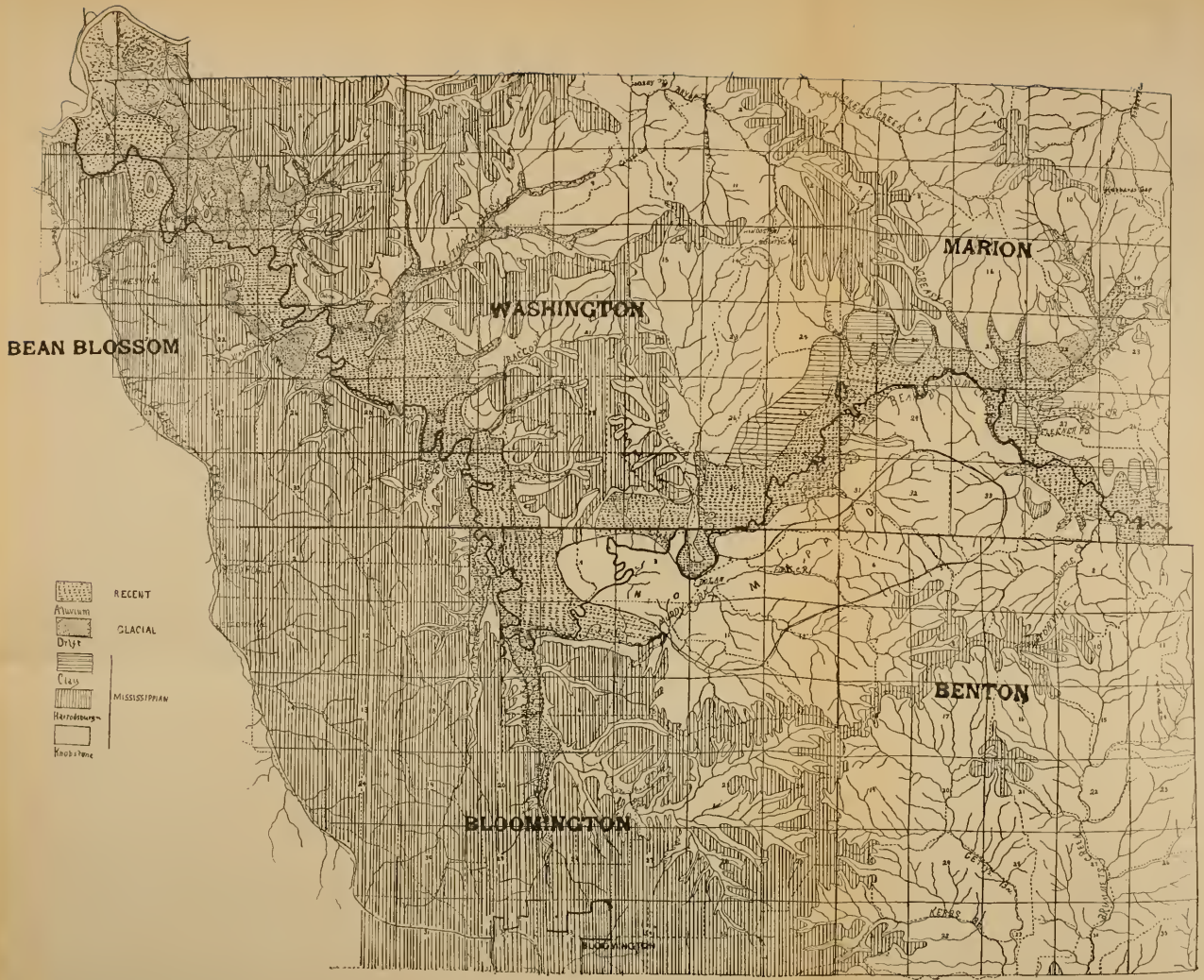
BEAN BLOSSOM
WASHINGTON
MARION
BENTON
BLOOMINGTON
RECENT
Alluvium
GLACIAL
Drift
MISSISSIPPIAN
Clays
Harrodsburg
Knobstone

Geology of Monroe County, Indiana, North of the Latitude of Bloomington.

By Albert B. Reagan.

This work was undertaken as independent research work in stratigraphic geology in Indiana University, in the summer of 1903, at the suggestion of Dr. J. W. Beede.

In 1880 Mr. G. K. Green published a paper entitled "Geology of Monroe County,"* in which he discusses the stratigraphy of the county, giving several sections and lists of fossils and a very generalized geological map of the county. Mr. C. E. Siebenthal has given a lengthy description of a considerable part of the the region here under consideration in his report on the "Bedford Oölitic Limestone."** Prof. V. F. Marsters describes the geography of Bean Blossom Creek in an article entitled "Topography and Geography of Bean Blossom Valley, Monroe County, Indiana."*** These papers will be discussed when the subjects with which they deal are taken up.

GENERAL REMARKS.

The rocks of this region, with the exception of the Glacial and post-glacial, are Mississippian in age. At the close of the Mississippian period or in the later Carboniferous time the region was raised above the sea. With the exception of a few cases due to local warping its strata dip gently to the southwest. After the area was elevated, the erosive agencies thoroughly dissected the region. The master stream, Bean Blossom Creek, and its numerous tributaries incised for themselves canyon-like valleys. Then on reaching grade, they widened their inner valley floors. On these floors the streams meandered, until a glacier, which crossed the northern part of the county, dammed the lower Bean Blossom and laked the region. Since the retreat of the glacier, side tributaries have, for the most part, recut their channels through the glacial debris to their former level; and

*2d Ann. Rep. Bureau Statistics and Geology, Indiana, pp. 427-449, 1880.
**21st Ann. Rep. Geol. Nat. Res. Ind. pp. 293.
***Proc. Ind. Acad. Sci. 1902 (for 1901), pp. 222-237.

Bean Blossom is now aggrading its channel. The region thus dissected by stream-cutting presents an intricate mass of small, deep canyon-like valleys separated by sharp ridges.

STRUCTURE.

The Mississippian rocks of northern Monroe County are divided into the following formations beginning at the top; Mitchell limestone, Salem (Bedford) limestone, Harrodsburg limestone and the Knobstone (the latter including the Riverside sandstone and the New Providence shales). These formations are exposed in the order named as one passes across the county from west to east. The dip is to the south of west.

