CORNELL UNIVERSITY,
ITHACA, N. Y., Jan. 10, 1896.

Prof. W. S. Blatchley, State Geologist:

DEAR SIR—I have the honor to transmit herewith a report of my work during the past field season.

Respectfully,

E. M. KINDLE,
Assistant Geologist.

THE WHETSTONE AND GRINDSTONE ROCKS OF INDIANA.

BY EDWARD M. KINDLE.

CHAPTER I.

TOPOGRAPHY AND GENERAL GEOLOGY.

POSITION.—The sandstones which supply the coarse and fine grained whetstones and the grindstones of Indiana, are confined principally to the western half of Orange County. The territory which has been mapped during the study of these beds embraces the western part of Orange, the southeastern portion of Martin, and the northeastern part of Dubois counties lying between the second principal meridian and range line four west, and extending from the northern to the southern boundary lines of Orange County.

TOPOGRAPHY.—This region lies south of the southern limit of the drift, and presents a variety of topography very different from that found in the central and northern portions of the State. The surface of the country preserves unmodified by ice action all of the sculpturing left by the agents of erosion since the elevation of the regions above the sea.

Two very different types of topography occur in this area. Over the western and southern portion, where sandstone is the predominant rock, high narrow and crooked ridges with deep intervening valleys constitute the characteristic configuration. The larger ridges have a general east and west direction corresponding to the direction of the principal streams. Running off from the larger ridges are numerous smaller ones cut out by secondary streams, and these are indefinitely lobed.

The crests of the ridges rise from 200 to 350 feet above the valleys. A few prominent points on the ridges rise considerably higher than this. Mt. Arie, near West Baden, and Burtin Hill, southwest of French Lick, are two of the highest points in this region. Toward the northeast the ridges become less prominent until they are nearly entirely replaced to the east of Orangeville by a comparatively level limestone country, the surface of which is pitted with numerous "sink holes," or cone-shaped basins, usually ten to twenty yards across, and from eight to fifteen feet

deep, connecting through openings at the bottom with underground drainage channels in the limestone. Sometimes these "sink holes" cover one or more acres, and by the filling up of the subterranean outlet they are frequently transformed into ponds. The "sink holes" constitute the most characteristic feature of the topography between Orangeville and Orleans.

DRAINAGE.—Two streams, the Patoka River and Lost River, with their tributaries drain most of this region.

Lost River has its source in the St. Louis limestone region in the western part of Washington County. In the northeastern part of Orange County (Sec. 4, Tp. 3 N., R. 1 E.), it sinks and flows for a distance of about eight miles through an underground channel in the lower Kaskaskia limestone. Through the region where the channel of Lost River is underground numerous basins and ravines ending in "sink holes" collect the surface waters and transmit them through underground channels to the main stream. Two of these underground streams come to the surface and disappear again in a large sink hole called the "Gulf," about a quarter of a mile northeast of Orangeville. It is evident that the two streams which unite here have their sources distant from each other from the fact that rains in a quarter which renders one of them turbid do not affect the other.

Lost River leaves the underground channel at Orangeville. The old surface channel or "dry bed" unites with the stream a short distance below the "rise." This channel is dry, except after heavy rains, when the excess of water continues down from the first sink to three other sink-holes in sections 8, 13 and 11, Tp. 3 N., R. 1 W. The increase in the volume of water at the "rise" at such times causes it to flow backward up the old channel until it is filled, thus presenting the curious phenomenon of a stream flowing in two directions at the same time.

Below Orangeville Lost River meanders much, but keeps a general westerly course to White River in Martin County. A comparison of the distance in a straight line between Orangeville and the junction of Lost River and White River, with the actual length of the stream between these two points, will indicate the extent of its meanders. The distance from Orangeville to the mouth of Lost River in a bee line is about 15 miles. In covering this distance the stream traverses more than 36 miles. Throughout its course Lost River is sluggish. Below Orangeville the valley plain or bottom is usually a quarter to a mile in width. In some places the channel of the stream is cut in the alluvial material of this plain, while in others it is in limestone or sandstone.

The Patoka River and its branches drain the southern part of Orange and the northeastern part of Dubois counties. The Patoka is similar to the Lost River in its sluggish character and extensive meandering. A striking peculiarity of the Patoka is its great length as compared with

its volume. Its comparatively small volume is due to the small drainage area, which it divides with two other streams, the Ohio and the White rivers, lying on either side of it. The valley of the Patoka is cut through the Kaskaskia beds and the Mansfield sandstone. At the contact of the limestone and sandstones numerous springs break forth, furnishing an abundance of excellent water.

GEOLOGY.

GENERAL RELATIONS.—The rocks of the whetstone region all belong to the Mississippian or Lower Carboniferous formations. The subdivisions of these and their taxonomic relations are indicated below:

System.	*Series.*
Carboniferous	Coal Measures.
	Mansfield sandstone.
Mississippian	Kaskaskia.

The beds have a gentle dip to the southwest, so that in passing across the region from east to west the Kaskaskia beds, which are the predominant and almost the sole rocks in the east, are seen to pass under the Mansfield sandstone, and are found in the west only in the bottom of the valleys.

All of the Kaskaskia Limestone beds of this region, and the sandstones below the uppermost of these, are referred to the Kaskaskia group. It comprises, where typically developed, three beds of limestone and two of sandstone. These different beds will be designated respectively as the Lower, Middle and Upper Kaskaskia Limestones, and the Lower and Upper Kaskaskia Sandstones. The following section of Kaskaskia strata taken at Foote's Spring in S. W. ¼ of S. W. ¼, Sec. 11, T. 1 N., R. 2 W., shows about the average thickness of its different beds except the Lower Kaskaskia Limestone, which is only partially exposed at this point:

Slope with Mansfield Sandstone fragments	18 feet.
Upper Kaskaskia Limestone	15 feet.
Upper Kaskaskia Sandstone	35 feet.
Middle Kaskaskia Limestone	16 feet.
Lower Kaskaskia Sandstone	30 feet.
Lower Kaskaskia Limestone	6 feet.
Blue Shale	3 feet.
Lower Kaskaskia Limestone	5 feet.

LOWER KASKASKIA LIMESTONE.—The Lower Kaskaskia Limestone is usually a light ash gray in color. In structure it is a close, fine textured, uncrystalline stone breaking with subconchoidal fracture. This stone is so fine and even textured that it would make in many places a lithographic stone, but for the presence of very fine seams of calcite running through it. Rough irregular shaped nodules of chert, gray to blue or black in color, occur in this limestone at some localities.

A thin bed of sandstone occurs at some localities in the upper part of this limestone which contains numerous stems of *Sigillaria*. This Sigillaria bed is well exposed at the forks of the road just west of Buck Grove Church, and at William Shirley's, S. E. ¼ of N. W. ¼ Sec. 12, T. 2 N., R. 2 W.

DISTRIBUTION.—Over the eastern and northeastern part of the region the Lower Kaskaskia Limestone is the principal formation. The Upper Kaskaskia beds have been almost entirely removed over the region east of Orangeville. This limestone extends down the Lost River Valley about two miles below Roland Postoffice. Above this point it extends well up the valleys of the tributaries of Lost River. The Lower Kaskaskia Limestone does not extend so far west along the Patoka. It dips below the bed of the stream in the east part of Sec. 16, Tp. 1 S., R. 1 W.

LOWER AND UPPER KASKASKIA SANDSTONES.—These beds which are separated by the Middle Kaskaskia Limestone vary widely in thickness and in lithological characters. They are composed of strata of sandstone of medium coarseness, buff to light gray or white in color. In many places iron in the form of limonite concretions occurs in the massive sandstone. Thin seams of coal three to six inches in thickness are found in them at some localities. One of these thin Kaskaskia seams has been opened in the S. W. ¼ of the S. W. ¼ Sec. 24, Tp. 2 N., R. 2 W. Beds of shale sometimes in part replace the sandstones. The Lower and Upper Kaskaskia Sandstones outcrop extensively along the valleys of the Upper Patoka and Lost Rivers, and of their tributaries. The distribution of the outcrops of these shales which are of economic value will be given in detail in another part of this report.

MIDDLE KASKASKIA LIMESTONES.—This limestone is usually a close-textured, semi-crystalline, gray limestone. It is usually fossiliferous containing a rich brachiopod fauna. At some localities the Middle Kaskaskia limestone has a perfect oölitic structure developed. This structure is well shown at the spring on the north side of the road in the N. E. ¼ Sec. 4, Tp. 1 N., R. 2 W. Two systems of planes nearly at right angles to each other are often developed in this limestone. Weathering always proceeds most rapidly along the joints of these planes when they are present. In such a ledge weathering reduces the limestone to a mass of chips and slabs split off parallel with the bedding, and with trough or ditch-like depressions running through the mass of debris corresponding in position to the original joints. Where one of these troughs of weathering is much more thoroughly developed than the others, as often happens along the terrace of a hill, the resemblance to an artificial stonework thrown up by man is often striking. Good examples of this kind of weathering occur in the N. E. ¼ Sec. 28, Tp. 2 N., R. 2 W., and south of Geo. Pruitt's in the N. W. ¼ Sec. 3, Tp. 2 N., R. 2 W.

The Middle Kaskaskia limestone varies in thickness from 30 to 5 or 6 feet. Its distribution is nearly coextensive with that of the Upper Kaskaskia limestone, which is indicated on the map by the line of contact between the Mansfield sandstone and the Kaskaskia.

UPPER KASKASKIA LIMESTONE.—The Upper Kaskaskia limestone is the highest of the Kaskaskia series. It is a dark to light gray, usually crystalline limestone, composed largely of crinoid stems. This limestone is usually characterized by an abundance of *Archimedes*. This fossil is comparatively rare in the middle limestone. Like the middle limestone the Upper Kaskaskia is sometimes oölitic in structure. Sometimes it has bands of chert two or three inches or more in thickness running through it. These chert bands are of slight lateral extent and thin out to attenuate edges. They are the result of the replacement of the limestone by silica. Crinoid stems and other fossils which have been perfectly silicified occur in the chert.

DISTRIBUTION.—The distribution of the Upper Kaskaskia limestone is sufficiently indicated on the map. All of its outcrops will be found near the line separating the Mansfield sandstone from the Kaskaskia limestone.

MANSFIELD SANDSTONE.

Mansfield sandstone is the name given by Mr. T. C. Hopkins, of this survey, to the sandstones and associated strata lying above the subcarboniferous limestone and below the coal measures. The term is equivalent to Conglomerate heretofore used in the Indiana reports for this horizon.

The Mansfield sandstone comprises in this region a series of strata from 150 to 200 feet in thickness, which vary greatly in lithologic features, both laterally and vertically. Sandstone ranging in texture from coarse conglomerate to the fine-grained Hindostan whetrock constitutes the bulk of the formation. Interbedded with the sandstone are thin beds of coal, shale and fire-clay. The Mansfield sandstone generally contains a considerable amount of iron, which is concentrated in limonite nodules and bands of highly ferruginous sandstones.

DISTRIBUTION.—The map indicates in detail the distribution of the Mansfield sandstone over this area, but some account will be given here of the lithologic characters of the formation in the different portions of the region.

Southeast of French Lick the Mansfield sandstone is represented only by detached remnants 15 to 40 feet thick on the top of the higher ridges and hills. In this quarter the sandstone is usually coarse, containing much iron, with occasional thin strata of small quartz pebbles.

South of the Patoka, in southwestern Orange and in Dubois County, the Mansfield sandstone consists of thick beds of massive sandstone. Southeast of Centerville, in sec. 30, the sandstone is characterized by

marked cross-bedding. West and southwest of Ellsworth, in Dubois County, the sandstone outcrops frequently at the head of or along the sides of deep ravines, in cliffs of massive, loosely cemented, coarse buff sandstone, 30 to 80 feet high.

