

of this strath probably marked the close of Tertiary time, for its further development was arrested by the events of the Glacial epoch, which are described in the succeeding paragraphs.

KANSAN OR PRE-KANSAN DEPOSITION.

The further development of the Parker strath was arrested probably at the beginning of the Glacial epoch by the invasion of the ice sheet of the earliest stage of glaciation known to have affected this region. This ice sheet, moving from the north, transported great quantities of rock debris from the region over which it passed and deposited much of the same as gravel, sand, and silt over the glaciated area. This constitutes the Kansan or pre-Kansan drift sheet. This drift sheet covered an area in northwestern Pennsylvania extending to a line roughly drawn from the point where Beaver River intersects the northern boundary of Beaver County through Keenerdell, Oil City, Tionesta, and Warren, following thus the north side of the Allegheny from Oil City northeastward. (See fig. 1.) From this drift sheet great quantities of material were washed down the Allegheny and deposited by the overloaded waters upon the Parker strath. The deposition of this material continued until 100 to 130 feet had accumulated in the valleys, as is indicated by the fact that stream-borne pebbles are now in some cases found on the hillsides 130 feet above the strath.

Drainage modifications.—With the advent of warmer climatic conditions the ice sheet receded, leaving the surface covered with drift and all the old valleys filled to great depths. This valley filling was so great in many cases that the streams were deflected from their pre-Glacial courses and the new drainage relations, described on a former page, were established.

INTER-GLACIAL VALLEY EROSION.

After the drainage changes at the close of this earliest stage of glaciation the Allegheny, now the lower Allegheny, enlarged to four times its original volume, was flowing upon its bed of glacial debris. This material was attacked by the river and mostly removed, leaving only those portions which have been described as covering the remnants of the Parker strath. The work of the river did not end, however, with the removal of these deposits; it continued until a trench over 200 feet deep had been excavated in the rock below the level of the strath.

Causes of down cutting.—Leverett holds that the increased volume of the river resulting from the enlargement of its drainage basin, combined with the accession of waters from the melting ice, which had dropped their load of sediments, was mainly responsible for the trenching of the strath described above. His views are expressed in the following paragraphs.

The deepening of the Allegheny in inter Glacial times has probably been caused in part by the enlargement of its drainage area and by the accession of glacial waters which have dropped their burden of detritus near the continental divide. In addition to this the upper Allegheny region has been raised in recent times to a higher altitude compared to the country to the west, and possibly this uplift also covers the middle and lower Allegheny regions. In that case the streams have been given a better gradient for eroding their channels than prevailed before these trenches were cut. The precise influence of each of these factors has not been determined. The enlargement of the watershed to four times its former area would quadruple the erosive power. An increase in gradient sufficient to double the fall of the stream would multiply the erosive power about eight times, it being a fair working rule that the power of a stream to erode varies as the cube of its slope or the sixth power of its velocity. From this it will be readily understood how the trenching of the Allegheny has been brought about.

The similar trenching of the lower courses of the Monongahela, Youghiogheny, and Conemaugh rivers (see Campbell, Masontown, Uniontown, Brownsville, Connelville, and Latrobe folios) and Mahoning Creek is due to the adjustment of these tributaries to the bed of the master stream, the Allegheny-Ohio, for there is no evidence that there has been any increase in the volume of these streams since early Glacial times.

It is of interest to note in this connection that the headwaters of tributaries of the Allegheny are still flowing on the old straths, because more time is needed to effect complete adjustments to the Allegheny trench. For the same reason the Allegheny trench is still narrow, the time having been insufficient for the breaking down of the bluffs by weathering.

It is admitted that this increased volume was a factor in producing the result, but, for reasons presented in part on a former page, the writer thinks that elevation was the greater factor. Leverett admits the possibility of some differential elevation, but he believes it better to hold to certain causes rather than to introduce the more hypothetical one of uplift. The writer believes that at the time of the completion of the Parker strath the old Clarion-Allegheny had reduced its bed to a gradient so low that down-cutting was practically at a standstill, and erosion was confined mainly to a widening of the valley. It is believed that such a condition would have been reached only when the stream beds stood at a level much lower than 1000 feet above the sea—the present altitude of the Parker strath. If this contention is correct, the region must have been elevated to bring the gradation plain to its present elevation and thus give the Allegheny, after removing the glacial deposits, an opportunity to intrench itself in the underlying rock. The second argument is that an uplift at this time would have been in harmony with the history of the region since the close of Paleozoic time. The successive uplifts preceding the formation of the Schooley, Harrisburg, and Kittanning peninsulas, and that preceding the formation of the Parker strath, are generally admitted. Why, then, should the assumption of an uplift preceding the inter-Glacial down-cutting of the Allegheny Valley meet with strenuous objection? The third argument for uplift in this region is the well-known fact that uplift throughout northeastern United States in Glacial time is a well-established fact, and is admitted by Leverett to have affected southwestern New York. It does not seem improbable that it extended to the lower Allegheny also.