SECTIONS.*

Section 1.—From Stout's Creek east to the top of the divide on the half section line of Section 8, Bloomington Township:

Harrodsburg limestone—

		Feet.
1.	Unseen	20
2.	Thin-bedded limestone	15
3.	Very thin-bedded, gray limestone (crinoid stems abundant).	5
4.	Thin-bedded limestone	10
5.	Massive limestone forming base of cliff	20

Knobstone—

6.	Massive sandstone	20
7.	Shaly sandstone and sandy shale	32
8.	Unseen	25
	Total	147

Section 2—On small creek near northwest corner of northeast ¼ Section 7, Bloomington Township:

Oölitic—

		Feet.
1.	Unexposed	70

Harrodsburg limestone—

2.	Thin-bedded limestone (Spirifer)	2
3.	Unseen	12

*The strata of the sections are numbered from the top downward.

		Feet.
4.	Dark, irregular, non-fossiliferous limestone weathering rough. (There are rusty particles in this stone which forms the falls in the stream.)	10
5.	Limestone	4
6.	Rather massive, dark, iron-gray limestone forming second fall	2

Knobstone—

7.	Very hard, thin-bedded, light-colored sandstone	4
8.	Massive, hard sandstone	4
9.	Thin-bedded limestone grading into massive sandstone. Forms third fall	25
10.	Unseen. Sandstone?	5
11.	Sandstone	5
12.	Massive, thin-bedded, soft, light-colored sandstone	20
13.	Light-colored sandstone weathering to yellow and brown	10
14.	Shaly sandstone and sandy shale	20
15.	Unseen	20
	Total	213

Section 3—On the west line of Section 5, Bloomington Township, near southwest corner:

Knobstone—

		Feet.	*Inches.*
1.	Massive sandstone with reddish-brown bands	4	0
2.	Laminated white sandstone with reddish-brown bands	5	0
3.	Massive light-colored sandstone	2	0
4.	Laminated soft, brown sandstone with reddish-brown bands	0	8
5.	Shaly sandstone	9	4
6.	Massive, rather soft, light-colored sandstone. Weathered surface dirty brown, rough, pitted	10	0
	Total	31	0

Section 4—Near the northwest corner of the southeast ¼ of the northeast ¼ of Section 25, Bloomington Township:

Harrodsburg limestone—

		Feet.	*Inches.*
1.	Light to dark gray limestone	5	0
2.	Very thin-bedded, rough, non-fossiliferous limestone.	12	0
3.	Unseen. Limestone?	10	0
4.	Dark gray limestone weathering rough and pitted. Very fossiliferous	0	2
5.	Thin-bedded limestone, gray in color and weathering a pitted surface	5	0
6.	Laminated, thin-bedded, fine-grained, gray limestone	0	6
7.	Unseen	5	0
8.	Thin-bedded, course, iron-gray limestone weathering rough. Forms an escarpment	10	0

Knobstone—

9.	Sandstone	40	0
	Total	87	8

Section 5—Just east of Andrew Stine's residence, one and one-half miles east of Stinesville.

Glacial—

		Feet.	*Inches.*
1.	Unseen	2	0
2.	Cross-bedded brown sand, indurated at the top	12	0
3.	Unseen	5	0
4.	Very finely laminated, yellow sand, banded with brown	0	4
5.	Closely compacted gravel composed mostly of angular fragments, many of which are foreign to the region	1	0
6.	Irregularly stratified sand (moulding)	5	0
7.	Uncemented, light-brown sand	25	0
8.	Reddish-brown sandy clay	5	0

Harrodsburg limestone—

9.	Limestone forming precipice in ravine	0	4
10.	Very hard, thin-bedded, dark-gray sandstone	5	0
11.	Very hard, bluish-gray sandstone	15	0

		Feet	Inches.
12.	Thinly-bedded gray sandstone, banded with streaks of white	0	4
13.	Thin-bedded, light-colored sandstone	10	0
14.	Sandstone	35	0
15.	Unseen	20	0
	Total	140	8

The sand represented in the upper part of this section was deposited at the foot of the glacier. The mouth of the little stream was closed by the ice and its basin laked, allowing the deposit of the stratified material. The stream has since cut a gorge through the center of the deposit. The lateral extent of the deposit is not great because the little lake was small and narrow.

Section 6—In railroad cut 1 mile north of Stinesville:

Thicknesses, in part, estimated.

Harrodsburg limestone—

		Feet.	Inches.
1.	Massive to thin-bedded limestone	40	0

Knobstone—

2	Very hard, rough-feeling, granular, calcareous sandstone weathering to a rusty brown	0	3
3.	Bluish-gray, massive sandstone	3	0
4.	Bluish-gray sandstone filled with chert and geodes	0	8
5.	Soft, blue sandstone	0	3
6.	Calcareous, fossiliferous, somewhat cherty sandstone	0	6
7.	Bluish-gray, very soft shale	0	8
8.	Thin-bedded, soft, very light-brown sandstone	2	0
9.	Stratum of chert concretions	0	4
10.	Massive, brown sandstone weathering dark and pitted	6	0
	Total	53	8

Section 7.—On the road an eighth of a mile west of Bowman Schoolhouse, Bean Blossom Township:

Glacial

	Feet.	Inches.
1. Yellowish, jointy clay with small rock fragments and occasional bands of brown moulding sand one to six inches thick	12	0
2. Very light-brown sand, when wet (white when dry), and extremely fine	40	0

Section 8.—On the road west of the Able Schoolhouse, just east of Mr. Maple's residence, Bean Blossom Township:

Glacial material--

	Feet.
1. Yellow clay grading into moulding sand	15
2. Light-colored clayey sand	10
3. Yellow sand	10
4. Light-colored sand with occasional bands of gravel and a few bowlders	55
5. Yellow clayey sand	4
6. Gravel	3
Knobstone—	
7. Sandstone	2
Total	99

Section 9.—Township line, ¾-mile north of Lemon P. O.
A section in delta deposit. Glacial—

	Feet.
1. Yellow clay	3
2. Thinly-bedded, finely-stratified, yellow to light-brown clay breaking down to a hard yellowish-brown clayey earth	3
3. Yellow, laminated, extremely fine moulding sand, banded with bands of yellow, brown and white indurated material	10
Total	16

Section 10.—North and south section line, 420 yards west of Lemon P. O., on the south side of the ridge.