Between the Patoka and Lost rivers, in Dubois, Martin and western Orange, the Mansfield sandstone has developed in it, in some localities, thin seams of coal, ten to twenty-four inches thick, and associated beds of shale and fire-clay. At Sutton's coal bank, in the S. W. ¼ of the S. W. ¼ Sec. 27, Tp. 1 N., R. 3 W., the coal is 24 inches thick. The section exposed there is the following:

Coarse sandstone	? feet.
Gray shale	8 feet.
Coal	24 inches.
Fire-clay	9 feet.
Upper Kaskaskia limestone	? feet.

West of French Lick and West Baden and northwest of Orangeville, the Mansfield sandstone includes the very fine-grained sandstone beds which furnish the Hindostan whetstone.

The conglomerate structure of this formation is best developed in the sandstone cliffs at Shoals and southwest of there. On the east side of the river, at the High School building, a bed of massive sandstone forty feet thick outcrops. This sandstone is composed of loosely cemented coarse sand with some mica and numerous well rounded quartz pebbles. The stone has distinct cross-bedding dipping southeast. This is well shown in the sidewalk, just north of the railroad in Shoals, which is cut out of the sandstone in place. A half mile north of Shoals the sandstone is well exposed in vertical cliffs on the west side of the river. At the "Pinnacle" the section is approximately as follows:

Mansfield Sandstone	110 feet.
Upper Kaskaskia Limestone	10 feet.

The sandstone here is a dark buff, coarse grained stone containing much muscovite mica. Quartz pebbles are sparingly scattered throughout the thickness of the sandstone. At intervals they are aggregated together in sufficient abundance to form a typical conglomerate structure.

The sandstone is rather loosely cemented and sometimes weathers into striking forms. One of the most interesting results of weathering is seen in the "Jug Rock,"* which is a quarter of a mile north of West Shoals. The "Jug" is a pillar of conglomerate sandstone about forty feet high standing on the slope of a hill. The lower portion is about sixteen feet in diameter, while toward the top it diminishes to about five feet. The top is surmounted by a slab of much harder stone about

*An excellent reproduction of a photograph of this rock is found in the Report of this Department for 1870.

twenty-three feet in diameter. The general outline gives the impression of a jug if the observer has a sufficiently vivid imagination. The surface of the pillar is marked from top to bottom with distinct cross-bedding.

The Upper Kaskaskia Limestone, which underlies the sandstone about "Jug Rock," is absent from the section at Shoals, the sandstone extending down to the level of the river bed. A half mile south of Shoals the limestone reappears in the river bank showing a thickness of eight or ten feet; vertical cliffs of sandstone sixty or seventy feet high resting upon it. The limestone and sandstone with occasional conglomerate structure continues as far down the river as Johnson and Chenoworth's kaolin bank in Sec. 27, beyond which I have not traced it. At the kaolin bank the section is:

1. Conglomerate Sandstone.....40 feet.
2. Kaolin..... 4 feet, 6 inches.
3. Limestone.....14 feet.

The sandstone here is a typical quartz pebble conglomerate. A geode was seen imbedded in the sandstone near this section. Geodes which have weathered out of the sandstone are common on the surface of the ground in Sec. 27, Tp. 3 N., R. 4 W. One was seen ten inches in diameter. Geodes which have weathered out of the conglomerate are also frequently seen in and about Shoals. These geodes appear to be identical in every respect with those which occur so abundantly in the Keokuk Limestone in the counties to the north and east of this region. If these geodes have been derived from the Keokuk, as they seem to have been, then the Keokuk beds to the north or east must have been elevated above the sea a sufficient length of time to have been considerably eroded previous to the formations of the conglomerate beds. Kaskaskia and Keokuk rocks doubtless formed the shore line of the Carboniferous Sea across a part of the southwestern portion of the State, while the Mansfield Sandstone was being deposited. The streams eroding these rocks set free the geodes and carried them to the shallow coast waters, whence they were transported by wave action to their present position in the conglomerate beds.

At three or four points in Martin County north of Lost River the relations of the Mansfield sandstone and Upper Kaskaskia limestone observed seemed to indicate erosion of the limestone subsequent to the deposition of the sandstone. The presence of superficial deposits over the direct contact of the two at the critical points make the presence of unconformity not quite certain.

Along the branch in the west part of the sections 17 and 20, Tp. 2 N., R. 3 W., a bed of limestone 10 to 50 feet thick outcrops below the conglomerate sandstone. Near the intersection of the one-half mile line and the north and south line of Sec. 17, Tp. 2 N., R. 3 W., on the east side of the road, the line of contact of the two suddenly descends, the base of the sandstone being 8 or 10 feet lower than before. Similar relations

of the two exist near the center of Sec. 8, Tp. 2 N., R. 3 W., on the south side of the ravine heading at Frank Felkaroi's; also in the S. E. ¼ of S. E. ¼ of Sec. 5, Tp. 2 N., R. 3 W., opposite A. W. Stuart's.

At the B. & O. S. W. R. R. cut in the S. W. ¼ Sec. 29, Tp. 3 N., R. 3 W., a section 20 feet thick is exposed. It consists of a light gray sandstone in strata ½ to 2 inches thick, interbedded with dark blue clay. At another cut on the same road, in the N. W. ¼ Sec. 22, Tp. 3 N., R. 3 W., about 55 feet of sandstone, mostly thin bedded, is exposed.

COAL MEASURES.—An area embracing about six square miles to the southeast of Shoals, including the higher part of the water-shed between the Lost River and the White River, is referred provisionally to the Coal Measures. These beds have not been directly correlated with the Coal Measures to the west by tracing their connection across the country, but their lithological characters seem to indicate that they are the eastern-most outlines of the true Coal Measures. The character of the strata at the horizon is well shown at Sampson's Hill, S. E. ¼ of N. E. ¼ Sec. 6, Tp. 2 N., R. 3 W. The section there is approximately as follows:

1.	Upper hill slope, loose fragments gray sandstone not in place	15 feet.
2.	Dark blue potter's clay	6 feet.
3.	Shaly impure coal	1 foot.
4.	Light gray silicious clay	4 feet 6 in.
5.	Thin shelly sandstone	4 feet.
6	Hard light gray, rough bedded sandstone	6 feet.
7.	Clay, light gray with thin strata of limonite and limonite nodules	12 feet.
8.	Clay and sandstone	25 feet.
9.	Coal	3 feet.

CHAPTER II.

HINDOSTAN WHETSTONE.

LITERATURE.

OWEN, DAVID DALE.—In the year 1838 David Dale Owen visited one of the Hindostan whetstone quarries while making a geological reconnoissance of the State and afterwards published* a brief description of the stone. He states that the Hindostan whetstone had at that time a good reputation in the market. No fossils had then been found in the whetstone except the impressions resembling worm trails.

OWEN, RICHARD.—Richard Owen, Assistant State Geologist. visited Orange County in 1859. In a very brief description† of the Hindostan

*Report of a Geol. Reconnoissance of the State of Indiana, 1838, p. 16.
†Report of a Geol. Reconnoissance of Indiana, 1859-60, p. 144.

whetstone he gives the names of the men owning quarries at that time and mentions the well preserved ferns and Lepidodendra occurring in the whetstone.

COX, E. T.—In the report on Martin County,* Professor Cox states that Hindostan whetstones and grindstones are extensively manufactured from sandstones lying between the "upper archimedes" limestone and the oölitic limestone bed in the southeastern part of Martin County. Cox evidently confused the Hindostan stone with the coarse sandstone beds, since the former lie above both of the mentioned limestones. The account was doubtless written without visiting the part of the county mentioned, for whetstones have never been manufactured there except to a very limited extent.

Five years later Cox published† in his annual report a list of seven species of plants from the whetstone determined by Leo Lesquereux.

SMITH, S. I.—Several years ago a fossil insect wing found in the Hindostan whetstone quarry of Mr. T. V. Braxton, near French Lick, was presented to the Hanover College Museum, where it is at present. Prof. E. T. Nelson, of Hanover, sent the specimen to Yale College to be studied. It was described and figured‡ by Sidney I. Smith, who named the insect *Paolia vetusta.* The locality of the specimen in this description is incorrectly given as a "grit" quarry near Paoli.

LESQUEREUX, LEO.—In the Coal Flora,§ Lesquereux gives a list of fossil plants from the whetstone beds of Indiana, including three species of Lepidodendra and seven ferns.

ELROD AND MCINTIRE.—In 1875 Dr. M. N. Elrod and Dr. E. S. McIntire published‖ a report on the Geology of Orange County. In this report they refer the Hindostan whetstone beds to the Conglomerate or Millstone Grit on the authority of Leo Lesquereux, to whom fossils were submitted. A brief description of the whetstone is given.

GRISWOLD, L. S.—While preparing a report on the whetstones of Arkansas, L. S. Griswold visited the Hindostan whetstone quarries and published¶ an accurate description of the process of quarrying and manufacturing the stone. He also gives the results of a microscopic examination of one slide of Hindostan stone. Mr. Griswold makes the statement** that the Hindostan stone was first discovered and worked at Hindostan Falls, about 1850. This is an error, since no Hindostan stone is known to occur nearer to Hindostan Falls than ten or twelve miles. The stone was well known at least as early as 1838.***

*Geol. Surv. of Indiana, 1870, p. 105.

†Geol. Surv. of Indiana, 1875, p. 7.

‡Notice of Fossil Insect from the Carboniferous Formation of Indiana. Am. Jour. Sci., Ser. III, Vol. 1, pp. 44-46.

§2d Geol. Surv. Penn. Coal Flora, Vol. III, p. 852.

‖Geol. Surv. Indiana, 1875, pp. 205-238.

¶Geol. Surv. of Arkansas, Vol. III, 1890.

**Loc. cit., p. 82.

***Geol. Reconnoissance of Indiana, 1838, p. 14.

HISTORICAL SKETCH.

The Hindostan whetstone rock was first discovered and used early in this century. Joel Charles, who built a fort on the present site of the French Lick Springs Hotel, is said to have first discovered the stone about 1810. Wm. Kliphart and John Pinnick opened the first whetstone, where the Braxton quarry is now located, about 1825. At first the whetstone was taken from the quarry and shipped in the rough down Lost River in flatboats to Hindostan, in Martin County, where it was manufactured. The Brooks Bros. operated a whetstone quarry at this place for a number of years. From Hindostan the stone was shipped to the New Orleans market in flatboats, and came to be known by the name of the place of manufacture. The old factory has long been abandoned, and the town itself is extinct; but the name Hindostan remains inseparably attached to the whetstone. At New Albany Mr. Wm. Galbraith and Mr. J. G. Wright erected a whetstone factory in the year 1855.* They manufactured Hindostan whetstone until succeeded by Mr. F. C. Dishman, who manufactured both Arkansas and Hindostan stone at New Albany. In 1889 this factory was closed because of sharp competition in business. After the death of Mr. Dishman in 1893 the factory was sold for other purposes.

A small factory was formerly operated at Jeffersonville, Indiana, by Mr. Lewis. Only a small amount of stone was produced here. All of the Hindostan stone produced at present is manufactured in mills near the quarries.

Until three years ago the owners of the different whetstone quarries disposed of their output independently to various dealers. Since 1892 the Pike Manufacturing Company, of Pike Station, New Hampshire, has contracts with the owners of all active quarries for their entire output.