WISCONSIN DEPOSITION.

Between the earliest stage of glaciation already described and the latest or Wisconsin stage were two intermediate stages—the Illinoian and the Iowan. No drift belonging to either of these stages is certainly recognized in western Pennsylvania, and it is presumed that the ice did not reach the region. During the Wisconsin stage the ice again invaded northwestern Pennsylvania and deposited its load of drift over approximately the area covered by the earlier drift. Its margin lay nearly parallel to the margin of the older drift, but not quite so far to the southwest. The outwash from this drift consisted of coarse pebbles and boulders near the margin, but farther south, within the limits of the Kittanning quadrangle, it was composed mainly of fine silt, which covered the bottom of the Allegheny Valley to a depth of about 50 feet. Since that time the river has been eroding its present channel in these deposits and probably reworking them to a greater or less extent.

COMPARATIVE LENGTH OF GLACIAL AND POST-GLACIAL TIME.

This can be estimated by comparing the amount of work accomplished by the Allegheny during the two epochs. During Glacial time over 100 feet of glacial detritus was deposited in the valley; this material was then removed and a trench cut 200 feet into the solid rock, after which the 50 feet of Wisconsin silts were deposited. Since the end of Glacial time the river has merely trenched the soft Wisconsin material to a depth of 40 to 50 feet. These facts indicate that the Glacial epoch was many times longer than post-Glacial time.

RECENT DEPOSITION.

During post-Glacial time the alluvium forming the modern flood plains was deposited by the streams as they overflowed their banks from time to time, just as they may be observed to do at the present day.

MINERAL RESOURCES.

In the preparation of this chapter the reports of the Second Geological Survey of Pennsylvania, particularly Report H5, by W. G. Platt, have been freely drawn upon.

Coal.

Coal is to-day the most important mineral resource of the Kittanning quadrangle. There are but few areas within the quadrangle where there

does not exist one or more workable seams of coal, and these barren areas are small and belong without exception to the Allegheny formation.

Detailed sections of the various coal seams are given on the coal-section sheet, and a number of analyses of the coals are given in the table at the end of the text.

Brookville coal.—This coal lies near the base of the Allegheny formation. It is at present nowhere worked, nor is it known to be worth working anywhere in the quadrangle. It is reported by Platt to have been opened at one time on the Nickels farm nearly opposite the mouth of Long Run, in West Franklin Township, where the seam is 3 feet 2 inches thick, but so much broken by shale as to be worthless (see sec. 1 of coal-section sheet).

What appears to be this coal was observed partially exposed in the bed of Limestone Run near its mouth and may be there 2 feet thick.

Craigsville coal.—On a former page this name is adopted for a coal apparently of small extent in the vicinity of Craigsville. It was observed north of Buffalo Creek, where it lies about 50 feet below the Vauport (Ferriferous) limestone. There is an opening in this coal about 2 miles northwest of Craigsville and just north of Buffalo Creek, where the coal is 3 feet thick (see sec. 2). It was opened on the hill three-quarters of a mile northwest of Craigsville, where it is reported 2½ feet thick. The blossom of this coal was observed in the road 1½ miles north of Craigsville, and small pockets were seen in a heavy sandstone at West Winfield, where the coal is 40 feet below the Vauport limestone and 25 feet below the Clarion coal. Nothing is known of a coal in this position elsewhere in the quadrangle, and the coal at Craigsville is probably a local development of possible value only in that vicinity.

Clarion coal.—This coal is workable only at West Winfield, where there is a bank from which coal is obtained for use by the company engaged in quarrying at that place. It is there 3 feet 8 inches thick (see sec. 4). The Clarion coal is reported 2 feet thick about 2 miles northwest of Craigsville, in the same section in which the Craigsville coal is shown. It is 15 feet below the Vauport limestone at this place. At Buffalo Mills it is a worthless shaly bed 25 feet below the limestone, and at the base of the bluff just north of Applewood it is a variable bed of no value 25 feet below the limestone (see secs. 3 to 7 of coal-section sheet).

Platt reports the Clarion coal 1 foot thick on Whiskey Run in Bradys Bend (Second Geol. Surv. Pennsylvania, Rept. H5, p. 224), and a mere streak on Limestone Run (Rept. H5, p. 275).