Harrodsburg limestone—

		Feet.	*Inches*
1.	Thin bedded, bluish-yellow limestone	5	0
2.	Thin-bedded, gray to brown limestone, poor in fossils and weathering pitted	20	0
3.	Brown to gray, rather hard limestone, composed of crinoid stems and Bryozoa	5	0
4.	Yellow, non-fossiliferous limestone with rusty particles	0	6
5.	Blue-gray limestone weathering yellow and brown	5	0
6.	Very hard, speckled limestone	0	6
7.	Very hard, rough, gray limestone, composed largely of crinoid stems	2	0
8.	Yellowish-blue limestone	1	0
9.	Massive, hard, fossiliferous limestone	4	0
10.	Limestone	10	0
11.	Thin-bedded, very hard, fossiliferous limestone (crinoids and Bryozoa)	1	0
	Knobstone—		
12.	Sandstone	45	0
13.	Unseen	30	0
	Total	129	0

Section 11.—Near Mr. C. C. Fulford's home on Indian Creek, half a mile west of Canada Gap:

Knobstone. Thickness estimated—

		Feet.
1.	Sandstone grading into coarse shales	100
2.	Bluish-gray, very soft shale	25
	Total	125

Section 12.—Up ravine near the northeast corner of northwest ¼ of Section 3, Bean Blossom Township, near Mr. Samuel Kid's residence:

Harrodsburg limestone—

	Feet.
1. Massive, white to gray, hard limestone with many geodes	15
2. Thin-bedded, very fossiliferous, iron-gray limestone (Bellerophon, Productus and Spirifer.)	4

Knobstone—

3. Thin-bedded, rusty sandstone with geodes	4
4. Massive, bluish sandstone	3
5. Thin-bedded, blue sandstone	3
6. Massive, bluish-gray sandstone	5
7. Very thin-bedded, shaly sandstone, weathering to white sandy clay	20
8. Thin-bedded sandstone	35
9. Massive sandstone	10
Total	99

Section 13.—Ellet's Hill, ¾ mile west of Lemon Schoolhouse, south of the west side of Ellet's graveyard.

Oölite—

	Feet.
1. Fine-grained, whitish-gray, oölite, like that quarried at Stinesville and Bedford	25
2. Massive, coarse-grained, dark-gray oölite	10

Harrodsburg limestone—

3. Limestone	65

Knobstone—

4. Sandstone and sandy shale	100
Total	200

Section 14.—In ravine north of Mrs. W. E. Wood's house near the center of the north line of the south east ¼ Section 32, Washington Township:

Harrodsburg limestone—

1. Mostly thin-bedded, very hard, steel-gray limestone with crinoid stems	10

Knobstone—

		Feet.
2.	Soft, brown, massive sandstone	10
3.	Thin-bedded, bluish-gray, soft sandstone shaling on weathering	45
4.	Shale	20
5.	Unexposed	10
6.	Yellowish-brown sandstone	5
7.	Not exposed	10
8.	Thin-bedded, yellowish-brown sandstone	2
9.	Covered	15
	Total	127

Section 15.—45 rods west of township line on Hindostan road near Mr. T. J. Farr's house:

Harrodsburg limestone—

		Feet.
1.	Hard, rough, dark-gray limestone containing fossils	15
2.	Covered slope	5
3.	Hard, gray limestone weathering rough, dark, and pitted	5
4.	Thin-bedded, hard, cherty, fossiliferous limestone	10

Knobstone—

5.	Sandstone	4
	Total	39

Section 16.—Ravine west of road, one-half mile south of Bean Blossom Church, north of Unionville:

		Feet.
1.	Oölitic limestone	
2.	Very hard, thin-bedded, light-gray limestone, weathering rough and pitted. Contains fossils	20

Knobstone—

3.	Sandstone, varying from shaly to massive, very soft, blue, weathering yellow and brown	90
4.	Covered slope	10

Stobo limestone, lens—

		Feet.
5.	Hard, rough, gray, crinoidal limestone	1
6.	Hard, gray limestone, few fossils	15
7.	Hard, gray limestone with rusty particles and crinoid stems	5
8.	Soft, blue, sandy shale	10+
	Total	151

STRATIGRAPHY.

The Knobstone is the surface rock over the greater part of the region here considered. It extends from Brown County west to the Harrodsburg limestone contact which extends in a general northwest and southeast direction, crossing the country east of Bloomington. Northeast of this line, however, there are several detached patches of limestone resting on the Knobstone. The entire thickness of the Knobstone is not exposed in this area; but according to Mr. Siebenthal it is about 600 feet. The formation, as far as examined, is composed of a series of alternating, friable, arenaceous shales and sandstones. On the whole the formation is non-fossiliferous. At intervals, however, as at Stobo Post Office, there are intercalated, lenticular beds of limestone and calcareous septaria with rich faunas. This formation, on account of its incoherent, loosely-cemented, easily-eroded condition, has been cut up into a confused tangle of crooked ridges and deep hollows which trend in all directions. Commercially the Knobstone is of little value on account of its friable condition, but the arenaceous shales may be of value in the making of brick and cement.

The Harrodsburg limestone lies on the Knobstone and below the Salem (Bedford) limestone. In the main, it forms a belt from three to five miles in width along the eastern outcrop of the Salem limestone or oölite, and is bordered on the east by the broken hills of the Knobstone. This limestone once covered the entire region east of the oölitic contact, as is attested by its patchy remains in various parts of the county. The triangle between Bean Blossom Creek and White River from Mt. Tabor east to within one mile of Canada Gap is capped with it. A large, irregular, much lobed area of it occurs as the surface rock in the vicinity of the Farr

schoolhouse east of Hindostan, and another just west of Hubbard's Gap. East of the railroad, about two miles southeast of Gosport, a small area of this formation is half submerged in glacial sand. Another small triangular area, with strata dipping to the east, lies on the east side of a ridge a mile south of the Bean Blossom Church. Besides the patches mentioned, there are several other small ones of this formation in the area. In addition to these, main lobes extend to the east from the limestone belt for several miles. One of these lobes extends in a linear strip to Unionville. From there it turns back toward the northwest for three miles. This strip is the watershed of the region through which it extends. On the limestone lobes are located most of the roads in the Knobstone region. The Harrodsburg limestone as exposed on Ellet's hill is 65 feet thick. Its lower portions are limestones containing a great number of geodes, or "mutton heads," which range in size from a pea to a bowlder two feet in diameter. Above the geode layers the stone contains pyrite, is somewhat crystalline, and is tinted with blue, gray, or green.

This limestone is thin-bedded. The bedding planes separating the strata are, in many instances, lenticular, intercalated masses of chert. The strata were found to be more massive toward the top of the formation. Also as the top of the formation is approached the limestone gives up its molluscan fauna and takes on a Byrozoan fauna.

"The contact of the Harrodsburg and oölitic limestones is almost always marked by a 'crowfoot' (stylolite), with which are associated masses of silicified oölitic fossils and black siliceous masses."*

To the present time the Harrodsburg limestone has proved of commercial value only for macadamizing purposes.

