GEOMORPHOLOGY OF THE CENTRAL WASHITA RIVER BASIN[1]

D. W. Goss,[2] A. R. Ross, P. B. Allen, and J. W. Naney

U. S. Department of Agriculture, Southern Plains Watershed Research Center, Chickasha, Oklahoma and Department of Geology, Oklahoma State University, Stillwater, Oklahoma

The purpose of this study was to reconstruct the history of the Washita River valley near Chickasha, Oklahoma. Data from observation wells revealed that the ancient valley was deep, with a bedrock terrace. Radiocarbon dates indicated the valley fill began more than 11,200 years ago. Quartzite is present throughout three valley terraces but is more common in the highest terrace and at the alluvium-bedrock contact. Apparently, much of the alluvium has been derived from the ancient Rocky Mountains *via* the Ogallala formation. It seems possible that the Ogallala formation once extended much farther east.

The Washita River heads along the Texas High Plains Cap Rock, flows into Roger Mills County of Oklahoma between the North Canadian and North Fork of the Red River, and then takes a southeast course through Oklahoma to Lake Texoma on the Red River (Fig. 1). The river flows for the most part over deep alluvium deposited over Permian materials. Only in the headwater region where the river drains the Ogallala formation and in the Arbuckle Mountains in southeastern Oklahoma is the deep alluvium absent.

Over the past seven years, the Soil and Water Conservation Research Division of the Agricultural Research Service, U.S. Department of Agriculture, in cooperation with Oklahoma State University has made extensive studies to determine the effect of upstream flood control structures and conservation practices on the Washita River. An attempt is being made to determine the geomorphic history of the river, which will present past conditions and aid in predicting the geologic future of the river.

GEOGRAPHY

The Washita River has flow characteristic of most Oklahoma streams, but is different in geomorphology and appearance. This difference was first recognized by Willis (1) in 1903. He described the river in Custer County as being a clean stream with heavily timbered bottom land and in general having other characteristics of a stream one would expect in Ohio. Gould (2) also described the Washita as resembling an eastern more than a western river, with steep mud banks and heavy timber along most of its course. Gould also pointed out that the Washita has more precipitous bluffs, a greater diversity of topography, and a much smaller area of sand dunes than

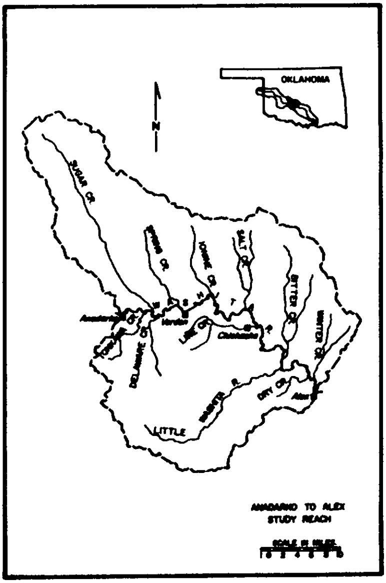

FIGURE 1. Location of research area in Oklahoma.

[1] Contribution from the Soil and Water Conservation Research Division, Agricultural Research Service, U.S. Department of Agriculture, in cooperation with the Oklahoma Agricultural Experiment Station.

[2] Present address: U.S. Department of Agriculture, Southwestern Research Center, Bushland, Texas.

Brand names are used for simplicity and easy reference and do not constitute endorsements.

Proc. Okla. Acad. Sci. 52: 145-149 (1972)

any other river in Oklahoma. He ascribes the characteristics of the Washita to the nature of the Permian material it drains.

Another anomaly of the Washita River basin is the greater depth of alluvium as compared to the alluvium in nearby rivers. The depth of the alluvium in the river valley is generally 60 to 100 feet, whereas the depth of alluvium in valleys of similar and larger rivers of Oklahoma is 20 to 40 feet.

Throughout most of the present valley there are three terraces above the present flood plain. The third or highest of these terraces is sparse and generally unassociated with the present river. This terrace is most abundant on and near the tributary stream divides and the highest areas of the basin. The two lower terraces are associated with the present river, are well defined, and are in general typical river terraces.