DESCRIPTION.—Hindostan stone from different quarries and from different strata in the same quarry presents considerable variation in physical characters. The best grade of stone, which is called "Washita finish" stone, from its resemblance to the Arkansas Washita stone, has a creamy white color and a hardness of about 3. Most of the other grades of stone are light gray to bluish gray in color and slightly softer than the "Washita finish" stone. Some of the stone called Orange stone has an orange tint. Occasionally the strata are colored with iron to various shades of red. Frequently alternate layers of the stone have different shades of color, giving a prettily banded structure. Sometimes the penetration of the iron laterally from the joint seams results in a banded structure running vertically through the stone instead of horizontally. The red stone is not used for whetstones, but many fancy articles

*Letter to the writer from Mrs. F. L. Dishman.

are carved from it. In some layers of the stone iron and manganese are disseminated through it in minute masses, giving it a closely speckled or peppered appearance. Dendrites of manganese sometimes occurs on the surface of the whetstone strata.

STRUCTURE.—Thin sections of the strongly marked varieties of the stone have been examined by the microscope. The examination shows the stone to be composed of very fine quartz grains. Some of these are as small as .01 mm. in diameter, while the largest measured was .0325 mm. in diameter. The great bulk of the grains are of a nearly uniform size, averaging about .02 mm. The quartz grains have generally somewhat rounded outlines, though some are distinctly angular. Some scales of mica and occasional small crystals of tourmaline are associated with the quartz grains. A few crystals of zircon and some chlorite occur in the stone.

Small masses of limonite are disseminated through all of the sections. In a slide of "Washita finish" stone from Chaillaux's quarry the iron is distributed among the quartz grains in numerous small brown and black masses. In a slide of the bluish gray Hindostan stone from Moore's quarry the limonite is more abundant, some of it occurring in lathe-shaped masses $\frac{1}{3}$ mm. in length by .05 mm. in diameter.

A thin section from the old Jackman quarry, one mile northwest of Roland, shows the extreme type of the ferruginous Hindostan stone. The limonite in this stone is in irregular masses, many of which are $\frac{1}{3}$ mm. in length. These limonite masses are fringed with numerous tooth-like projections and often terminate in clusters of sharp needles.

All of the slides are somewhat clouded with earthy matter, distributed through the ground mass. This is slight in the "Washita finish" and light colored stone, but quite marked in the bluish gray stone. The cementing material seems to be the earthy matter and iron disseminated through the stone. Pieces of the stone left standing for several days in strong hydrochloric acid remained unaltered, showing that no carbonate is present as a cement.

MANUFACTURE.—Most of the whetstone is manufactured at small mills situated near the quarries and run by horse-power. A horse-power whetstone mill comprises a circular open shed forty or fifty feet in diameter sheltering the team and driver, and a smaller closed shed at one side, in which the rub-wheel is placed. The power is supplied from a heavy vertical shaft of wood set in the center of the large shed. A horizontal pole to which the team is attached projects from the lower part of this shaft, while from the upper part projects several horizontal wooden shafts, twelve or fifteen feet in length, over the bifurcate ends of which passes a heavy rope connecting with the shafting in the rub-wheel shed. The rub-wheel consists of a cast iron disk about one inch thick and from four to six feet in diameter. This revolves horizontally and is supplied with sand and

water, while the sandstone is held against it by hand. Four of these mills are located near the quarries northwest of French Lick.

At Paoli, Braxton Brothers have erected a steam whetstone mill. It is not used at present, however, their stone being manufactured near the quarry. Mr. J. A. Chailleaux owns and operates a well equipped whetstone factory, which is furnished with a steam engine, three miles northwest of Orangeville. This factory is furnished with two rub-wheels and has a capacity of 1,200 pounds of stone per day.

The whetstone rock lies in layers often exactly the thickness of the whetstones. When thicker than desired the strata split readily to the required thickness. The stone is taken from the quarry in rough slabs three or four feet across. These are ruled off with a scribe awl into spaces corresponding to the size of the whetstone to be made. The slab is then broken into pieces along the ruled lines by means of a chisel and hammer. The rough whetstone thus prepared is taken to the mill where it is ground smooth on the rub-wheel. The sand used in grinding is obtained by pulverizing the coarse sandstone, which is abundant about the quarries. An average day's work at grinding is 300 pounds of large stone, or 125 pounds of small stone. Women and girls sometimes assist at the rub-wheel. As soon as the stone is ground smooth it is washed and then stacked up in sheds and allowed to dry thoroughly before packing. The drying produces a lighter color and hardens the stone slightly. Before shipping, the stone is packed in boxes called "cases," each holding about 100 pounds.

KINDS AND USES.—Several different sizes and varieties of whetstones are manufactured. A class of stones intended for carpenter's and bench use is made in two sizes, viz.:

No. 1 Regular, 8 x 2 to $2\frac{1}{4}$ x $\frac{3}{4}$ to $1\frac{1}{2}$ inches.
No. 1 Small, 8 x 2 x $\frac{1}{2}$ to 1 inch.

A white or buff stone with a smaller proportion of earthy matter than the ordinary is branded as "Washita Finish" stone and sold at a slightly higher price than No. 1 Regular.

About one-half dozen different sizes and shapes of small thin stones, with rounded edges, are made and sold under the name of "slips." These are used mainly by carpenters in sharpening gouges, bedding planes and similar instruments.

A considerable number of axe stones $2\frac{1}{2}$ inches square by $\frac{1}{2}$ inch thick are manufactured. These are used largely in the pine regions.

The glass-maker's file is a stone 8 inches long by $\frac{1}{4}$ to $\frac{3}{4}$ of an inch square. It is used by glass-makers in finishing glass work, and also for sharpening some kinds of tools.

The hacker stone is about 8 inches in length and of oval form. It is used in the turpentine regions to sharpen the broad-bladed hacker knives

with which the incisions are made in the turpentine trees. About 400 gross of this stone and 40 to 50 gross of scythe stones are made annually.

The doctor stone is a large stone 4 x 4 x 2 inches in size, used in the calico mills to sharpen "print doctor" knives which are used to remove ink from the cylinders on which calico is printed. From 3,000 to 4,000 pounds of these are manufactured annually. Orange stone is the name given to a variety of the stone having a pale orange color.

A few razor hones are manufactured, nearly all of which are sold to the visitors at French Lick and West Baden Springs.

Besides whetstones, there are a considerable number of fancy articles such as books and paper weights made from the whetstone rock and sold to visitors at the Springs for souvenirs. The banded and colored strata are selected for this purpose. Mr. Gabriel Dougherty, who makes most of these articles, estimates that about $300 worth of them are sold annually.

LABOR EMPLOYED.—About 25 men are engaged in the Hindostan whetstone business during part of the year. Some of the quarries are owned by farmers who close them during the summer while tending their crops. Mr. J. A. Chailleaux and Braxton Bros., each employ six to eight men during most of the year. The other quarries, when running, use about three men each. Laborers receive from 65 cents to $1.00 per day.

OUTPUT AND PRICES.—About 300,000 pounds of Hindostan stone were manufactured in 1894. Of this amount the output of the several producers was approximately as follows:

J. A. Chailleaux, Huron	109,000 pounds.
Braxton Brothers, Paoli	100,000 pounds.
Brown Moore, French Lick	20,000 pounds.
Gabriel Dougherty, West Baden	20,000 pounds.
Wm. Able, French Lick	20,000 pounds.
W. F. Osborn, Louisville, Ky	11,000 pounds.

The prices received by the quarrymen for the finished stone vary according to its size and shape. For the larger sizes 1½ to 2 cents per pound is received. For the smaller kinds, which require more labor to manufacture, the prices are from 3 to 5 cents per pound, wholesale. The Hindostan stone retails at from 5 to 30 cents per pound, according to the size and quality.

CHAPTER III.

COARSE SANDSTONE WHETSTONE.

DESCRIPTION.—The sandstone from which the coarse whetstones are made is a white or very light colored, loosely cemented, porous rock composed of coarse quartz sand. Some muscovite mica occurs through the stone. Iron in the form of limonite or pyrite concretions about the size of a pea also sometimes occurs. Stone containing small iron concretions is avoided as much as possible, but it is difficult to find it entirely free from them.

The microscope shows the quartz grains composing the stone to have a diameter of about .14 of a millimeter. In the Hindostan stone the quartz grains average .02 of a millimeter in diameter.

MANUFACTURE.—The manufacture of coarse whetstone was begun as early as fifty years ago by Nathaniel Spaulding. When the industry began, the gang saw used at present to cut the stone was unknown, and the stone was sawn in the ledge by hand.

All of the coarse whetstones are quarried and manufactured about three and one half miles southeast of French Lick, along French Lick Creek. Four quarries are operated at present. The stone occurs in massive beds, from twenty to thirty-five feet thick, which outcrop along the valleys of the streams. Only the lightest colored part of the bed is used for whetstone. Usually only five or six feet of ledge is sufficiently white and free from iron to be used. The rock is blasted or wedged out of the ledge in blocks, which can be conveniently dragged at the end of a chain by a pair of horses to the mill. The stone is sawed into slabs the thickness of the finished whetstone by a gang saw run by horse power. The block to be sawed is placed under a rectangular frame fitted with eight to twelve thin strips of iron about three inches wide. The four corners of the gang frame are supported by ropes which are connected with a single rope passing over a wheel and having one end weighted. This arrangement permits the saws to descend on the rock as it is cut. The forward and backward motion of the gang saw is transmitted from the horse power through a piece of shafting, which at one end is connected with the large cogwheel revolved by the team, and through a wheel at the opposite end with a wooden shaft at right angles to it, which is attached to the gang saw. During the process of sawing the stone is kept supplied with water. The sawed slabs are deeply marked with a scribe awl and broken into rough whetstones; these are rubbed smooth by hand on a block of similar stone. The machinery used in a sawing plant costs about $8,000.

KINDS.—Four principal sizes of whetstones are made. These are known to the trade as "medium sand," "small sand," "large table"

and "small table" stones. The "medium sand" is a stone $1\frac{1}{2}$ inches square and 8 inches long. "Small sand" stones are $1\frac{1}{4}$ inches square and 8 inches long. The "large table" is $5x2\frac{3}{4}x10$ inches in size; while "small table" stones are $2\frac{3}{4}$ inches square by 10 inches long.

This stone is well adapted to produce a very coarse harsh edge. It is largely used for shoemakers' and fishermen's knives. The extreme brittleness of the stone renders it liable to break readily on rough handling.

OUTPUT.—The total output of the coarse whetstone quarries for the year 1894 was about 15,000 pounds. Of this amount Mr. Solomon Lashbrook, of French Lick, and Mr. Wm. F. Osborn, Louisville, Ky., produced each about 6,000 pounds. Mr. David Bledsoe, of French Lick, produced about 2,000 pounds, and Mr. Stephen Flick about 1,000 pounds. Twelve to fifteen men are engaged in the quarries when they are running.

All of the coarse whetstone at present made is bought by the Pike Manufacturing Co., of Pike Station, New Hampshire. The quarrymen receive one cent per pound for the finished stone. In 1886 the stone was worth three cents per pound. The lower price has greatly reduced the average annual output. There is probably not more than one-fourth as much coarse whetstone manufactured now as ten years ago. The coarse whetstones retail at five to eight cents per pound.

CHAPTER IV.

RELATIVE VALUE AND IMPORTANCE OF INDIANA WHETSTONES.

The comparative importance of the Indiana whetstone industry can best be indicated by giving a brief account of the production of whetstones elsewhere in the United States. There are but eight States in which whetstones are manufactured for more than local use. These are Arkansas, Missouri, Indiana, Michigan, Ohio, New York, Vermont and New Hampshire.

ARKANSAS.—Arkansas furnishes two kinds of whetstone, the Arkansas and the Ouachita stones. The Arkansas stone is made from novaculite, a white stone composed of nearly pure silica, and having about the hardness of quartz. The Ouachita stone differs from the Arkansas stone mainly in being much more porous. The abrasive qualities of both depend upon the presence of minute cavities formed by the leaching out of calcite rhombs.*

*Novaculites of Arkansas, Vol. III, 1890.