The Salem limestone lies above the Harrodsburg limestone and beneath the Mitchell limestone. It forms a belt about three miles in width. It begins near Gosport and extends beyond Bloomington, embracing the quarry districts of Big Creek, Stinesville, Elletsville and Bloomington. Beside the belt strip there are several detached areas. One caps Ellet's hill, near Lemon Post Office. This latter patch covers an area of about ten acres. The oölite of this patch is of average thickness and is of fair quality. It is massive, free from lamination and bedding planes.

*Siebenthal, loc. cit. p. 298.

Analyses of Salem limestone:

Sample 1 from Adams quarry--

	Feet.
Residue insoluble in acid	.44
Lime (CaO)	52.76
Magnesia (MgO)	1.04
Carbon dioxide (CO_2)	43.80
Alumina and ferric oxide (Al_2O_3, Fe_2O_3)	1.57
SO_3	.06
Total	99.67

Sample 2. Johnson quarry, Bloomington--

	Feet.
Residue insoluble in acid	.77
Lime (CaO)	54.67
Magnesia (MgO)	.60
Carbon dioxide (CO_2)	43.04
Alumina and ferric oxide (Al_2O_3, Fe_2O_3)	.42
Phosphorus peroxide (P_2O_5)	.19
SO_3	.19
Total	99.88

For exhaustive treatment of the Salem (Bedford) limestone the reader is referred to Siebenthal's article already mentioned.

THE GLACIAL DEPOSITS.

The glacial deposits, so far as the writer's observations extend are: Glacial till, outwash and eolian deposits, bench or terrace deposits and delta deposits.

GLACIAL TILL.

The drift deposit was first observed on Jack's Defeat Creek in the neighborhood of the old Dutch church. From there it continues in a northeasterly direction, crossing Bean Blossom Creek near the mouth of Camden Branch. According to Siebenthal's description* it then bends south of Lost Ridge, near the mouth of Indian Creek, and follows the course

*21st Geol. Rep Ind. p. 300.

of the latter creek to Canada Gap, continuing in the same direction and, passing a half mile south of Godsey Post Office, it crosses into Morgan County three-quarters of a mile east of Godsey. Swinging southeastward it re-enters Monroe County where Hacker's Creek leaves it, extending up that creek to the neighborhood of Hacker's schoolhouse. From here eastward the drift limit becomes harder to trace. The ice-sheet must have been very thin, since the topography shows little, if any, modification. Scattered erratics are found all over the ridge dividing the waters of Roberts' Creek from the headwaters of Honey and Hacker's creeks. It seems probable that the foot of the ice-sheet rested on this hill, and that the drift found in the head waters of Honey Creek was carried there by the water resulting from the melting of the glacier. Many large granite bowlders from one to three feet in diameter are found along the small stream leading north from Hubbard's Gap, in Sec. 11 (10 N., 1 E.), and along the other tributaries of Roberts' Creek. In section two of the same township heavy deposits of sand, gravel and till lie against the hillsides. In the neighborhood of Godsey Post Office the same phenomena may be seen. Heavy beds of gravel and till lie against the hillsides bordering their slopes on the south. In Canada Gap, section 9 (10 N., 1 W.), the evidences of ice occupation are plain though the quantity of drift material is very limited. The territory between Indian Creek and Bean Blossom Creek and White River displays evidence of ice occupation in many places in modified topography and deposits of till, sand and gravel. Till, sand and gravel occur in the valleys leading south from Hubbard's Gap in the vicinity of Fleener Post Office, and patches of these same materials are occasionally met with south of the divide east of that gap. On the whole the drift is thick in the valleys and thin on the hills. This light drift on the hills indicates that the ice-sheet which crossed them was comparatively thin.

OUT-WASH AND EOLIAN DEPOSITS.

North of Mount Tabor and between there and Gosport, as well as the south slope of the hills between Mount Tabor and Ellet's hill are covered with a heavy deposit of sand. A sand apparently identical with the above caps several hills and fills several preglacial ravines on the south side of Bean Brossom Creek near Andrew Stine's residence about two

miles east of Stinesville. The sand near Andrew Stine's residence was evidently deposited in water. That it was of glacial origin is attested by the fact that it is banded with erratic gravel. The sand here is cross-bedded, stratified and, in several instances, finely laminated. The lamination and stratification, however, are not constant. Towards the top of this sand the stratification ceases. This top seems to have been of eolian origin. This sand was deposited as an out-wash in front of the advancing glacier after it had filled the channel of Bean Blossom. That it was deposited in front of the advancing ice-sheet is clearly shown by evidence that after its deposition the glacier passed over it, crushing it under its weight until now the sand is almost as compact as the Knobstone formation beneath it. Still further evidence that the sand was deposited just in front of the ice-sheet is the fact that the Bean Blossom was filled at that point with ice. Had it been filled with sand instead of ice to the level of the present deposits some remnants of the sand would still remain on the south side of the inner valley of Bean Blossom Creek, which is not the case. The sand in the vicinity of Mt. Tabor and Gosport is very fine and flour-like. It usually forms a loose or slightly compact, massive bed twenty or more feet in thickness. Occasionally it shows indications of stratification, but at no place is the stratification constant. In speaking of this sand Mr. Siebenthal says that it seems to have been deposited from high water resulting from a melting ice sheet.* It is therefore out-wash material. How it came to be deposited as it is, however, is quite a mystery. The deposit is V-shaped with the apex to the west. A limestone ridge separates its legs. On this ridge the sand is thin and suggests by its distribution that it might be eolian in origin. It seems clear, then, that the sand on the south side of the ridge must have come around the west end of the ridge instead of over it, and that the whole deposit was laid down in the slack water between Bean Blossom Creek and White River at the time of the high water that accompanied the melting of the ice-sheet. This opinion is strengthened by the fact that the sand plain gets lower and lower toward the east instead of higher as it would had the sand come over the ridge. This conclusion is further strengthened by the fact that this sand does not occur on the current, or south side of the Bean Blossom as it probably would had it not been deposited in slack water. The sand, on the whole, seems to have been an eddy deposit.

*Op. cit.

BENCH OR TERRACE DEPOSITS.