Lower Kittanning coal.—This is the most persistent and probably the most valuable deposit in the quadrangle. Wherever found it is of minable thickness. Owing to its low position in the Allegheny formation, it underlies nearly the whole quadrangle, being absent only where it has been eroded in the deeper valleys. Such areas are small, however, and mostly confined to the northeastern part of the quadrangle. Buffalo Creek and its tributaries, Long Run and Patterson Creek, have cut below and removed considerable areas of the Lower Kittanning coal on the axis of the Kellersburg anticline from Fosters Mills southward to 2 miles below Buffalo Mills and from the head of Long Run westward to Nichols. Buffalo Creek and Rough Run both cut below the coal for a distance of about 2 miles above their junction.

The Lower Kittanning coal is rarely less than 2½ feet thick; it generally runs nearer 3½ feet, and even reaches 4 feet occasionally. It is often much broken by shale partings, which impair its purity, while iron pyrites in many places detracts from its value as a fuel. Secs. 8 to 23 of the coal-section sheet exhibit fairly well the thickness and character of the seam as developed in the various parts of the quadrangle.

The Lower Kittanning coal is at present mined on a commercial scale within the quadrangle only at the Riverview mine at Riverview or Cosmus, at the Monarch mine north of Allegheny River, about 1 mile above the mouth of Redbank Creek, and at the Keystone mine on the south side of Allegheny River above Phillipston. The Great Lakes Coal Company has taken up a large tract of land in the northern part of the quadrangle, and is making preparations to mine the coal on a large

scale. Its mines are located near Kaylor. The coal is also largely mined for use at the Kittanning Clay Manufacturing Company's brick works at Kittanning. In addition to these larger operations there are many country banks distributed over the quadrangle from which considerable quantities of coal are taken, or were formerly taken, for local use.

Middle Kittanning coal.—A number of abandoned openings were observed in what is apparently this seam in the region between Allegheny River and Sherrett, Morrows Corner, and Adrian, but as these are now all closed nothing could be learned concerning the coal. On the ridge between Huling Run and the river, about 1 mile south of Wattersonsville, a bank in the Middle Kittanning is now open and shows the relations illustrated by sec. 24 of the coal-section sheet.

In the bluff of the river north of Applewood this coal has a thickness of 15 inches. So far as the writer's knowledge goes, this coal is nowhere else open for observation and measurement, and its value is entirely conjectured, though probably it is slight.

Upper Kittanning coal.—This coal is usually a mere streak, only a few inches thick, but swells locally to minable thickness. At Somerville, where it probably is best known and most extensively worked, it is described as a bituminous coal of fair quality, occurring as a seam 2 feet thick at the outcrop and thickening rapidly to 5 feet within the mine, where the bottom of the seam remains about horizontal. The coal is underlain by a bed of canal shale of no value, which thickens downward from the outcrop even more rapidly than the coal until it attains a thickness of 7 feet, thus making the total thickness of coal and canal shale 12 feet (Second Geol. Surv. Pennsylvania, Rept. H5, p. 222.) The coal and shale thus occupy a depression in the underlying shale. This mode of occurrence of the seam where it becomes minable seems to be typical of the Upper Kittanning coal in this region and has earned for it the name "pot vein." There is a working bank on this coal at Kaylor and another in Washington Township near the top of the north side of a hill about 1½ miles due northeast of Morrows Corner. There are a number of abandoned openings in the vicinity of Sherrett and Adrian and in the region between those places and Allegheny River. It was formerly mined in the vicinity of Cowansville and on Long Run in West Franklin Township, and sections of the seam at those places, taken from Platt's Report H5, together with sections from other localities, are given on the coal-section sheet (secs. 25 to 31.) The sections should probably be regarded as good only for the immediate locality from which each one was obtained. They seem to indicate, however, the probability of deposits of considerable value in parts of Washington and Sugarcreek townships and in the northern parts of East Franklin and West Franklin townships. The only other locality known to the writer where this coal has been opened is just west of the county line in Donegal Township, near the road eastward from Rattigan. There is an old opening here that appears to be in the Upper Kittanning coal.

Lower Freeport coal.—So far as known this coal is workable only in comparatively small areas. The largest of these extends along Glade Run from the southern border of East Franklin to Cowansville, and thence possibly through the hilltops to Peach Hill, where it is of good thickness over a small area near the top of the hill. It makes a good showing in the road near the top of a narrow ridge in the western part of Sugarcreek Township, 1½ miles slightly northwest of Sherrett. It is about 5 feet thick in the tunnel 1 mile southwest of Cowansville and about 4 feet in the cut midway between Cowansville and Adrian. It was formerly mined in the vicinity of Kittanning, but its thickness there is too uncertain to justify attempts at mining on a large scale. There is a considerable area in southern Donegal and northern Clearfield townships, where the Lower Freeport is probably workable.

The Lower Freeport coal is mined on a commercial scale only at Cowansville, where the Cowansville Mining Company is operating. There is a bank at Walkchalk, another 1 mile south of Walkchalk on Glade Run, and two more on a western branch of Glade Run in the southwest corner

Kittanning H5