PROCEDURE

The Washita River reach between Anadarko and Alex, Oklahoma was selected for intensive study (Fig. 1). Observation wells were drilled through the alluvium to bedrock on 1-mile centers, and at several cross sections using 200-foot drill hole intervals. Additional cross sections were drilled to bedrock in other areas of the river in order to develop a bedrock profile. During the drilling operations, the nature of materials being removed was noted. Of particular interest was the texture of the alluvium strata and the presence of organic stratum suitable for radiocarbon dating.

Field surveys were conducted throughout the intensive study reach and through various other portions of the river to determine the nature of the river system, its terraces, and the nature of the alluvium at the surface.

RESULTS

The first step of geomorphic studies of the Washita River basin was to describe the present river valley, to determine the origin of its large quantities of alluvium, and to establish early geologic conditions of the Washita basin.

Data from observation wells were used to obtain information on the shape of the aggraded valley and the nature and depth of alluvium in the intensive study reach.

The observation wells revealed that the ancient river channel was 80 to 100 feet below the present alluvial surface. Throughout the reach examined in detail, a broad bedrock terrace was found about 40 to 50 feet below the present surface (Fig. 2).

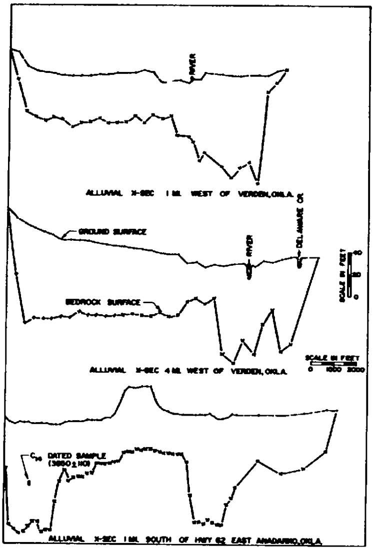

FIGURE 2. Bedrock cross-section showing bedrock terraces and deep valley, Washita River.

An attempt has been made to reconstruct a bedrock topographic map in the reach between Anadarko and Alex, Oklahoma. Since sufficient control points were not available to produce a complete topographic map, data obtained from the observation wells were used to recalculate a contour map. A Benson-Lehner plotter in conjunction with an IBM 1130 computer was used to calculate and contour the observation well data. The resultant topographic map is shown in Figure 3. The deep narrow central valley is not evident in the contour map, probably because of its narrowness as well as insufficient data points to define its location. However, the general relation between the bedrock terrace and the central valley can be seen in the detailed bedrock cross sections presented in Figure 2. The bedrock terrace indicates the river ex-

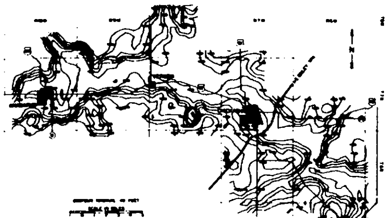

FIGURE 3. Computer developed bedrock topographic map of Washita River Basin from Anadarko to Alex, Oklahoma.

perienced a fairly long period of maturity before rejuvenation began eroding the narrow valley.

Dating of alluvial deposits was very important in the development of the geomorphic history of the valley. Animal bones recovered from near the surface of the flood plain and terrace deposits have been identified by personnel of the Museum of the Great Plains at Lawton, Oklahoma, as were those of modern cattle, canines, and bison. The way the bones were oriented with the sediments indicated that they were buried *in situ* shortly after death. Radiocarbon dating of one group of bison bones, by the USDA Sedimentation Laboratory, Oxford, Mississippi, showed the bones to be less than 200 years old. The laboratory at Oxford also dated organic material from two buried soils found beneath the lower terrace. The deepest soil, 10 feet below the terrace surface, was dated as 1,760 ± 150 years Before Present (B.P.). The shallowest soil, 8 feet below the surface, was dated as 1,000 ± 100 years B.P. In addition, charcoal samples collected 7 and 9 feet below the surface of the alluvium were dated as 2,025 ± 150 and 2,215 ± 150 years B.P., respectively. Several pieces of wood were recovered from a depth of about 50 feet during drilling operations near Anadarko. Samples of this wood were dated, by Isotopes, Incorporated, as 3,850 ± 110 years B.P.