These deposits have been described both by Mr. Siebenthal and Professor Marsters. In speaking of them Mr. Siebenthal says: "Terraces occur in the valley of Bean Blossom Creek above the crossing of the drift limit. Drift deposits occur below that, but are irregular in height and have not the level top of terraces. The terraces range from mere knolls to benches a mile wide. The lower portions of these beds consist of sand and erratic gravel with sand and smaller gravel above, and over all sandy clay and loam. These terraces seem to have been deposited by high waters which must have resulted from the melting of the glacier which covered the head waters of the creek in Brown County, and the drainage of the glacier which crossed its lower course. The various tributaries of Bean Blossom Creek have similar deposits in a smaller way, the materials of which are, however, of local origin. The fact that the drift material of foreign origin is confined to the creek itself, argues that it was derived from the glacier occupying the upper course of the creek."

In speaking of the same terraces Professor V. F. Marsters says:*

"Rimming the valley slopes are to be found a number of benches of variable widths, with surfaces sometimes as flat as a floor or with an exceedingly gentle decline valleyward, with outer edges lobate in shape and descending with a marked angle to the level of the valley floor. These occur at various points within the limits of Monroe County, invariably situated on the north and east sides of the valley, and varying in elevation from twenty feet in the lower part of the stream to seventy or more feet in the upper part of the valley near the east line of Monroe County. In all the cases examined they were found to be composed of mixtures of clay and sand undoubtedly derived from the disintegrated rock formations constituting the surface of the uplands. No glacial debris of any sort was found either on the surface or in any of the sections or cuts in the benches noted within the limits of Monroe County."

It will be readily seen that the two authors quoted above differ from each other concerning the origin of the bench material. Mr. Siebenthal says in substance, that it is of glacial origin; and Professor Marsters gives a directly opposite view, stating that no glacial material of any

*Proc. Ind. Acad. Sci. for 1901, p. 225.

kind was found in any terrace within the limits of Monroe County. The difference of opinion may be explained in part, by the fact that Mr. Siebenthal has included the delta plains in his terraces and Professor Marsters has omitted them, as is found later in his paper.

To turn to the terraces themselves, the most of them are capped with ten or more feet of a mixture of clay and sand undoubtedly derived from the disintegrated rocks constituting the surface of the uplands. Some of the other benches are capped with glacial material; others with both glacial and residual material. Underneath the loose material are always to be found friable sandstone, or more frequently sandy shales many feet above the water in Bean Blossom Creek. The bench lying between Mt. Tabor and Ellet's hill is composed of shale and shaly sandstone except at the top. The sandstones and shales are exposed at several places along the road leading east from Mt. Tabor as well as in the ravines north of the road. The top is capped by a thin layer of sand or sandy clay. The bench on which Pleasant Valley Church is situated is all shale except the top part which is composed of a few feet of residual clay on which rest ten feet of erratic gravel and clay. The bench on the north side of Bean Blossom Creek, beginning almost one-half mile east of Bean Blossom Church and extending to the Brown County line is composed of blue shale resting upon which are ten to twelve feet of residual clays.

The benches seem to be due not to glacial agencies in the main, but to the bench-weathering of the arenaceous shales of the region, together with the formation of small side deltas which have become confluent. This opinion is strengthened by the following facts: (1) The terraces are higher above the creek bed at the east than at the west, when if they had resulted from a laking of the basin as Mr. Siebenthal supposes they were, they would have been higher at the west. (2) The material did not come from the foot of the glacier in Brown County, as this author supposes, because the finer material is along and just west of the Brown County line, the coarser, farther down the creek. (3) While the benches rise toward the east the deltas of the larger tributaries do not always do so, thus leaving gaps that would have been filled had the bench material come down the creek from the glacier which crossed its upper tributaries. (4) The benches rise toward the east with the rise of the shales.

In preglacial time Bean Blossom Creek, as we shall see later, cut its channel to base level. At that time all its tributaries likewise cut to grade. Both the creek and its tributaries began to meander and to etch back

their valley sides. The thin Harrodsburg limestone being removed as well as the upper Knobstone, the shaly slopes, weathering flat, became, with the modifications mentioned above, the terraces of today.

This subject will be further investigated in the near future. At that time it is hoped that the origin of the terraces can be more definitely determined.

After the ponding of Bean Blossom Creek the tributaries silted up their channels which became miniature estuaries. They then began to form deltas in the lake and in the slack water regions. The western tributaries, for example, Buck Creek, built their deltas in a direct line toward the center of the lake. This demonstrates that the water in which the delta was built was free from strong currents. The deltas of the eastern tributaries swing westward, often forming an east and west bar, now a ridge, thus indicating that these tributaries entered a swollen, westerly-moving stream. The eastern deltas also attest that Bean Blossom Creek was not then ponded but was a slowly moving stream reaching from bluff to bluff. When the estuaries were all filled and the deltas had reached the level of the benches the tributaries spread their debris over the benches as well, so that today it is hard to tell, so far as topographical appearance goes, where the terraces leave off and the deltas begin. Two of the most conspicuous deltas are those of Buck and Wolf creeks. In writing about these Prof. Marsters says:*

"Besides the portion of each creek, wriggling across the valley bottom, there are rather long and narrow strips or delta-like accumulations similar in content to the benches already described, and extending from the valley slope to within a few yards of the Bean Blossom channel which hugs the south slope of its valley. The surface does not attain the characteristic flatness of the rimming benches, but is slightly irregular in relief and increasingly so towards the slope to which it is attached. This is especially true for the Buck Creek case, but not for the Wolf Creek. The increasing irregularity may be in part due to the nearly complete burial of a projecting spur, whose top is barely coated over with the delta deposits now spread almost across the entire width of Bean Blossom; but it must be said that no outcrops of limestone or sandstone, such as make the slopes of the valley, have been discovered within its limits. On the other hand, the irregularity of relief may have been produced by

* Loc. cit. p. 235.

the piling up of the great load of silt within Bean Blossom by the tributary, but did not succeed in building it up to the lake level; in other words, it is an incomplete delta, or bar.

The Wolf Creek case differs from the former only in having a moderately flat top, or at least the higher flats on it attain about the same level, thus suggested that it was built up nearer to water level, and hence more even and uniform in relief. These differ from the rimming benches only in that they *extend across the valley floor*, while the former, being made by smaller streams close to each other, have built a series of small benches or deltas which have become confluent, and hence continuous *along the valley side*."

The delta material is derived from the disintegrated rocks of the adjacent uplands or is of glacial origin or is of both glacial and residual debris according to the source of the tributary and the proximity of the foot of the ice-sheet. The ice-sheet entered both Canada and Hubbard's gaps and at several places between these two gaps its foot rested on top of the Bean Blossom Creek—White River divide. Consequently glacial material is to be found in the deltas of Indian and Honey creeks leading south from these respective gaps. Below are sections from some of the most conspicuous deltas of the area:

Sections taken on the Buck Creek delta:

Section 1.—Well on Dolan road one mile north of Dolan.