The Arkansas stone is used largely for sharp pointed instruments and tools requiring a very fine edge, such as engravers', surgeons' and jewelers' instruments The best quality of Arkansas bench stone is quoted at $4 a pound; while the best grade of Ouachita sells at 60 cents per pound.

MISSOURI.—The Missouri whetstone is sold under the name of Adamascovite grit. It is manufactured at Pierce City, Missouri, by the Adamascovite Stone, Lime and Mining Co. The whetstone is made from a compact, fine-grained, rather soft sandstone, resembling somewhat the Hindostan stone. Only about 8,000 pounds per annum are manufactured. It retails at from 50 to 65 cents per pound.

MICHIGAN AND OHIO.—The production of whetstones from these two States is controlled almost exclusively by the Cleveland Stone Co., of Cleveland, Ohio. Berea, Ohio, and Grindstone City, Mich., are the principal places of manufacture in these States. Most of the whetstones made are scythe stones. They sell at from $5 to $17.25 per gross.

NEW YORK.—A whetstone known as Labrador stone was formerly quarried at Labrador Lake, in Courtland County. This quarry is not worked at present, however. The only whetstone made in the State is Arkansas oil-stone, which is made at Manlin's Station by the Pike Manufacturing Co.

NEW HAMPSHIRE AND VERMONT.—All of the quarries of these two States are operated or controlled by the Pike Manufacturing Co., which has factories at Evansville, Vermont, and Pike's Station, New Hampshire. Scythe stones constitute the larger part of the whetstone product of these States. They are manufactured mainly from schists. Some of the principal brands of Vermont stone are the "Black Diamond," "Tamoille," "Green Mountain," and "Willoughby Lake." The "Indian Pond," "Chocolate" and "Farmer's Choice" are New Hampshire stones. These stones sell at from $5 to $24 per gross.

INDIANA.—For the past three years the Pike Manufacturing Co. has controlled the output of the Indiana whetstone quarries. This has resulted in increasing slightly the price of the stone to the quarrymen and in producing a better quality of whetstones. The Hindostan 8x2 inch stone retails at from 8 to 12 cents per pound, while the Hindostan slips bring from 20 to 40 cents a pound. The coarse sandstone retails at from 5 to 8 cents per pound.

STATISTICS.—The following table* gives all the available statistics of whetstone productions in the United States for the years 1892 and '93:

* Mineral Resources of the United States, 1893, p. 673.

Production of Whetstones by the Pike Manufacturin Co. in 1892 and 1893.

State.	Kinds.	Output, 1892.		Output, 1893.	
		Pounds.	Value.	Pounds.	Value.
Arkansas	Washita stone	400,000	$60,000	300,000	$45,000
	Arkansas stone	20,000	12,000	12,000	12,000
New York	Labrador stone	500	50	200	20
Indiana	Hindostan stone	300,000	15,000	250,000	13,000
Vermont and New Hampshire	Sandstone	100,000	2,000	100,000	2,000
	Chocolate stone	20,000	2,000	20,000	2,000
	Scythe stones	16,000	50,000	13,000	40,000
	Total.....Pounds...	856,500	$141,050	682,000	$114,020
	Gross.....	16,000		13,000	

Markets.—From 50,000 to 60,000 pounds of Hindostan stone is exported annually. About 30,000 pounds of this goes to the European market. Less stone is shipped to Europe than formerly because of the reduced price of the product of trans-Atlantic quarries. Australia, South Africa and South America take annually from 20,000 to 30,000 pounds. The larger part of this amount goes to Australia and the Colonies. The coarse whetstone is not exported extensively because of its liability to breakage in long transportation. From 6,000 to 8,000 pounds are shipped to South America annually.*

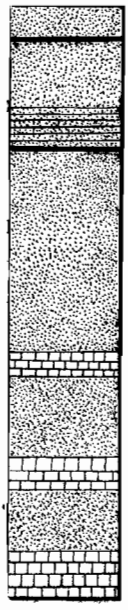
A limited amount of Hindostan stone is sent to Canada and Mexico. Whetstone shipped into Canada from the United States is subject to 30 per cent. duty. The Hindostan stone used in the United States is consumed largely in the Middle and Southern States. It would seem that a new market for the Hindostan stone could be developed in the Pacific Coast States. There are no quarries of any importance in these States. The principal whetstones used on the Pacific coast at present are the Washita stone from Arkansas and the Tam O'Shanter and Water of Ayre stones from Scotland.

CHAPTER V.

WHETSTONE BEDS.

As previously stated, two kinds of whetstones are quarried in the whetstone region from beds belonging to two distinct geological horizons. These are the Hindostan, and the coarse sandstone whetstones; or the "fine" and "coarse grits" of the quarrymen. Since both are not well developed at the same locality their relations may be shown by a generalized section.

* Letter from Mr. E. B. Pike, Pres. Pike Manufacturing Co., Nov. 29, 1895.



Mansfield Sandstone.

Kaskaskia.

(11) Coarse sandstone ..... 14 feet.
(10) Coal..... 1 foot.
(9) Coarse sandstone ..... 35 feet.
(8) Hindostan whetstone..... 20 feet.
(7) Coal..... 14 in.
(6) Coarse sandstone and shale.....100 feet.
(5) Upper Kaskaskia limestone .... 13 feet.
(4) Upper Kaskaskia sandstone (coarse whetstone sandstone).. 40 feet.
(3) Middle Kaskaskia limestone.... 15 feet.
(2) Lower Kaskaskia sandstone .... 35 feet.
(1) Lower Kaskaskia limestone .... 18 feet.

COARSE WHETSTONE BEDS.—The sandstone which furnishes all of the coarse whetstones quarried at present is the Upper Kaskaskia, No. 4 of the above section. This sandstone outcrops extensively along the upper Lost River and Patoka valleys and along their tributaries. It is only locally, however, that this bed has the proper lithologic characters for a whetstone. Along the valley of French Lick this stone is more generally suitable for whetstones than elsewhere. Along the upper portion of this valley this stone outcrops frequently in fine ledges thirty to sixty feet above the stream. The entire thickness of the sandstone bed is not apt to be sufficiently white and free from iron to be used for whetstone. Where suitable for whetstones the stone is a white, coarse-grained, friable sandstone, resembling loaf sugar. It contains no animal and but few plant fossils. The principal difficulty in collecting this stone is in getting that which is entirely free from iron nodules and concretions.

At Solomon Lashbrook's quarry (S. E. $\frac{1}{4}$ of S. W. $\frac{1}{4}$ Sec. 13, Tp. 1 N., R. 2 W.), the following section is exposed:

Middle Kaskaskia limestone .....12 feet.
Sandstone .....14 feet.
Slope of hill—rock unseen .....45 feet.
Upper Kaskaskia limestone..... 4 feet.
Mansfield sandstone..... 3 feet.

The upper two feet of No. 2 is thin bedded and is quarried for grindstones. The four or five feet below it, which is quarried for whetstone,

is a soft white sandstone with occasional small limonite concretions. The lower part of No. 2 is a brownish stone, unsuitable for whetstones, but a very good building stone.

At Stephen Flick's old quarry the ledge has been worked for about 200 yards along the brow of the ridge. The bed worked here is a white sandstone about five feet thick and quite free from iron. This quarry is located in the S. W. ¼ of the S. E. ¼ of Sec. 13, Tp. 1 N., R. 2 W.

Mr. W. F. Osborn and David Bledsoe own quarries in Sec. 18, a short distance above the Flick quarry. The quarries mentioned above are the only "coarse grit" quarries which are operated at present.

Quarries were formerly worked at the following localities:

S. E. ¼ Sec. 27, Tp. 1 N., R. 2 W.
N. W. ¼ Sec. 25, Tp. 1 N., R. 2 W.
N. W. ¼ Sec. 24, Tp. 1 N., R. 2 W.
N. E. ¼ of the S. E. ¼ Sec. 30, Tp. 1 N., R. 1 W.
N. E. ¼ of the S. E. ¼ Sec. 7, Tp. 1 N., R. 2 W.
N. E. ¼ of the N. E. ¼ Sec. 3, Tp. 1. S., R. 3 W.

HINDOSTAN WHETSTONE BEDS.—The Mansfield sandstone formation, in which the whetstone beds occur, varies greatly in lithological characters. Highly ferruginous coarse sandstones, fine-grained sandstones, shales, fire-clays and thin coal seams make up the formation. No single one of these beds, however, is co-extensive with the formation. Each of them has strong local developments, away from which they graduate into other lithologic types. The fine-grained sandstones and interstratified shales composing the Hindostan bed constitute one of these local lithologic phases of the Mansfield sandstone. The stratigraphic position of the whetstone bed is from 60 to 100 feet above the base of the Mansfield sandstone.

The Hindostan bed comprises about 25 feet of fine-grained sandstone, in strata from ½ inch to 2 or 3 feet in thickness, interbedded with shale. Several characteristic fossil plants are associated with the strata.

GEOGRAPHICAL POSITION.—The Hindostan whetstone bed is practically confined to the northwestern part of Orange County, though traces of it occur along the southeastern margin of Martin County. The whetstone bed occupies only the upper portions of the higher ridges; the greater part of the original beds have been removed by erosion.

The valley of Lost River separates the whetstone area into two geographically distinct regions, which may be designated by the names of the towns nearest them, as the Orangeville and French Lick regions. The quarries of these two districts are distant from each other about nine miles. The Mansfield sandstone formation has been almost entirely eroded from this intervening area. That the whetstone bed formerly extended continuously between these now detached regions is indicated by

its presence along the summit of the long north and south ridge, which terminates near Roland postoffice.

FRENCH LICK REGION.—The character of the whetstone strata is such that they weather away on the hill slopes without leaving outcropping ledges, so that the rock can seldom be seen except where quarried. For this reason it is difficult to examine the structure of the beds toward their lateral limits or to determine exactly where these are.

The eastward extension of the beds near French Lick conforms to the outlines of the eastern slopes of the ridges west of French Lick Creek valley. To the east of this valley all of the Mansfield sandstone, where not entirely removed, has been eroded to a level lower than the horizon of the whetstone. Towards the south and west the beds appear to become coarser and pass into a sandstone not distinguishable from the ordinary coarse variety of the region. In the N. W. ¼ of the N. W. ¼, Sec. 1, Tp. 1 N., R. 3 W., and in the S. W. ¼ of the S. W. ¼ of the same section, outcrops occur along the road which seem to belong near the southwest edge of the whetstone beds. The stone is in thin layers and has the characteristic whetstone fossils, but is much coarser than at the quarries.

On the north the whetstone beds of the French Lick region extend no farther than the upper slopes of the high ridges facing Lost River.

All the quarries of the French Lick region lie on the slopes of the ridges from 40 to 100 feet below their summits. The largest and probably the oldest of them is the Braxton quarry in the S. W. ¼ of the S. E. ¼, Sec. 32, Tp. 2 N., R. 2 W. The following is the section at this quarry:

1.	Sandstone, coarse, yellowish brown	4 feet.
2.	Clay-lead, gray, slightly silicious	5 feet.
3.	Vegetable mold (black)	8 in.
4.	Sandstone, fine-grained, light gray; in strata two to eight inches thick with shaly partings	4 feet 6 in.
5.	Sandstone, fine-grain, light gray	14 in.
6.	Shale	6 in.
7.	Sandstone	26 in.
8.	Shale and sandstone, alternating in thin layers	3 feet 5 in.
9.	Sandstone	3 feet.
10.	Coal (not seen)	1 foot 2 in.
11.	Shaly clay	7 feet.
12.	Sandstone, coarse	60 feet.
13.	Greenish shale	1 foot.
14.	Sandstone, coarse	25 feet.
15.	Limestone	6 feet.
	Total	125 feet 8 in.

