributary drainage systems. Such an interpretation is suggested by the above radiocarbon dates in the Ohio River valley. The comment by Ray implies that he considered the alluvium overlying the sample to be flood plain alluvium rather than what this writer has described as a separate and distinct "high bottom" alluvial unit. The character of the alluvium overlying the dated sample is like that of the "high bottom" deposits rather than "first bottom" alluvium. Most geologists have not in the past differentiated the valley bottom lands as is done in this paper.

Cache Valley

Alexander and Prior (1968) have named the broad valley bottom surface in the Cache valley of southern Illinois the Brownfield terrace and note that at present this terrace surface is partially inundated only during those floods, such as that of 1937 in the Ohio valley, with an occurrence frequency of one in a hundred years. They correlate the Cache valley Brownfield terrace with the terrace level in the adjacent portion of the Ohio River valley that correlates with the Wabash and Ohio valley surface dated by Fidlar (1948) and Ray (1965) as late Cary in age. Soil maps of counties that include the Cache valley show the lowest valley bottom surface to have shallow soils with very weak subsoil B horizon development in silt and fine sand sediment and the highest remnants of the Cache valley fill (the Brownfield terrace) to have soils with good zonal profile development. The lower surfaces in the Cache valley, with incipient soils, would seem to be what I have described as the "high bottom" level.

Alexander and Prior (1968, p. 23) present some radiocarbon dates of interest:

750 ± 75 B.P. (GX0340)—Stump in silt, 7 m (25 ft) beneath flood plain at southern tip of Black bottom along the Ohio River.

870 ± 80 B.P. (GX0843)—Stump in clay-silt, 9 m (30 ft) deep beneath flood plain at Ropers Landing on the Ohio River.

2495 ± 110 B.P. (GX0670)— Stump in blue clay, 7 m (25 ft) deep beneath flood plain along the Ohio River between Bay City and Hamletburg.

6000 ± 480 B.P. (GX01083)—Fine grained organic particles, probably remnants of leaves, in silt, 9 m (32 ft) deep beneath the Brownfield terrace in Cache valley 2 km east of U.S. 51.

14,000 ± 550 B.P. (BX0537)—Wood in blue clay, 10 m (34 ft) deep beneath Brownfield terrace at western end of Cache valley.

13,180 ± 330 B.P. (GX0538)—Woody fragments in clay, 12 m (40 ft) deep beneath Brownfield terrace at western end of Cache valley.

Taking into account the differences in surface elevation at the above sample sites, it seems possible that the above radiocarbon dates could be from nearly the same horizon, allowing for a westward gradient down the Ohio and through the Cache valley similar to the gradient of the present terrace and flood plain surfaces.

The 13,000 to 14,000 year B.P. dates must come from within the Brownfield/Cary-Maumee fill, whose surface and un-eroded zonal soils correlate with the Cary-Maumee surface and un-eroded zonal soils in the lower Ohio and Wabash valleys. The younger dates, however, clearly come from below a younger post-Cary-Maumee alluvial fill. They come from organic material at approximately the same level and span a period from about 6000± to 750± years B.P., suggesting a long-stabilized valley bottom correlative with the buried surface interpreted elsewhere in the Ohio basin.

POSSIBLE CAUSES OF POSTGLACIAL STREAM REGIMEN CHANGES

Ogden (1966) presented a detailed and extensively radiocarbon dated pollen profile from Silver Lake in west-central Ohio and correlated its zones with a zonation sequence widely recognized in pollen stratigraphies in the southern Great Lakes region and the Eastern United States. Practically all the mid-west and eastern U.S. pollen profiles show an abrupt termination of boreal spruce forest elements and a rapid rise in oak and hickory pollen at a level that has been widely radiocarbon dated at 10,000 to 11,000 years B.P. In the Silver Lake pollen profile, Ogden (p. 395) interprets this trend to have reached a warm-moist maximum between levels radiocarbon dated at 5090 ± 265 and 3600 ±. The next pollen zone above this, to a level that radiocarbon dates at 1300 ± 423, records the widely recognized warmer and drier period (xerothermic interval) when prairie elements expanded eastward into Indiana, Ohio, and southern Michigan. The remaining segment of the Silver Lake pollen profile, which radiocarbon dates near its base at 1160 ± 250, reflects a slightly cooler and more moist condition and the establishment of present vegetational associations. The very top of the Silver Lake pollen profile, radiocarbon dated at 260 ± 108, reflects the catastrophic effects of forest clearance and European agriculture.

There is no obvious causal relationship between the early postglacial vegetational and climatic record and the alluvial history postulated for the Ohio basin. It is clear, however, from the radiocarbon dates and the deciduous trees comprising the buried organic layer that the stable valley bottom condition in Ohio basin valleys was not attained until after the postglacial boreal to humid temperate climatic change. The regimen changes that caused Ohio River and other streams to begin their late-glacial and postglacial entrenchments in earlier valley train deposits were changes in water volume and debris load ratios resulting from the termination of meltwater and outwash contributions to their valleys. This adjustment was completed, and the graded condition reached in the Ohio River valley about 9000 years B.P. and in tributary valleys about 7000 years B.P.