	Feet.
1. Yellow clay	18

Section 2.—Well on Dolan road, one-half mile north of Dolan.

	Feet.
1. Black soil	1
2. White sand	6
3. Yellow clay	15

Section 3.—On A. Oliver's place on the Dolan road one mile north of Dolan. A well was once dug here through yellow clay for 47 feet.

Section 4.—Solomon Laughlin's well about a mile south of Dolan.

	Feet.
1. Clay and sand	36
2. Solid rock	?

Section 5.—On the road on the half section line between sections 34 and 35. Washington township, one and three-fourths miles north of Dolan.

		Feet.
1.	Yellow clay breaking down to yellow earth	5
2.	Whitish-yellow clay	1
3.	Yellow clay	1
4.	Whitish, laminated clay becoming very hard on exposure	5
5.	Yellow jointed clay	5
6.	Yellow to brown jointed clay	5
7.	Shale	1+

No glacial material of any sort was found in this delta.

INDIAN CREEK DELTA.

Section 1.—Well at Lemon Post Office.

The section here was composed entirely of loose material. The bottom of the well was in loose erratic gravel at a depth of 20 feet.

Section 2.—Marion Coater's well, forty rods east of Lemon Post Office.

		Feet.	*Inches.*
1.	Black earth	2	0
2.	Yellow clay	8	0
3.	Yellow coarse sand	0	8
4.	Gumbo clay	14	0
5.	Fine quicksand	3+	

The Indian Creek delta is composed more or less of glacial material, as is shown by the sections. This, of course, was anticipated as the stream heads in Canada Gap.

Sections taken in the vicinity of the Honey Creek delta.

Section 1.—Well north of the road one-eighth of a mile east of Pleasant Valley Church.

		Feet.
1.	Clay	5
2.	Erratic gravel	7

Section 2.—Another section near the preceding one.

		Feet.
1.	Gravel	18
	Bowlder stratum	4

Like the Indian Creek delta this delta contains glacial material. The glacial material came through Hubbard's Gap.

A section taken on a delta at the mill south of Dolan gave the following:

		Feet.
1.	Bedded, jointed yellow clay banded with red, burns red	20
2.	Bedded, laminated, jointed blue clay, hard when dry, soft when wet	5
3.	Very soft, massive, blue clay, burning white	20

POST GLACIAL DEPOSITS.

Under this head will be considered the alluvium and the alluvial fan deposits.

Alluvium.

At the close of glacial times Bean Blossom Creek and its tributaries recut their channels to an unknown depth. Then a process of meandering and slight aggrading set in, which has continued to the present time. As a result the creek and its tributaries have developed large alluvial plains. The alluvial plain of Bean Blossom will average a mile in width throughout Monroe County, while many of its branches have bottoms a quarter to a half mile wide in their lower courses. The depth of the alluvial deposits was not ascertained, but in lower Bean Blossom Valley they are probably quite thick. The best farms of the region are located on these plains.

Alluvial Fans.

A number of small V-shaped valleys with very steep channels were found traversing the steepest, southern slopes of Bean Blossom Valley. These on reaching the valley-floor spread out their debris in the form of alluvial fans, their channels disappearing altogether where the fan intercepts the valley floor. The fans project but a few yards beyond the mouths of the valleys. These are evidently fans as they do not possess the flat tops and steep outer margins of the deltas. That they are post-glacial is evident from the fact that some of the little valleys have cut their channels through glacial debris. The one just east of Andrew Stine's house will serve as an example. In addition to this the fans are built on the alluvial floor of the creek which has been made since glacial times.

PHYSIOGRAPHY.

Springs.

The springs of the area are to be found mostly in the limestone regions. They owe their origin to underground drainage. None are mineral springs so far as the writer knows. They furnish the water supply for the city of Bloomington and supply the water for domestic use throughout the region where they are found.

Abandoned Swamps.

About three-quarters of a mile north of the Lemon schoolhouse, on the top of the north bench of Ellet's hill, is a deposit of iron ore gravel. This limonite is scattered over a large area and is evidence of the existence of a large swamp which has now dwindled down to a pond. This swamp probably dates back to glacial times. It was most likely formed between the foot of the ice-sheet and the ridge that terminates Ellet's hill at the south.

Salt Licks.

Several salt licks are to be found in Indian Creek and Bean Blossom valleys. They seem to be evidence of saline shales beneath the valley floors.

Boulders not Glacial in Origin.

In a ravine just north of Ellet's hill, about a mile northwest of Lemon Post Office, are several large bowlders some of which will weigh several tons. These bowlders are not glacial in origin because they are neither scratched nor worn, but are large concretions weathered from the adjacent sandstones of the ravine. That this conclusion is correct is attested by the fact that a half-weatheredout concretion of large size is in situ projecting from the sandstone wall of the ravine near by. The concretions are largely composed of silica and are very hard.*

Lost Ridges.

Standing in line with a point between White River on the left and Bean Blossom Creek on the right in section 5, Bean Blossom Township, is a subcircular knob called Indian or Pasture Mound. This mound being

*In the vicinity of these bowlders were several granite bowlders of glacial origin.

in line with the mound to the north and being composed of the same kind of material suggests that the two were once continuous and are yet continuous beneath the valley floor.

South of Bean Blossom Creek, opposite the railroad cut in section 9 of the same township, there is another ridge standing in line with the projecting "mainland" east of Jack's Defeat Creek. It is almost a third of a mile in length, about 400 yards wide and some 80 feet above the valley floor. It seems to have been a ridge between Jack's Defeat and Bean Blossom creeks before the aggrading of the valley floor caused the former creek to change its channel to the east through a former wind gap in the ridge. This left the ridge isolated.

North of the Bean Blossom, in section 24 of this same township, there is another conspicuous ridge known as "Lost Ridge." It is in line with the "main land" to the north, from which it is separated by only about a hundred yards of flat floor, through which a small stream runs from the Bean Blossom Valley to join Indian Creek. In this case, as in the previous one, the trend of the slope and the trend of the adjacent valley slope, together with the fact that the composition of the rocks is identical, suggest attachment beneath the present valley floor. There are several other similar islands in the Bean Blossom Valley.

These bits of relief are "islands" surrounded by alluvial material. They strongly attest that the Bean Blossom Valley has been aggraded very considerably.

Half Submerged Points and Peninsulas.