The stratum of coal (No. 10), which seems to underlie most of the quarries, marks the base of the whetstone grit. All of the stone used

at this quarry comes from No. 9 of the section. To work this layer necessitates the removal of about 16 feet of the overlying strata. The layers above this do not split so readily.

The strata here, as in all of the quarries, are generally divided into rectangular or diamond-shaped pieces by narrow, vertical seams at intervals of a few feet. The sides of these seams are coated with iron oxide. Generally the iron ore is deposited on the edges of the strata, in the joints, as an incrustation from percolating waters which have dissolved it out of the coarse ferruginous sandstone overlying the whetstone. On being redeposited in the joints, the iron has penetrated the strata laterally, coloring them various shades of red and orange which fade out a few inches from the joints. Very little of this lateral penetration of the iron is seen in Braxton's quarry, but it is quite common in the "Red Quarry." The stone here is very light in color, contains but little earthy matter and makes an excellent whetstone.

On the opposite side of a deep ravine from this quarry is the quarry of Mr. Brown Moore in the northeast of northwest quarter, Sec. 5, Tp. 1 N., R. 2 W. This quarry was opened about 50 years ago. Although but a few hundred yards from the quarry described above, the character of the strata is quite different as will be seen from the following section:

		Feet.	Inches.
1.	Clay, gray and yellow, silicious	6	
2.	Sandstone, fine-grained, light gray		18
3.	Shale		21
4.	Sandstone	4	6
5.	Sandstone, bluish-gray, in layers ½ to 2 inches thick (whetstone rock)	10	
	Total	23	9

In No. 5 the stone is a bluish-gray color, and contains some argillaceous matter with very thin layers of clay between the strata. The surfaces of the strata have the rough or wavy appearance of ripple marks. The upper surface of the layer is always slightly softer than the lower. This fact is recognized and taken advantage of by the quarrymen, who always rule the slab with a scribe awl on the upper surface. The greater softness of the upper part of the stratum is probably due to that portion containing a larger per cent. of earthy matter than the lower.

In removing stone from this quarry the workmen have uncovered the trunk of a Lepidodendron, 12 inches in diameter, standing upright in the whetstone layers. About 6 feet of the trunk is exposed; the base was not seen, but probably rests in the thin layer of coal said to underlie the whetstone. The bark is altered to coal, while the interior of the trunk is replaced by sandstone identical with the whetstone, except that it is not stratified. The impression of another Lepidodendron, as large as the one described, occurs a few feet from it. Mr.

Moore states that the trunks of three others have been found standing upright in this quarry.

A short distance to the northwest of the Moore quarry, in the southeast quarter of the southwest quarter of Section 32, Tp. 2 N., R. 2 W., is the quarry of Mr. W. F. Osborn, which has been opened for about 20 years. The strata exposed here resemble closely those at the Brown Moore quarry. The finished whetstone from some of the layers has a mottled or marbled appearance. The different parts of the layers furnishing this stone vary in the amount of iron and earthy matter contained in them, and consequently in color from a bluish gray to an ash. The arrangement of these varied colored layers into slightly undulating layers gives rise to a marbled appearance in the finished stone by exposing different layers in the same plane. At the old Osborn quarry fossil ferns are abundant in the strata.

In the southwest quarter of the southwest quarter of Sec. 32, Tp. 2 N., R. 2 W., Mr. Gabriel Dougherty has opened up a quarry within the last year or two in which the following section is exposed:

		Feet.	Inches.
1.	Clay and decomposed sandstone	3	
2.	Sandstone	4	6
3.	Shale		18
4.	Sandstone, fine grained, light gray		6
5.	Sandstone, fine grained, in layers 1 and ½ inches thick, worked for whetstone	2	6
6.	Sandstone, fine grained, thin strata, uneven bedded and sharp dipped (worked for whetstone)	2	

Unlike the quarries previously described, in which the strata were horizontal or nearly so, the strata in this quarry show evidence of the presence of strong currents during their deposition. While the upper strata in the above section are nearly horizontal, the lower ones have a very uneven, wave-like bedding. In places in the bottom of the quarry, the whetstone layers bulge upward over a space of 4 or 5 feet and dip off sharply on either side. The worked layers have a dip of about 11 degrees towards the southwest. The stone here makes fair whetstones, but the unevenness of the layers interferes with its working.

At the old Dougherty quarry, in the northeast quarter, Sec. 6, Tp. 1 N., R. 2 W., the following section is exposed:

		Feet.
1.	Clay, residual	2
2.	Sandstone, fine grained, light gray, in layers ½ to 3 inches thick	13

The abundance of fossil Lepidodendra in this quarry has led to its abandonment. A portion of one of these standing upright is exposed which measures 15 inches in diameter. In a portion of this quarry the

strata are horizontal, but in the west part they dip 10 to 15 degrees towards the southwest.

In the northwest quarter Sec. 32, Tp. 2 N., R. 2 W., Mr. Wm. Able owns the quarry known as the "Old Red Quarry." The section exposed is:

		Feet.	Inches.
1.	Yellow clay	4	
2.	Sandstone, fine-grained, in undulating layers, one-half to 3 inches thick	1	6
3.	Shale, white, silicious, in layers one-eighth of an inch thick	4	6
4.	Sandstone, fine-grained, in layers 3 to 6 inches thick	2	6
	Total	12	6

Some of the strata in this quarry are highly colored with iron. Often highly colored, rose tinted bands alternate with paler ones. Sometimes the iron has penetrated the strata laterally from a joint, giving the stone a vertical banded appearance. This quarry has not been worked for several years. In the same quarter-section, just north of the whetstone mill, a small quarry has recently been opened. But little of the stone was exposed when visited. Over most of the northwest quarter of Sec. 32, Tp. 2 N., R. 2 W., the whetstone lies near the surface. It is not overlain by a heavy bed of sandstone as in the neighborhood of most of the quarries.

On Mt. Arie, in the southeast quarter of the southwest quarter of Sec. 28, Tp. 2 N., R. 2 W , northwest of the observatory, Mr. J. E. Buerk has opened a quarry which exposes the following section:

		Feet.	Inches.
1.	Clay, residual	7	
2.	Sandstone in thin strata	12	
3.	Coal	1	6
4.	Fire-clay	(?)	
	Total	20	6

In the upper part of the bed the whetstone is in layers one-half to two inches thick; they become thicker in the lower part. The strata here have a local dip of twelve degrees to the east. Much of the stone is unevenly bedded.

Orangeville Region.—All of the Hindostan whetstone occurring north of Lost River is included under this heading. The known outcrops and quarries of this region occur along the wide ridge followed by the Vincennes road, and on the two southern projections of it lying on opposite sides of Sam's creek.

The only Hindostan whetstone quarry which has ever been opened in Martin county is in the northwest quarter of the northwest quarter of

section 13, township 2 north, range 3 west. This quarry has not been worked for 25 or 30 years and nothing can be seen of the stone except from fragments which have been thrown out. These contain much iron in the shape of minute specks of limonite distributed through the stone and indicate it to be of poor quality.

In the same quarter section as the above mentioned quarry, at the top of the hill on the grade road, is an outcrop exposing about 2½ feet of whetstone. The upper part is in thick layers containing much iron. Worm trails occur in some of the layers. The stone here has a dip of about 13 degrees toward the southwest. This does not represent the general slant of the beds, but is local and the result of the action of currents at the time of their deposition.

A whetstone quarry was opened some years ago about one-quarter of a mile northwest of New Antioch church by Mr. Gabriel Dougherty. But little stone was taken out owing to the thinness of the bed.

It is very probable that good whetstone could be found between Scarlet Chapel and Bond's P. O., along the ridge over which the Vincennes road passes. No quarries have ever been opened along this area and no outcrops of whetstone were seen, but the whetstone bed is doubtless continuous near the summit of the ridge between the Ritter quarry and the quarries to the east of Bond's P. O.

The quarries east of Bond's P. O. occur in sections 23, 24 and 26, township 3 north, range 2 west. The only quarries in this district which are worked at present are those belonging to Mr. J. A. Chaillaux, in the northwest quarter of the northeast quarter of Sec. 23 and the northwest quarter of southeast quarter Sec. 23, township 3 north, range 2 west. At the former quarry the following section was seen:

		Feet.	Inches.
1.	Clay	4	
2.	Shaly sandstone	2	6
3.	Sandstone, heavy bedded		14
4.	Shale		2
5.	Sandstone, heavy bedded	2	
6.	Sandstone, bluish gray in thin layers (whetstone)	3	6
7.	Heavy bedded stone	4	

This quarry is about 200 feet long and averages about 25 feet in width. The stone lies in even-bedded, almost horizontal, layers with smooth surfaces. There is a very slight dip of the bed toward the south.

About a half mile east of this, in the northeast corner of Sec. 23, is a small quarry owned by Samuel Lynn. An opening about 20x25 feet here shows 2½ feet of whetstone. The layers have uneven surfaces and would not work well.

At the old Dishman quarry, in the northwest quarter of southwest quarter Sec. 24, township 3 north, range 2 west, a very large amount of whetstone has been obtained. The quarry is not workable at present.

Stone was formerly shipped from it and manufactured at New Albany. The whetstone bed has here been opened for four or five hundred feet along the brow of the ridge. Fossil ferns are found abundantly at this quarry. At the Marshall Freeman quarry, in the northeast quarter of northeast quarter of Sec. 26, township 3 north, range 2 west, the section exposed is:

		Feet.	Inches.
1.	Clay and soil		20
2.	Shale	2	
3.	Whetstone		12
4.	Shale		8
5.	Sandstone, light gray		14
6.	Shale	2	
7.	Whetstone		20
8.	Shale		16
9.	Sandstone, heavy bedded	4	6

The stone here shows no dip or irregular bedding. It contains much iron oxide in the joints. Dendrites of manganese is frequently seen between the whetstone layers. The manganese and iron give some of the stone a closely specked appearance.

In the southeast quarter of the southwest quarter of section 23, township 3 N., R. 3 W., Mr. G. W. Bedster owns a quarry. This is one of the oldest quarries in the whetstone region, and a large amount of stone has been obtained here in the past; but the quarry has not been worked for a number of years. Most of the layers of stone have a wavy or ripple marked surface; some of the ripple marks in the bottom layers being three to five inches across, and running in a southwesterly and northeasterly direction. Fossil ferns are abundant and a portion of one Lepidodendron trunk was seen in a vertical position.

Palæontology of the Hindostan Beds.—The Hindostan whetstone beds, which were supposed to be barren of fossils at the time of Dr. Owen's visit to the quarries in 1837, have since been found to contain an abundance of fossil plants in an excellent state of preservation in some localities. Of these the Lepidodendra are especially interesting. They are frequently found in the quarries standing upright in the position in which they originally grew, imbedded in the thin, fine grained, sandstone strata. The trunks frequently have the bark transformed to coal, while the interior is a sandstone. The largest specimen seen measured four feet eight inches in circumference. The usual size is six to fifteen inches in diameter.

A series of fossils from the Hindostan beds was submitted to Mr. David White, of the United States National Museum, whose report is given below.

REPORT ON THE FOSSIL PLANTS FROM THE HINDOSTAN WHETSTONE BEDS IN ORANGE COUNTY, INDIANA.

The fossil plants from the Hindostan whetstone beds of Orange county, transmitted by Mr. E. M. Kindle, include nineteen specimens from localities as follows:

Nos. 2, 5 and 8, the Osborn quarry at French Lick.

No. 13, Braxton's quarry, French Lick.

Nos. 16, 17 and 18, from the Bedster quarry.

Nos. 1, 4, 6, 7, 9, 10, 11, 12, 14 and 15, from Dishman's quarry, Sec. 23 (T. 3, N., R. 2 W), near Orangeville. These appear to have been collected by Messrs. Elrod and McIntire.