A mammoth was uncovered in the headwaters of Tonkawa Creek which drains into the Washita River near Anadarko. The mammoth excavation was directed by the Museum of the Great Plains, Lawton, Oklahoma, and named by them the Domebo site. Radiocarbon datings of organic remains uncovered at the site indicate burial occurred about 11,200 years B.P. The site was very near the alluvium-bedrock contact and could possibly indicate the approximate time at which aggradation set in over the entire central Washita River valley. Table 1 shows the various radiocarbon dates, location of the dating site, depth of the dated stratum, and the average rate of aggradation since burial. The mean aggradation rate for the Domebo site was calculated by assuming that its date approximates the age of the deepest sediments in the Washita River valley. The true aggradation rate is probably cyclic, greater at some times than at others, with degradation possibly occurring during certain intervals. The average of the individual aggradation rates was 0.0072 foot per year and the estimated standard deviation was 0.0035 foot per year. Each individual aggradation rate falls within two standard deviations from the mean of the group, indicating that the extension of the Domebo site date into the main river valley may be valid.

It is generally believed that the Ice Age ended about 15,000 years ago. This date is rather arbitrary since it assumes the end to be concurrent with the disappearance of glaciers from northern Iowa and Minnesota. However, considering these dates and aggradation rates, it seems unlikely that sedimentation in the present Washita River valley was influenced by climatic changes occurring during the Pleistocene.

The most significant characteristic of the alluvium was the presence of quartzitic coarse sands and fine gravels in the lower 3 to 20 feet of the alluvium profile. This portion of the alluvium could not have originated from the local country rock because quartzite is not one of their common constituents. In addition to these quartzite deposits, the third or highest terrace of the river consists almost entirely of quartzitic coarse sands and fine gravels. Blanchard (3) believes these high terraces were deposited during late Tertiary or early Pleistocene on a high peneplained area by rivers migrating laterally over the areas and not cutting downward. The position of the high terraces most likely coincides with the old peneplain recognized by Fenneman (4). Hendricks (5) found similar materials associated with the Canadian River in Oklahoma and suggests their source as the Rocky

Mountains or the Tertiary and Pleistocene deposit of the high plains. General observations support the aforementioned findings.

The lack of materials available for radiocarbon dating in the high level terraces prevents ascertaining an accurate date for their deposition. However, since it probably took the river considerable time to cut down through the Permian materials to its maximum from the level of these terraces, it is most likely that they were deposited no later than late Tertiary. Thus they could have been deposited concurrently with the Ogallala formation of the High Plains. In addition, the high level gravels were probably deposited in the same manner as the Ogallala, namely, by streams meandering over a wide area similar to streams meandering over alluvial fans. Strain (6) concurs with this; he described the high terraces as being a result of gravels which were brought in from the west and spread over an area of low relief by meandering streams. Considering the facts that the composition of the Ogallala gravels and the Washita River basin high terraces are similar, that they were probably deposited at approximately the same time and in the same manner, and that the high terraces are often far removed and apparently unassociated with the present river, it is postulated that these high terraces are actually remnants of the Ogallala fomation, or reworked materials that remained as the Ogallala was removed. The eastern extent of the Ogallala has not been established; however, the high gravel terraces have been observed in the Washita River basin as far east as Grady County.

Apparently the present course of the Washita River was of post-Ogallala age, or if a pre-Ogallala course was defined, the Washita River has been superimposed on the present country rock. The latter is quite possible since the southeast trend of the Washita River agrees with the slope of the present Ogallala surface in the Texas High Plains. However, Smith (7) thought that the present Arkansas River course in Kansas was also of post-Ogallala age. These observations suggest that after deposition of the Ogallala had ended a period of degradation set in, removing and reworking the Ogallala throughout the course of the Washita River. The erosional period resulted in the Washita cutting deep into un-

TABLE 1. *Radiocarbon dates from the Washita River Basin.*

Material	Location	Depth in feet	Age (years B.P.)	Mean aggradation rate (feet/year)
Bison bones	Washita River bank	14	Recent	—
Bison bones	Washita River bank	4	< 200	—
Buried soil	NW 1/4, SE 1/4, sec. 20, T. 6N., R. 6W., Grady County	8	1,000 ± 100	.0080
Buried soil	NW 1/4, SE 1/4, sec. 20, T. 6N., R. 6W., Grady County	10	1,760 ± 150	.0057
Charcoal	SE 1/4, NE 1/4, sec. 25, T. 6W., R. 6W., Grady County	7	2,025 ± 150	.0035
Charcoal	SE 1/4, NE 1/4, sec. 25, T. 6N., R. 6W., Grady County	9	2,215 ± 150	.0041
Mammoth (Domebo site)	Tonkawa Creek	Streambed	11,200	.0089
Wood	Terrace near Anadarko	50	3,850 ± 110	.0130
			Average	.0072

derlying rocks and removing almost all of the Ogallala material.