Several tied-on, peninsula-like ridges, known as knobs and points, project from the valley walls into the valley of Bean Blossom Creek, with the connecting neck almost submerged beneath the alluvium of the valley. They also attest to the aggrading of the valley.

Abandoned Valleys.

In the glacial region on the south side of Bean Blossom Creek several of the short valleys that were filled with glacial debris still remain filled. The glacial filling of the other valleys have been removed wholly or in part. Those which remain filled have had no springs at their heads since glacial times. Since much of the drainage of that part of the county is underground drainage the little valleys have remained filled.

Young Valleys.

The steep-graded, V-shaped valleys of the south side of the Bean Blossom Valley have already been described in this article and shown to be postglacial. In writing of these valleys Prof. Marsters says:*

"Traversing the steepest slopes of Bean Blossom are to be found numerous V-shaped valleys, with remarkably steep channels, ending their lower course at the point of intersection of the valley floor with the adjacent slope. In all cases small alluvial fans are built on the valley floor with their apex projecting but a few feet or yards at most beyond the mouths of the young valleys. In none of the observed cases was it found that the level of the valley floor would extend into the mouth of the young valley. It is therefore believed that the greater part of the cutting of these young valleys may date subsequent to the preglacial filling. The fact that alluvial fans and not deltas with steep outer edges and flat tops occur at their mouths, suggest that they have been constructed since the laking of the valley, and hence are regarded postglacial."

Reversed Drainage Due to Aggrading.

In section 24, Bean Blossom Township, the little stream which flows through the little gap between the "mainland" and Lost Ridge normally should flow direct to Bean Blossom Creek instead of into Indian Creek. Its head waters are in Bean Blossom Valley proper, not in Indian Creek Valley. The reversal of drainage is due to the aggrading of Bean Blossom Creek, so that the fall is greater through the gap.

Change of Channel Due to Aggrading.

Jack's Defeat Creek, running northeast from Stinesville, from all appearances normally ran just east of the Monon Railroad track between the "mainland" and the lost ridge, previously described, to join the master stream. With the aggrading of Bean Blossom Creek this little creek likewise aggraded itself until, having dammed its lower course with debris, it turned east and joined Bean Blossom farther up stream.

Abandoned Channels.

There are two abandoned channels of considerable size in the region. The one, that of Jack's Defeat Creek, between the "main land" and the

*Loc. cit. p. 236.

lost ridge just east of the railroad, has already been mentioned. The other channel extends from the top of the divide just north of the Abel schoolhouse west to the limestone ridge that is half submerged beneath the sand just east of the railroad track in section 5, Bean Blossom Township. It is about a mile in width and extends from the Bean Blossom Valley north to the White River Valley. The bed of this channel, which is now filled with glacial sand, is at least twenty-five feet below the present surface, as is attested by the sections taken in the wells of the region. The origin of this channel is still undetermined. The data at hand seem to suggest that after the retreat of the ice-sheet from the immediate vicinity, an ice-gorge dammed White River and compelled it to cut a new channel. After the breaking of the ice dam the river, as the new channel was not as deep as the old, abandoned the new and resumed the old channel. As it was being abandoned the new channel became a slack water region in which was deposited the sand which now fills it.

Wind Gaps.

There are many wind gaps in the area. They are the result of the degrading action of small streams on opposite sides of a divide. The streams have etched back their respective channels until they have cut through the divide, thus forming a wind gap. Conspicuous among these are Canada and Hubbard's gaps. These two gaps are both on the divide between White River and Bean Blossom Creek. They were both in existence in glacial times as they have glacial material deposited in them. In each rested the foot of the ice-sheet, and through each was carried south into the Bean Blossom Valley large quantities of glacial debris as has been shown in the discussion of the deltas of Indian and Honey creeks; the latter creek heading in Hubbard's Gap and the former in Canada Gap. These gaps are in interest now as they furnish prospective routes for steam and electric railways.

Bean Blossom Creek.

Bean Blossom Creek enters Monroe County from the east a little south of the northeast corner of the county and flows a little south of west to the northwest corner of Bloomington Township.* Here it changes its direction to a northwest course. It continues in this direction until it

*The change in the course of this creek is due to its sheering off to the northwest on coming in contact with the harder Harrodsburg and Salem limestones. Its lower course follows the trend of these out-crops.

enters White River a mile below Gosport. Throughout the county it has a wide, flat-floored picturesque inner valley, averaging a mile in width, the sides of which range from 100 to 200 feet in height. In this valley the present diminutive creek persists in keeping to the southwest side. The slopes of the valley usually range somewhere between 25° and 40°; the steeper slopes being usually on the south side, the south slopes of Ellet's hill and Mt. Tabor north of the creek being the only examples to the contrary. Rimming the valley slopes are a number of benches of variable widths, as has been previously noted, while projecting above the alluvium of the valley are hummocks and ridges, "islands" whose content is precisely the same as the country rock on either side of the valley. Beside these, tongues, promontories and tied-on ridges project into the valley.

This stream has had a varied history as has been already roughly outlined. It will be discussed under three heads, Preglacial, Glacial, and Postglacial history.

Preglacial History of Bean Blossom Creek.

At the close of the Mississippian period, or later in preglacial time, Bean Blossom Creek incised its channel to a depth much below its present level. That the incision was made in preglacial time is indicated by the following facts: (1) The old valley is now half filled with debris some of which is glacial in origin. (2) Its tributaries to the north as well as the wind gaps due to preglacial drainage likewise have glacial debris in them. (3) The glacier which crossed the northwestern part of Monroe County passed over and filled the creek, as is evidenced by the sand and glacial drift left in its valley. That the channel was deeper in preglacial time than now is demonstrated by the following evidence: The creek now meanders on a flat floor a mile in width. The floor, which is composed of alluvium for the most part, is still being aggraded. (2) Wells dug in the valley floor north of the channel, show that the loose material has great thickness. Mr. James Hughes' well, at his home on the road one mile east of Mt. Tabor nearly in the center of the southeast quarter of section 10, is 65 feet deep, yet it does not penetrate the entire thickness of the valley filling at that place. (3) Many of the meander-cut slopes have been largely buried beneath the valley filling. (4) Many of the tributary valleys, such as Jack's Defeat Creek, are aggraded for some distance up stream.