Nor is there any alluvial stratigraphic evidence so far of effects on Ohio basin stream regimens of the warm-moist maximum shown by the Silver Lake pollen profile between 5090 ± and 3600 ± or the warm-dry xerothermic interval from 3600 ± to 1300 ±. Apparently, the stable valley bottoms remained moist and well vegetated with trees through both the warm-moist period and the warm-dry xerothermic interval. The development of forest openings and the intrusion eastward of prairie elements during the xerothermic interval was apparently a vegetation change restricted to the uplands.

The only possible causal relationship between the postulated Ohio basin postglacial alluvial history and the climatic record inferred from the pollen data is at the termination of the xerothermic interval and the beginning of the slightly cooler and more moist period ending with the present. This point of change is bracketed in the Silver Lake pollen profile by radiocarbon dates of 1300 ± and 1160 ± years B.P. As has been suggested, alluviation of the "high bottom" sediments began about 1000 years B.P. The near coincidence in time of the above events suggests a possible cause and effect relationship, but the way in which the post-xerothermic vegetational and climatic changes may have initiated alluviation is difficult to assess. Ogden (1966, p. 396) has pointed out that changes in vegetational associations revealed in pollen diagrams may have been due to either temperature or precipitation changes and not necessarily both.

Another event roughly coincident with Ohio basin "high bottom" alluviation was the establishment of relatively large and widespread agriculturally based Indian populations of the Mississippian Tradition during the period 700 A.D. to 1700 A.D. Finds of sizeable permanent villages and abundant refuse pits containing charred beans, squash, and maize, some of the latter apparently new and improved strains, point to an intensification of agriculture among these people (Silverberg, 1968, p. 295). If extensive burning of forested areas was practiced, this may have affected run-off and stream regimens.

OTHER VALLEYS IN THE MID-WEST

A number of radiocarbon dates elsewhere in the mid-west are from alluvial sections strikingly similar to those in the Ohio basin. Some examples are:

6600 ± 200 (LJ-281) Mississippi River alluvium, Ill.—Wood from tree trunk found standing erect 16.5 to 16.8 m below the surface in bank of the Mississippi River near Wood River, Ill. (Hubbs, Bien, and Suess, 1963, p. 257).

4840 ± 300 (W-823) Hutchins Creek, Ill.—Wood from terrace segment of Hutchins Creek, Union County, Ill. Log taken at 7 m (24 ft) depth below terrace surface in silt containing layers of well-preserved leaves as well as two large logs (Rubin and Alexander, 1960, p. 138).

6200 ± 125 (I-3056) Tama County, Iowa—Organic carbon from alluvium in side of valley of Four Mile Creek, Tama County, Iowa. Alluvial section: 3.4 m (11.4 ft) of alluvial silt with wood in base, lying on partially leached till. (I-3057)—7710 ± 130, and (W-235)—6800 ± 300 from the same organic unit at nearby localities. Ruhe (1969, p. 214-215) suggests that these dates mark a major valley fill that correlates with the beginning of the prairie in Iowa.

6070 ± 320 (W-1138) Portage Series, Wis.—Base of stump at depth of 6 m (20 ft) in alluvium along the Wisconsin River near Portage, Wis. (Ives and others, 1964, p 49).

6040 ± 350 (W-1139) Portage Series, Wis.—Log of drift wood with other organic matter at depth of 2 m (7 ft) in alluvium of the Wisconsin River. R. F. Black comments that these samples date the alluviation in the Wisconsin River valley (Ives and others, 1964, p. 49).

Most of the above descriptions refer to a layer of organic debris at the base of the alluvium, and one (I-3056) mentions partially leached till beneath the organic layer, suggesting a significant period of valley bottom exposure to weathering. Although comments with two of the samples (I-3056 and W-1139) indicate that workers considered the dates to mark the beginning of alluviation in those valleys, none of the above dates is necessarily a maximum or minimum date for the buried organic layer. Alluviation could have begun considerably later.

Postglacial attainment of the graded condition, the period of stable valley bottoms, and the following alluviation may not have been entirely synchronous throughout the upper Mississippi basin drainages, but stratigraphic data and radiocarbon dates suggest similarities in sequence of events. If changes in postglacial climate and vegetational associations were controlling factors, synchroniety of events would not be expected as the postglacial pollen zonations in Minnesota and farther west are not time-synchronous with those in the eastern United States (Wright, 1968, p. 85). The xerothermic interval in Minnesota radiocarbon dates between 8000 and 4000 years B.P. in contrast to dates of 3600 to 1300 years B.P. in the Silver Lake, Ohio pollen profile, and others in the east.

CLOSING COMMENTS

The postglacial sequence of events in valley development herein postulated applies with some certainty only in the upper Whitewater basin, southeastern Indiana, assuming the Berry Farm radiocarbon dates to be valid. Further detailed studies of alluvial stratigraphies, with detailed radiocarbon dating, are needed elsewhere in the Ohio basin and other mid-west valleys to confirm or deny its regional scope, and to establish relationships, if any, with the postglacial vegetational-climatic, archaeological, and historic records.

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