No. 3 is accompanied by no other geographical information than the name of the county.

The material is nearly all finely preserved and shows well the superficial details. The Lepidodendra are specially interesting, being less compressed than usual.

No. 6, *Sphenopteris hoeninghausii* (Brongn). The specimen appears to represent the form designated by Stur as *Dicksonioides*. It is perhaps only a small example of the former, apparently fertile, the sporangia resembling *Renaultia*.

Nos. 1, 3*a* and 4, *Pseudopecopteris muricata* (Brongn), Lx. The form of the species represented is that common at the Dade mines in Georgia, at various localities in Alabama and in the Horsepen group of West Virginia. I have seen it in other collections from the Indiana whetstone beds. This form differs much from the typical form in Europe, which is much closer to the *Ps. nervosa*.

No. 2 belongs to the same group. It is a small fragment and seems intermediate to *Pseudopecopteris muricata* and the Tennessee form of *Ps dimorpha*, Lx. It is probably nearer the former.

Nos. 3*b* and 7 appear to belong to the Dade, Ga., form of *Neuropteris smithsii*, Lx. It is distinct, however, from the original type of this species, and probably belongs rather to one of the small lateral pinnæ of one of the stratigraphically later phases of *N. biformis*, Lx.

No. 8, which also represents a large form, with rather distant odontopteroid nerves, commonly referred to *Neuropteris smithsii*, is almost certainly a part, a little lower in the frond, of the form next enumerated.

No. 5, *Neuropteris biformis*, the Tennessee form. This form, not uncommon at Rockwood, Tenn., is also found in the Horsepen group on New River, West Virginia. It is much more lax than the original form from Alabama.

The remaining specimens are all *Lepidodendron* of the group represented by *L. veltheimianum* Sternb. It is more than possible that all belong to a single form of the above named species, so remarkably changed are the features of different parts of the same trunk by the accidents of fossilization.

Nos. 11 and 12, *Lepidodendron veltheimianum* Sternb., as commonly seen in this country. In No. 11 the bolsters are truncated at the base as in *L. clypeatum* Lx.

Nos. 13 and 14 are probably the same species, the protruding leaf scars having been compressed towards the upper end of the bolster in fossilization. No. 13 is the form from Dade, Ga., identified by Professor Lesquereux as *L. vestitum* Lx.

No. 9, *L. veltheimianum*, as identified by Professor Lesquereux, from Washington county, Ark., and Tracy City, Tenn. The leaf scar is very large and broadly rhomboidal, the form being extremely close to *L. rhodeanum* Sternb , from the Waldenburg beds in Silesia.

No. 15 is the younger stage of the same form.

Nos. 16, 17 and 18, all fragments of the same trunk, should be compared with *Lepidodendron clypeatum* Lx. It differs, however, from that species by the narrower leaf scars. I suspect it to be merely a phase of *L. veltheimianum*, not uncommon in the upper part of the Horsepen group

The number of species is so small that it is impossible to trace the paleontological equivalence of the Hindostan beds in other portions of the Appalachian coal field with a satisfactory degree of preciseness. Still it is at once apparent that we have here common and typical forms of the Pottsville Conglomerate Series. The species are distributed in the Pottsville from Pennsylvania to Alabama, and are almost exclusively confined to that series. But little attention has been paid in America to the variations of individual species of fossil plants in time, and until these variations, which are of the highest value in stratigraphic paleobotany, have been described and defined, it is necessary to refer to them as phases or forms characteristic of the various stages or regions.

Basing our correlation on such criteria, it appears that the age of the Hindostan whetstone beds can hardly be younger than the Sharon coal of Ohio, the Sewell stage in West Virginia, or the Sewanee stage in Tennessee.

The plants, few as they are, seem rather by their peculiar phases or forms to find a closer relation to the floras of the upper part of the Horsepen group* of West Virginia, the vicinity of the Dade seam in Georgia and Tennessee, or possibly the middle of the Pottsville section in the Southern Anthracite Field of Pennsylvania.

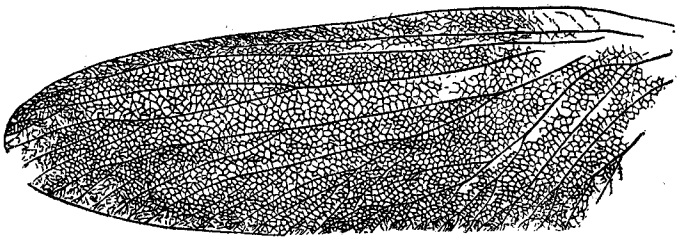
DAVID WHITE.

*See Bull. Geol. Soc. Amer., Vol. VI, 1895, p. 316.

The following species of fossil plants not included in the collection referred to Mr. White have been reported from the Hindostan beds by Prof. Leo Lesquereaux.*

Sphenopteris latifolia.	*Lepidodendron veltheimianum.*
Sphenopteris tridactylites.	*Lepidodendron rushvillense.*
Neuropteris elrodi.	*Lepidophloios crassicaulis.*
Lepidodendron dichotomum.	*Ulodendron minus.*

PAOLIA VETUSTA.—S. J. Smith. The insect remains thus far discovered in the whetstone beds are limited to a single specimen, the wing of a Neuropterid insect. This specimen was found in the Braxton quarry near French Lick and presented to the museum of Hanover College. The wing was first described by Mr. S. J. Smith,† whose figure is here reproduced,



as a new genus and new species.

GEOLOGICAL HISTORY OF THE WHETSTONE BEDS.—The shallow sea conditions which existed during the deposition of the sediments constituting the Hindostan beds, doubtless began during the Kaskaskia epoch. The St. Louis formation, lying below the Kaskaskia, is composed of limestones containing a fauna indicating a sea of some depth. In passing to the Kaskaskia a great change in the fossils occurs, and beds of limestone alternate with those of sandstone. Thin coal seams in the Kaskaskia indicate shallow waters, and the presence of cross-bedding in the sandstones points to the existence of both shallow waters and strong currents during their deposition. The cessation of sandstone formation and the renewal of limestone formation, which twice occurred during the Kaskaskia, may have resulted either from the temporary deepening of the sea, the lessening of erosion over the areas whence the sand was derived, or from a change in the direction of the currents which transported it. The sandstones and shales of the lower Mansfield indicate a continuance of shallow ocean waters after the close of the Kaskaskia. The eastern shore line of the carboniferous sea at this time lay not far east of this region. Immediately preceding the deposition of the Hindostan whetstone beds, the ocean became shallow enough over the region to produce

*Coal Flora Penn. Vol. III, p. 852 and Geol. Surv. of Indiana, 1875, p. 7.
†Am. Jour. Sci., Ser. III, Vol. I, pp. 44-46.

marshes in which coal plants grew, and where their remains accumulated and formed the thin coal seam underlying the whetstone bed. The luxuriant carboniferous vegetation overspreading this low lying marsh included, besides several varieties of ferns, jungles of Lepidodendra. The sea marsh condition did not continue long and was followed by a slight depression of the land causing the shore line to shift to the east. The sediments composing the whetstone bed then began to be deposited. We may presume that sedimentation went on rapidly, since we find numerous Lepidodendra standing upright, as they grew, in the whetstone bed. They must therefore have been imbedded in the fine silicious sediments before there was time for them to decay sufficiently to be overthrown by winds or waves.

The very fine sandy sediments, which constitute the whetstone beds, were doubtless derived from the same region of quartzose rocks as supplied the coarse sand of the Mansfield sandstone. The disintegration and erosion of the granite rocks from which the Mansfield sandstone was derived, and its long transportation would necessarily reproduce much fine as well as coarse sand. The difference in the specific gravity of the very fine and comparatively coarse sand grains would lead to their assortment by the water, and cause them to be deposited either in different layers or in different areas. In the assortment and deposition of sediments which gave rise to the whetstone beds, the fine and coarse materials were deposited in different areas. The Hindostan beds therefore represent a local peculiarity of sedimentation, and are the stratigraphic equivalents of beds of very different character to the west of them.

CHAPTER VI.

GRINDSTONE GRITS.

Sandstones which make a good quality of grindstones occur at a number of localities in western Orange, northeastern Dubois and southeastern Martin counties.

DEVELOPMENT.—At present these grindstone grits are not used except locally. A small number are made annually and sold in the local market. Twenty-five years ago grindstones were made somewhat extensively in this region, and numbers of them were sold throughout Indiana and in adjoining States. These stones, which were made entirely by hand, gained for themselves a good reputation in the market. The introduction elsewhere of machinery in the manufacture of grindstones caused those made in Ohio and Michigan to be placed on the market at a lower price than they could be manufactured by hand. This led to the

Ohio stones displacing Indiana stones in the market. On account of a lack of railway facilities for shipping the finished product, the parties owning grindstone quarries in Orange county did not introduce machinery to manufacture the stone. This objection was removed several years ago by the building of the Paoli and French Lick branch of the Monon railroad. There seems to be no reason why the grindstone industry could not be successfully developed in this region by the introduction of the grindstone turning lathe. Such a lathe could be operated in connection with a whetstone mill. An engine used to furnish the power for the rub-wheels could also supply power for a turning lathe.

MANUFACTURE.—It may be well to describe here the process and machinery used in manufacturing grindstone at Berea and Amhurst, Ohio, by the Cleveland Stone Company, which is the largest producer of grindstones in the world. The stone at Berea is quarried in massive blocks by channelers. These blocks are split into slabs the thickness of the desired grindstone. The circular outline of the grindstone is marked on the slab with a scribe awl, and the stone is then broken to a roughly circular outline with a hammer. In this form, which is called the grindstone "pattern," the stone is taken to a factory. Here it is prepared for mounting on the lathe by having a square hole or "eye" picked through the center with a rock pick.

The turning lathe consists of a horizontal steel shaft about three inches in diameter supported by three journals. Near one end a fly wheel connects it by belts with the power shaft. The grindstone pattern is placed on the opposite end and clamped. After the stone is in position a heavy piece of timber, attached to one end of the lathe frame by a hinge, is swung close against the stone, which then hangs vertically between two heavy wooden timbers, the upper sides of which are set with iron pins which serve as braces for the steel bars used in turning the stone. In the process of turning two men stand on opposite sides of the stone, each with a steel bar, the point of which is pressed against the side of the stone inside the rough periphery. The rapidly revolving stone quickly cuts off the rough outer iron against the tips of the steel bars. The face of the stone is leveled up, if rough, by holding the point of the bar lightly against the different parts of it. The process of finishing a stone occupies from one to two minutes.

ADAPTABILITY.—The uses to which grindstones are put cover a wide range. The qualities needed in stones for different purposes are correspondingly different. The character of work which a stone will do depends upon the shape and size of the quartz grains comprising it and the hardness or softness of the stone. To select a stone intelligently, therefore, its coarseness or fineness and degrees of hardness must be considered, as well as the degree of the qualities needed for the work to be done.

Grindstones are used for three purposes: to smooth surfaces, to reduce metal to a given thickness and to sharpen edge tools. A considerable number of grindstones are consumed annually in the manufacture of machinery and implements. For this work a coarse, hard stone is generally best adapted. The Indiana grindstone grit ranges from medium coarseness to very fine. The most of it is soft. It will be found well adapted to grinding carpenters', mechanics' and machinists' tools.

DISTRIBUTION OF GRINDSTONE ROCKS.—Sandstone, having the qualities of good grindstone "grit," is not confined to any one geological horizon. Grindstones have been made from both the lower and upper Kaskaskia sandstones and from the Mansfield sandstones. Neither of these sandstones is suitable for grindstones throughout its extent, but each of them affords good grindstone "grit" at many localities. Only the localities where these grindstones have been made will be mentioned here.