After incising the valley and widening it by meander cutting, Bean Blossom Creek began to aggrade its channel and at the close of the preglacial time had filled it nearly to the level it is today. The evidence in favor of such a conclusion is as follows: (1) At all points where the creek was protected from the invasion of glacial debris by promontories, such as Mt. Tabor and Ellet's hill, it still flows on the north side of its valley. At all other places it was driven to the south side by glacial debris. (2) The greater part of the clay and silt occupying the valley floor is of precisely the same kind as that covering the unglaciated highlands and valley slopes. It is evident that this filling simply represents the wash and soil-creep from the slopes and uplands on either side of the valley. (3) At the mouth of the creek where the glacier crossed the country only a patchy film of sand associated with bowlders composed partly of crystalline rocks cover the underlying clays, silts, etc.

This conclusion agrees with the following statement of Prof. Marsters concerning the preglacial filling of the valley:

"Inasmuch as the greater part of the clay and silt occupying the valley floor is precisely the same in kind as that covering the unglaciated uplands and valley slopes, it is evident that this filling simply represents the wash and soil-creep from the slopes and uplands on either side. Moreover, the rate of filling was so far in excess of the ability of the stream to carry off its load that the preglacial valley became clogged with the waste to such a degree that the stream now occupying the valley floor is for much of its course quite unable to spread its meanders over the entire width; only at the narrowest sections does Bean Blossom succeed in occupying the entire valley from slope to slope.

"Inasmuch as the filling of Bean Blossom at its mouth and for some little distance up stream is covered over by a patchy film of glacial sand associated with bowlders, composed partly of crystalline rocks, the underlying clays, silts, etc., antedate the glacial coating. Moreover, the occurrence of benches (to be associated with the glacial history) resting upon the valley filling also point to the same conclusion, that the present filling of the valley, less the benches and the glacial sands, etc., near the mouth of the valley, is preglacial."

The valley fillings, less the glacial sand, are, therefore, mostly preglacial.

Glacial History of Bean Blossom Creek.

As has been previously stated Bean Blossom Creek was laked by the ice-sheet which crossed its lower course. At the time of its laking there were deposited in its valley the deltas together with the loose materials that now cover the benches on either side.*

Post-Glacial History of Bean Blossom Creek.

Since glacial time Bean Blossom has been a diminutive, meandering creek in a broad, flat-floored valley, and throughout all postglacial time it has persisted in keeping to the south or west side of its valley. Evidently it does not fit its present valley. This fact suggests that the creek has not been able, on account of its diminutive size and the lack of time, to do much constructive work since the ice retreated. It is now at grade for ten miles above its mouth and must be actually aggrading its channel.

We quote Prof. Marsters for a more detailed description of this topic.**

"Since the close of the laking stage Bean Blossom River has developed a meandering course on its broad floor. Only in the narrowest sections of the valley has it succeeded in spreading its meander belt across the entire floor. For the most part it keeps to the west or south side of the valley, and yet still assumes a meandering habit for considerable stretches. In other words, the stream does not fit the present dimensions of the broad valley, which, accordingly, must have been brought about by other conditions than that resulting from lateral cutting, by a mature stream. Cross sections of the valley at its broadest places reveal a slight curvature of surface in the center and occasional abandoned meandering channels. This slight variation from a plain surface suggests flood plain construction. Whether this constructive work antedates the glacial episode of Bean Blossom is not certain, but it would seem from the data at hand, that the present postglacial Bean Blossom has not had time or the ability to do much constructive work since pleistocene time."

Two more things of interest in connection with Bean Blossom Creek remain to be explained. They are: (1) The reason for the channel of the creek keeping to its south bank, and (2) the reason why the slopes on the south side of the valley are steeper than those on the north.

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*See Marsters, loc. cit. for further discussion of this subject.

**Loc. cit. p. 236.

The explanation of the former seems to be that the branches from the north carried in much more material than those from the south. The tributaries from the north are more numerous and larger than those from the south and carried into the valley great quantities of glacial material from the foot of the ice-sheet or material from the slopes near its foot. This caused a greater accumulation of sediment on the north side of the valley, and the deltas thus formed drove the stream to the south side of the valley. The deltas of Buck and Wolf creeks, for example, extend nearly across the valley to the south side. Where Mt. Tabor, or Ellet's Hill, protected the valley from glacial or upland sediments from the north, the channel finds its way to the north bluff. To sum up, it seems from the foregoing statements that the creek keeps to its south bluff because of accumulated material from its tributaries in the north side of the valley.

The answer to the other question, Why are the valley slopes steeper south of Bean Blossom than north of it? seems to be as follows: It was observed that the variation in the slope had a direct relation to the minuteness of dissection, or the spacing of the streams crossing it, and that the closer the streams are to each other, the more subdued the slope. As a greater number of streams cross the valley slope on the north side of the valley we find the more subdued slopes on that side. In addition to this the stream occupying the south side of the valley has confined its side-cutting to that side which has tended to keep these bluffs steeper.

Mineral Resources.

The principal mineral resources are rock, sands and clays. The rocks having been mentioned as to use and value, the sands and clays remain to be discussed.

Sand.

The sand of the area is in the vicinity of Mt. Tabor, and between that point and Gosport. This sand is very fine and flour-like and, consequently, it is not a plastering sand. However, it is a good quality of moulding sand and may be used for paving purposes. For these purposes it has been satisfactorily tried, several car loads being used. There is, besides detached patches, a continuous sand area covering several square miles to a depth of 20 to 40 feet.

Clays.

The residual clay derived from the breaking down of the Harrodsburg limestone is very stiff and of a deep red color. The clay resulting from the decomposition of the Knobstone shales is usually blue except on weathered surfaces, where it is light yellow. All the other clays of the region, those of the deltas being good examples, are yellow.

The blue clay is derived from the blue stone and shale of the Knobstone. Only three patches of this clay were noticed, one north of Bean Blossom Creek near the Brown County line, one just across Honey Creek on the road east of Fleener, the other in the delta (bench) south of Muddy Flat Creek, about a half mile south of Dolan. There are probably several other patches of this clay in the area, but as my investigations did not have reference to clays, no particular search was made for them. The clay of the first two patches mentioned is residual, while that of the last is probably stream wash and about 25 feet deep. On being burned in a kiln it burns white. The foreman of the tile mill at Dolan states that it is a good potter's clay. In burning tile the blue clay is mixed with equal parts of the yellow clay. This mixture produces a tile of fair quality.

Both the delta and bench formations in the Bean Blossom Valley are yellow above and sometimes down to a depth of 20 feet. This clay is the same in appearance as the yellow clay at Dolan that is made into tile. It is the opinion of the writer that a large tile and brick industry could be built up in this valley.

Indiana University, December 31, 1903.

Geology of the Fort Apache Region, Arizona.

By Albert B. Reagan.

(By title.)