That the Ogallala has furnished a portion of the materials deposited as recent alluvium in the Washita valley is indicated by the fact that the lower part of the present alluvium is composed of substantial amounts of quartzitic materials. The origin of these quartzitic materials was most likely the Ogallala overburden which, for the most part, has been removed.

The upper portion of the recent alluvium was generally devoid of quartzitic materials and was composed of finer materials than the lower portion. This upper portion was debris from the Permian geologic materials which presently make up the surface geology of the area. The Washita River is the only Oklahoma river that presently has almost its entire basin within Permian materials. Most of the Permian deposits are finer textured than the Ogallala or deposits of other periods occurring in basins of rivers flowing through western Oklahoma. Thus, the source of Washita River upper alluvium explains why its texture is finer than that of the alluvium of other Oklahoma rivers.

The finer texture may explain, in part, the greater thickness of the alluvium in the Washita River as compared to that in other Oklahoma rivers. The fine-textured, more fertile sediments in the Washita may have encouraged a lush vegetative complex which increased sedimentation. However, this fact alone does not account for the two to four times greater thickness of alluvium in the Washita. At this time no complete explanation can be given for the great thickness of the alluvium.

CONCLUSIONS

Observations and research on the central basin of the Washita River show that the Washita is quite different from other Oklahoma rivers. These differences are expressed in the depth, texture, and fertility of the alluvium. The fine texture and high fertility of the alluvium are apparently due to the nature of the Permian materials the Washita River drains. The fine texture of the source of the alluvium may partially explain the alluvium's great depth.

The presence of high level quartzitic terraces and quartzitic materials in the lower part of the recent alluvium indicates that the Ogallala formation may have extended as far east as Grady County. The sequence of events which produced the present Washita River apparently began in the late Pliocene when the river cut through the Ogallala. By late Pleistocene the river had cut to its maximum depth and had the characteristics of a mature river. During the late Pleistocene one or more periods of rejuvenation occurred, producing a deep narrow valley in the bedrock. About 11,000 to 15,000 years ago the Washita River began aggrading. The two terraces indicate that at least two major degradational periods have occurred. The terraces are too young to indicate that these periods were associated with Pleistocene climatic changes. However, they may be associated with recent climatic changes. Including the degradational periods, the mean rate of aggradation was about 0.0072 foot per year.

REFERENCES

1. B. Willis, *Wichita Mountain Projects*, in First Annual Report of the Reclamation Service from June 17 to December 1, 1902, Department of the Interior, U. S. Geological Survey, U. S. Govt. Printing Office, House of Representatives Doc. No. 79, Washington, D. C., 1903, pp. 267-270.
2. C. N. Gould, *Geology and Water Resources of Oklahoma*, U. S. Geological Survey Water Supply and Irrigation Paper No. 148, U. S. Govt. Printing Office, Washington, D. C., 1905.
3. K. S. Blanchard, *Quaternary Alluvium of the Washita River Valley in Western Caddo County, Oklahoma*, M.S. Thesis, University of Oklahoma, Norman, 1951.
4. N. M. N. Fenneman, *Physiographic Provinces and Sections in Western Oklahoma and Adjacent Parts of Texas*, U. S. Geological Survey Bull. 730, U. S. Govt. Printing Office, Washington, D. C., 1922, pp. 115-134.
5. T. A. Hendricks, Geol. Soc. Am. Bull. 48: 365-372 (1937).
6. W. S. Strain, *Pleistocene Geology of Part of the Washita River Valley, Grady County, Oklahoma*, M.S. Thesis, University of Oklahoma, Norman, 1937.
7. H. T. U. Smith, *Geologic Studies in Southwestern Kansas*, Kansas State Geol Bull. 34, Lawrence, Kansas, 1940.