ORANGE COUNTY.—A few grindstones have been made on the land of Wm. Able in the southeast quarter of the southwest quarter Sec. 36, township 3 north, range 2 west. The sandstone here is a light gray color speckled with brown. No grindstones have been made here recently and but little can be seen of the ledge formerly worked. In the northeast quarter of the northwest quarter of section 30, township 3 north, range 2 west, a few grindstones have been made on the land of Mr. W. A. Bruner.

In the northwest quarter of the southeast quarter of Sec. 6, township 2 north, range 2 west, a grindstone quarry is worked occasionally for local use. The stone, which is Upper Kaskaskia sandstone, lies in strata $2\frac{1}{2}$ to 6 inches thick. This stone makes a good fine grained grindstone. About a half mile southeast of Abydel in the southeast quarter of Sec. 30 a ledge of sandstone, most of which is massive and a good building stone, outcrops for about half a mile near the summit of the ridge. The upper part of the bed just east of the road lies in strata 2 to 8 inches thick. These strata are harder than the massive stone and make a good grindstone. Some stones have been made at this locality.

An old grindstone quarry, from which a considerable number of grindstones have been made, is located in the northeast quarter of the northeast quarter of Sec. 15, township 1 north, range 1 west, on the land belonging to the Travelers' Insurance Company. Eniza Wolfington manufactured grindstones at this place twenty years ago and peddled them through Illinois. This quarry is in the Upper Kaskaskia sandstone near the top of the bed. The stone is of medium hardness, and varies in color from nearly pure white to gray and brown with buff. The stone lies in strata three inches to two and one-half feet thick which split readily. One to three feet of stripping is necessary to secure the stone.

On the land of Solomon Lashbrook, in the southeast quarter of the southwest quarter of Sec. 24 (1 N., 2 W.), some grindstones for

local use and for coarse whetstones, have been made from the upper portions of the ledge. The stone here splits readily and has a sharp "grit."

An old grindstone quarry on the farm of Benj. Case, in the northwest quarter of the southwest quarter of Sec. 9, (1 N., 2 W.), has yielded more grindstones probably than any other in this region. This quarry was extensively worked about 28 years ago. In 1893, one hundred and fifty grindstones were made from it, but since then it has not been worked. The following section is exposed:

	Feet.	Inches.
Clay and soil	2	
Sandstone in three to 10-inch layers (grindstone layers)	15	
Sandstone, containing pieces of carbonized wood and much mica		15
Shale		10
Sandstone		12

The Upper Kaskaskia limestone outcrops a short distance down the ravine below the above section.

The quarry has been opened for three or four hundred yards along the east side of a ravine which exposes the ledge in places. In front of Mr. Case's house the grindstone ridge becomes massive, but it is said to split readily. A great deal of the stone is a rather fine-grained light-gray sandstone, finely speckled with brown and containing some mica. Another variety is a hard and firmly cemented stone without iron specks. An unlimited quantity of good grindstone grit can be obtained here.

In the southeast quarter of Sec. 1 (Tp. 1 N., R. 2. W.), on the land of David Baxter, a small quarry has recently been opened. The stone lies in layers from 3 to 10 inches thick, quite free from iron concretions and nearly white in color. A few grindstones of excellent quality have been made here for local sale.

In the southwest quarter of the southeast quarter of Sec. 26 (Tp. 1 N., R. 2 W) an outcrop of Upper Kaskaskia sandstone occurs, from which a few grindstones have been made. The lower 6 feet of the outcrop is a hard white, fine grained sandstone. The middle portion is softer and weathers more rapidly than the part above or below it. The upper 10 feet of the ledge is a white, even bedded, easy splitting sandstone which has been used for grindstones with fair success. In the northeast quarter of Sec. 20 (Tp. 1 S , R. 2 W.), on Isaac Kendall's farm, grindstones have been made from sandstone which outcrops on the south bank of Patoka river, near the mouth of Painter creek.

At Newton Stewart the Kaskasia sandstone outcrops in the river bank at the mill. About 15 feet of sandstone is exposed here, which is capped with 4 or 5 feet of clay and soil. The stone is rather coarse grained, white to buff in color, and lies in strata 2 to 15 inches thick. Some grindstones of good quality have been made from it.

DUBOIS COUNTY.—On the land of John Dudine in the northwest quarter of Sec. 14 (Tp. 3 N., R. 4 W.) grindstones have been made for a number of years from sandstone strata 1 to 8 inches in thickness. In the northeast quarter of the northeast quarter of Sec. 21 (Tp. 2 N., R. 4 W.) grindstone "grit" of good quality is said to occur on the bank of White river.

MARTIN COUNTY.—On J. M. Ragan's farm in the northeast quarter of Sec. 8 (Tp. 1 N., R. 3 W) a grindstone quarry has been worked occasionally for local use for the last ten years. About 2½ feet of rough stone and 18 inches of clay and soil lie above the grindstone layers. The stone is light gray and occurs in strata 3 to 8 inches thick. It makes a good rapid cutting grindstone.

The Selfe quarry is located in the southwest quarter of the southwest quarter of Sec. 11 (Tp. 1 N., R. 3 W.). The quarry is in the Mansfield sandstone which here is nearly white and somewhat streaked with buff and brown, rather soft and loosely cemented. About 7 feet of stone are exposed in the quarry. They lie in layers from 1 to 20 inches thick and capped with from 3 to 5 feet of clay. This quarry is worked occasionally to supply grindstones for local use. The stone will make a good rapid cutting, but also rapid wearing grindstone.

CHAPTER VII.

OTHER ECONOMIC RESOURCES.

SANDSTONES—A general account of the sandstones of this region suitable for building purposes will be found in the report of Mr. T. C. Hopkins in this volume. Such notes on outcrops and quarries will be given here as have been made while studying the whetstone and grindstone grits of the region. The position of many of the more important of those outcrops is indicated on the map. (Paoli Sheet.)

DISTRIBUTION OF THE KASKASKIA SANDSTONE.—Two beds of sandstone, separated by the Middle Kaskaskia limestone, which is from 10 to 25 feet thick, occur in the Kaskaskia group. Since there are no marked lithological differences between these two sandstones their outcrops will be considered together. The Kaskaskia sandstone outcrops occur mainly along the water courses, and for this reason they will be taken up in the order of the streams along which they are found.

NORTH SIDE OF LOST RIVER.—Most of the north drainage of Lost River is from small streams three to five miles in length flowing nearly south between high, narrow and crooked regions. The Kaskaskia sandstone outcrops at intervals along each of these streams. The long ridge

extending down into the loop of Lost River, which reaches its southernmost extent near West Baden, has much good sandstone in it. On the west side of this ridge, in the southeast quarter of Sec. 15, Tp. 2 N., R. 2 W., a fine ledge of Upper Kaskaskia sandstone, 30 feet thick, is exposed. The stone is light buff to nearly white in color and outcrops at the summit of the ridge where its surface is nearly bare of soil or clay. This bed of stone has been quarried in the southeast quarter of Sec 10 on John Able's land. Stone was obtained at this quarry for the abutments of the Lost River bridge near the Miller school house.

In the northwest quarter of Sec. 21, Tp. 2 N., R. 2 W., northwest of the divergence of the present channel of Lost River from the old channel, the Upper Kaskaskia sandstone outcrops in a ledge of good stone 10 feet thick. It is a light buff in color and weathers well.

About a mile and a half down the river from this outcrop, in the southeast quarter of Sec. 16, the Kaskaskia sandstone outcrops near the top of the ridge for a few hundred yards. Much stone has been quarried at this point for local use.

Numerous outcrops of Kaskaskia sandstone occur along either side of Sulphur creek from near its mouth to its source. On the west side of the creek, beginning at Taylor Robin's in the northwest quarter of Sec. 9, the sandstone outcrops nearly continuously for more than half a mile up the creek. Near the head of Sulphur creek, in the north part of Sec. 28, Tp. 3 N , R. 2 W., extensive ledges of good buff sandstone outcrop on both sides of the creek. On the west fork of the same creek in the northwest quarter of Sec. 32, Tp. 3 N., R. 2 W., on the north side of the road, are exposures of sharp gritted, gray sandstone in thin layers. This bed was opened some years ago for the purpose of making scythe stones, but only a few were made.

Sam's Creek.—Three quarters of a mile northwest of the mouth of Sam's Creek, in Sec. 24, the Kaskaskia sandstone is well exposed at Matherson's quarry. The ledge worked here is about 12 feet thick. The stone is gray to buff in color, and stands weathering well. It has been used locally for bridge abutments.

Along the west bank of Lost River, between Sam's creek and Big creek, in the southeast quarter of Sec. 24, a ledge of Kaskaskia sandstone, from 12 to 15 feet thick, outcrops for one-third of a mile near the summit of the ridge. In places this is a soft white stone, but the most of it is a firm buff stone of good quality.

Near the mouth of Buck creek the lower Kaskaskia sandstone forms the bed of Lost River.

Big Creek.—The Kaskaskia sandstone outcrops occasionally along the valley of Big creek and the sides of its branches nearly to their sources A quarter of a mile east of Natchez a ledge 18 feet thick outcrops. The lower part of this weathers rapidly, leaving a projecting

shelf above. Near the base of this ledge is about 2 feet of coarse conglomerate composed of sandstone pebbles.

The abutments of the bridge across Lost River in the northwest quarter of Sec. 21 (T. 2 N., R. 3 W.) are from Kaskaskia sandstone, outcropping just south of the bridge in the road. Some outcrops of Kaskaskia sandstone occur along the road near this. Below the Butler bridge, in the northwest quarter of Sec. 21, the outcrops of Kaskaskia sandstone are less important. Owing to the southwesterly dip of the strata, the Kaskaskia beds gradually disappear in descending Lost River, until only the upper Kaskaskia limestone is exposed in the river bank a short distance above Windom.

BEAVER CREEK.—In the northeast quarter of Sec. 2 (Tp. 3 N., R. 2 W.) the Kaskaskia sandstone outcrops for about a quarter of a mile in a ledge 20 to 25 feet thick. Much of the stone here is thin bedded, and of unequal hardness and unsuitable for quarrying. Outcrops of Kaskaskia sandstone occur as far down Beaver creek as Sec. 28, but these are of but little economic importance.

SOUTH OF LOST RIVER.

LICK CREEK.—The channel of Lick creek is cut in the Lost River limestone. The hills and ridges along Lick creek have a more gentle slope than those farther west, and the Kaskaskia sandstones do not crop out so frequently. In the southwest quarter of Sec. 35 (T. 2 N., R. 1 W.) a quarry has been opened which supplies most of the stone used for foundation work in Paoli. Two ledges, 6 and 9 feet thick, with 4 feet of stripping, are exposed in the quarry. The stone is light gray to buff in color, and works easily.

Three quarters of a mile southeast of Paoli, just east of the Leavenworth road, stone was obtained for the abutments of the Lick creek bridge at Paoli. The stone here contains much iron and works poorly. In the northeast quarter of the northeast quarter of Sec. 15 (Tp. 1 N., R. 1 W) is an old quarry which formerly furnished a considerable amount of stone for foundations in Paoli. Very good stone can be obtained here with but little stripping.

SULPHUR CREEK.—In the southeast quarter of Sec. 26, Tp. 2 N., R. 2 W., a ledge of light gray sandstone of fair quality outcrops for several hundred yards along the north side of a ridge facing north. About a half mile south of Abydel a ledge of good sandstone three to eight feet thick outcrops along the north side of a small tributary of Sulphur creek for about a half mile. A small amount of stone has been quarried from it near the road running south from Abydel. This exposure is well situated for quarrying. It lies along the brow of a flat topped ridge, where but little stripping would be required to quarry it.

In the southwest quarter of the southwest quarter of Sec. 5, Tp. 1 N., R. 1 W., a heavy bed of white to buff sandstone, twenty feet thick, outcrops at Painter's Cave. On the east side of the road in the same section good ledges of the same bed outcrop on each side of a small ravine flowing southwest to Sulphur creek.

North of Briner's spring a quarter of a mile, in section 8, a ledge of good stone outcrops on the west side of Sulphur creek. Six feet of light gray to buff sandstone, with moss covered face, is exposed.

FRENCH LICK CREEK.—A larger amount of good sandstone occurs along the valley of Freneh Lick creek than of any other tributary of Lost River. Uneven outcrops occur along the main stream and all of its tributaries. Along the upper part of the valley much of the sandstone is a white, sharp gritted stone, and is used for whetstones; this stone has been described in the chapter on whetstones.

At West Baden the Upper Kaskaskia sandstone caps the ridges running east from town. A quarry has been opened just east of town. Seven feet of light buff sandstone of very good quality is exposed here with three to four feet of stripping. North of the West Baden Springs hotel a quarry has been opened in the lower Kaskaskia. A bed of massive buff sandstone, 18 feet thick, with 18 inches of stripping, and resting on a bed of black shale is exposed here. This stone contains iron bands and concretions which make it inferior stone.

Good outcrops occur at the following localities: in the northwest quarter of the northeast quarter of Sec. 10, Tp. 1 N., R. 2 W., on the west side of the road; in the southwest quarter of the southeast quarter of Sec. 10, Tp. 1 N., R. 2 W.; in the northwest quarter of section 26, on the west side of the creek; in the southeast quarter of the northwest quarter of Sec. 25, Tp. 1 N., R. 2 W.

NORTHWEST OF MT. ARIE.—Two very fine exposures of Kaskaskia sandstone occur in the northwest quarter of section 28 and the southeast quarter of Sec. 20, Tp. 2 N., R. 2 W., on opposite sides of a small stream entering Lost River. On the northwest side of the stream the sandstone forms a vertical cliff of massive sandstone about 30 feet thick, and cut by vertical joints at intervals of 15 to 45 feet. The color of he stone is light buff. The face of the ledge is in places moss covered; in others it shows a pitted honey-comb like surface resulting from irregularity of weathering. On the opposite side of the stream in the northwest quarter of section 28, enormous bluffs of massive sandstone, 30 to 40 feet high, extend up either side of a small tributary.

CAVE CREEK AND BUCK CREEK.—Frequent outcrops of Kaskaskia sandstone are found along each of these streams, but they are not of much economic value. In many places the sandstone is thin bedded and soft.

PATOKA RIVER.—The Kaskaskia sandstone outcrops along the sides of the Patoka river as far down as the mouth of Lick Fork creek. At

Centerville and at Newton Stewart the channel of the streams is cut in Kaskaskia sandstone. Between Newton Stewart and Centerville the stream is bordered by lowland; the hills which are neither high nor steep, lie some distance from the river and have comparatively few outcropping ledges.

The most conspicuous outcrop of sandstone along the Patoka is on the north bank, a short distance north of the Government Mill, in Sec. 18, Tp. 1 S., R. 1 W. A bold ledge of light gray sandstone 18 to 25 feet thick outcrops near the top of the ridge. In the southwest quarter of Sec. 11, Tp. 1 S., R. 1 W., on the north side of the river, stone has been obtained for the abutments of the Patoka bridge near by. Five or six feet of good sandstone free from iron is exposed here. Some stone has been quarried for bridge work just east of the road in the northwest quarter of the southeast quarter Sec. 11, Tp. 1 S., R. 1 W. The stone at this place is uneven bedded, splits poorly and contains iron concretions.

Outcrops of Kaskaskia sandstone occur at intervals along the valleys of Painter creek, and Young's creek, which enter the Patoka from the north, from their sources to their mouths.

MANSFIELD SANDSTONE.—The Hindostan whetstone beds, which are economically the most important part of the Mansfield sandstones, have already been described. Over the southeastern part of the region covered by the map, the Mansfield sandstone is represented by a thin bed of sandstone, much impregnated with iron, capping the summits of the narrow ridges. It is of no economic value in this region.

Toward the west the Mansfield beds become thicker and finally in northeastern Dubois county entirely replace the Kaskaskia which dips southwest and disappears under the Mansfield sandstone.

SOUTH OF PATOKA RIVER.—The Mansfield sandstone forms numerous vertical cliffs twenty to eighty feet high at the heads and along the sides of the deep ravines south and west of Ellsworth. One of these cliffs, in the northwest quarter of Sec. 16, Tp. 1 S., R. 3 W., is called Raven Rock. Ravens are said to have nested on the inaccessible shelves of this cliff as recently as three years ago.

This cliff is about 75 feet high, shelving out from the base to the top, which projects about 35 feet beyond the base. The rock is massive, dark buff to brownish in color, composed of coarse, loosely cemented sand with some mica. The lower part of the ledge is characterized by numerous thin, wavy bands of iron ore running through the ledge in a most intricate fashion. The loosely cemented character of this stone makes it unsuitable for economic uses.

There are some ledges in this region, however, which furnish good quarry stone. On the land of Benjamin Rasche, in the northwest quarter of Sec. 6, Tp. 1 S., R. 3 W., a quarry has been opened. The stone here

is a light gray, easy working stone. From it stone is used for foundation work in Knoxville. In Sec. 4, Tp. 1 S., R. 3 W., stone has been quarried near the Patoka bridge for the abutments.

BETWEEN PATOKA AND LOST RIVERS.—At several localities along Dillon and Davis creeks, the Mansfield sandstone occurs as a finely cemented, light buff or gray sandstone, suitable for building purposes. At "Swinging Rock," near the line between Sections 33 and 34, Tp. 1 N., R. 3 W., on the north side of Cave creek, a cliff of sandstone about 35 feet high is exposed. The stone is a light gray, fine grained, and in strata two to three inches thick. This stone is locally used for chimneys.

About a quarter of a mile west of the school house in the northeast quarter of Sec. 34, Tp. 1 N., R. 3 W., a ledge of sandstone 25 feet thick outcrops just above the Upper Kaskaskia limestone. The upper six feet of this is good stone, the lower portion being soft. A conspicuous outcrop of sandstone about 20 feet high occurs on the south bank of Dillon creek in the southwest quarter of the northeast quarter of Sec. 35, Tp. 1 N., R. 3 W. The sandstone here contains too much iron to be of value. In the southwest quarter of Sec. 24, Tp. 1 N., R. 3 W., a ledge of sandstone from six to 20 feet thick, resting on the Upper Kaskaskia limestone, outcrops along the north and east side of the road for some distance. The stone in places is soft and crumbling, and in others contains too much iron to be of value. In the northeast quarter of the southeast quarter of Sec. 19, Tp. 1 N., R. 2 W., a quarry has been opened on Jeff Parson's land, which supplies stone for chimneys and other local uses. The stone is a handsome light gray, fine grained, hard stone. An excellent quality of stone is quarried for local use on Richard Spaulding's land in the northeast quarter of the southeast quarter of Sec. 21, Tp. 1 N., R. 2 W. This is a light gray, fine grained, hard stone, containing some mica. It splits readily. The worked stone is about five feet thick with four feet of stripping.

Prominent ledges of sandstone outcrop just north of Crystal, and along the sides of the branch entering Davis creek from the south at that point. A ledge of good light colored sandstone outcrops near the corners of Sections 7, 8, 17 and 18, Tp. 1 N., R. 3 W., on the west side of the road. The ledge here is eight feet thick with moss covered face. At most of the outcrops along Simmon's creek and its branches, the sandstone is loosely cemented and crumbles too easily for a building stone.

In the northwest quarter of Sec. 17, Tp. 1 N., R. 2 W., at Sand Hill, the Mansfield sandstone is locally colored, a dark reddish brown. Stone of this color outcrops in the road at the top of the hill, where it exhibits marked cross bedding. Just south of the road the red sandstone again outcrops in a ledge seven feet thick. The ledge here presents a firm moss covered face. A short distance to the southeast of the ledge, and somewhat lower, the red sandstone becomes soft and crumbling.

On the north side of the road the red stone becomes buff or gray in a distance of a few hundred yards. The area underlaid by red sandstone suitable for working is very limited, not exceeding a few hundred feet square. On the east side of the hill, in the road, the sandstone crumbles readily to sand, which is used in some of the whetstone mills.

Another small exposure of red sandstone occurs on the north side of the road, in the southeast quarter of the southeast quarter of Sec. 31, Tp. 2 N., R. 2 W. The stone here is composed of coarse sand with much mica, and is a pale red to chocolate brown. The red stone is almost bare of soil, and covers not more than a quarter of an acre.

North of Lost River.—The Mansfield sandstone outcrops frequently near the summit of the ridges north of Lost river, but it is not generally a good quarry stone. Extensive and conspicuous cliffs of Mansfield sandstone occur along the White river near Shoals, and along Plasterer's creek. The stone at these localities is unsuitable, however, for economic uses, since it is too loosely cemented to resist the weathering. A ledge of very good stone has been opened a half mile southeast of Shoals in the southwest quarter of the southeast quarter of Sec. 30, Tp. 3 N., R. 3 W. Stone has been obtained here for the basement of the High School building in Shoals. Ten feet of stone, with two to five feet of stripping, is exposed in the quarry. The stone is light gray, rather fine grained, and lies in strata three to five feet thick.

Stone has also been quarried in the northwest quarter of Sec. 32, Tp. 3 N., R. 3 W.

Limestones.—The three limestone members of the Kaskaskia group in this region exhibit most of the lithologic features possible to limestones. The lowest of these, the Lower Kaskaskia limestone, is generally a very compact, close textured, uncrystalline limestone.

"Glass Rock."—Where this stone is quite pure and light gray in color, it makes an excellent limestone for the manufacture of glass. It has been largely used for this purpose. At many localities along the upper valley of Lost river, and along Lick creek the limestone is suitable for glass making and has been quarried for this purpose. At Glass Rock station, on the French Lick branch of the Monon, the stone is quarried and shipped.

Lime.—The Middle and Upper Kaskaskia limestones, as well as the Lost River limestone, have been used for the manufacture of lime. Kilns were formerly burned near Lost River and the lime shipped down to New Orleans in flat boats. In many places the upper and middle Kaskaskia limestone have an oölitic structure. This kind of limestone is said to make particularly good lime. At a few localities lime is burned at present and used for a fertilizer on sandstone soils.

Marble.—Throughout much of its extent the Upper Kaskaskia limestone is a light gray crystalline stone. The Middle Kaskaskia limestone

also has a crystalline structure in many localities. Both of these stones, in some localities, will take a fair polish and make a nice looking marble.

A quarry has recently been opened in the Middle Kaskaskia limestone by Mr. Lowe in the northeast quarter of the northwest quarter of Sec. 17 (Tp. 1 S., R. 1 W.). This quarry is located in a ravine where a large amount of stripping must be removed in quarrying the stone. About 8 feet of stone is exposed in the quarry, lying in strata 6 to 14 inches thick. This lower part of the bed is a lead blue, compact, imperfectly crystalline stone. The upper part is a gray, crystalline limestone which takes a fair polish. The Upper Kaskaskia limestone, which outcrops where the quarry could be more easily worked, would probably make a better marble. A few tombstones have been made from the marble quarried here. Much of the Upper Kaskaskia limestone will take a good polish and make a marble of pleasing appearance. The badly weathered and cracked condition of the ledges in many places indicate, however, that much of it will make a marble which can not resist the destructive influences of freezing and thawing.

The position and extent of the Upper Kaskaskia limestone is sufficiently indicated on the map. All of its outcrops occur at or near the line separating the Kaskaskia from the Mansfield sandstone.

COAL.—The location of all the coal mines in the region mapped has been indicated on the map. Since it is the intention of the State Geologist to publish a special report on the coal of the State, no discussion of the coal of this region will be attempted here.

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