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is of little importance. But the prismatic form of the sandstone is much more interesting. The specimens gathered were on or near the surface, and were not seen *in situ*; but from their great abundance it must be argued that they extend downwards for a considerable distance. It was first thought that possibly a dike rock had once existed here, which had assumed the prismatic character, and that in some way by surface decay it had left moulds into which the sand had been carried. But a careful examination revealed no indication whatever of there ever having been a dike here, although they are quite common in the surrounding country. The granite close by is older [1] than the sandstone, and could not therefore have played any part in the matter by metamorphosing the sandstone in any way.

[1] See Bull. No. 5, Mo. Geol. Sur. p. 12, et seq.

THE TERTIARY SILICIFIED WOODS OF EASTERN ARKANSAS.

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The occurrence of silicified wood in the sands and gravels of the Tertiary of the Lower Mississippi Valley has long been known. Aside, however, from the numerous localities mentioned by Hilgard,* nearly all of which are in the State of Mississippi, little attention has been given it. Numerous geologists have spoken of it or incidentally studied it in connection with other investigations, but hitherto no attempt has been made to recognize the species and fix their taxonomic value, if, indeed, they possess any such value. Among those who have investigated the Orange Sands and other Tertiary deposits of the Mississippi Valley and who have added to our information as to the occurrence of these fossils are Hilgard,† Penrose,‡ and Knowlton.§

The last named has made the only microscopic study of these fossils which is on record. Since his investigations are based upon material which, for the most part, was collected by the writer, it is thought that it will be useful to place on record in this form, a more detailed statement of the conditions of the occurrence of the silicified woods, their peculiarities, their structural relations and their stratigraphical position, in the hope that it may eventually prove to be of use in correlating the deposits in which they are found.

These fossil woods occur throughout the area covered by Tertiary sands and gravels in the State of Arkansas. When in large masses they are apparently rarely far removed from beds of Tertiary lignite, if in small masses or in small

* Agriculture and Geology of Mississippi, 1860, pp. 20, 21, *et seq.*

† Agriculture and Geology of Mississippi, 1860, pp. 20, 21, *et seq.*

‡ First Annual Report of the Geological Survey of Texas, 1889; "A Preliminary Report on the Geology of the Gulf Tertiary of Texas from Red River to the Rio Grande." By. R. A. F. Penrose, Jr., pp. 1-101.

§ See Annual Report of the Arkansas Geological Survey for 1889, Vol. II, pp. 249-267, Plates IX-XI.

fragments they occur in the gravels of nearly all the region and in the beds of the streams and brooks of the area covered by the Tertiary. Occasionally whole trunks of trees are found, often partially buried in the sands or deeply imbedded in the gravels which cover the flood plains of the creeks and ravines within the Tertiary area and especially along Crowley's Ridge, from Helena to the Missouri line. Specimens have been obtained from logs or stumps *in situ* and in undisturbed Tertiary beds at the following points: Hope, Hempstead county; Camden, Ouachita county; near Red Land, Cleveland county; at Red Bluff, Jefferson county; at Helena, Forrest City, Wittsburg, Wynne, Harrisburg, Jonesboro, Gainesville, Boydsville, and St. Francis in the country traversed by Crowley's Ridge in the eastern part of the State. All of these localities have furnished examples of silicified wood from large logs or stumps in place and always imbedded in Tertiary sands or gravels. It is a remarkable fact that hitherto, in Arkansas, silicified woods have been seen but very rarely in the Tertiary clays. At all the localities mentioned above, except one, the wood is found only in gravels or sands *in situ*, or in redeposited gravels and sands in the low valleys.

The geological section of the Crowley's Ridge region, to which area this paper especially refers, shows the following sequence, seen in the generalized section in St. Francis county, which is characteristic for the southern portion.

GENERALIZED SOUTHERN SECTION ON LITTLE CROW CREEK.

1. A loess soil, with enough sand to render it decidedly siliceous. This is the surface member and is usually of but little depth.
2. Typical loess, varying in depth from thirty to ninety feet, eroding rapidly, and presenting a characteristic loess topography. This member caps the ridge even at its highest points.
3. A clayey, pebble-bearing, bluish or otherwise dark colored loess clay which forms the base of the typical loess deposits and probably marks the first stage in the loess deposition. This member varies somewhat in different localities, being often quite thin and is even sometimes wanting. The pebbles are most abundant in the lowermost portion.
4. Orange-colored gravels, irregular in thickness, rudely stratified, sometimes well assorted so that only coarse gravels, or *vice versa*, are seen; there are occasional pockets or lenses of sand derived from the underlying member. In rare instances this bed lies directly under the clays. Silicified coniferous wood often occurs in this member.
5. Party-colored sands, of variable fineness, often quite irregularly stratified, sometimes overlying the pebble bed, but usually occurring underneath it. The sand grains are well rounded. There are occasional masses or pockets of red, drab, white, or yellow pipe clay.
6. Blue, black or drab clays, horizontally stratified, with small, sometimes larger, pieces of coniferous lignite. This member constitutes the greater portion of the body of the ridge. Along its margin it is to be seen only in the deepest ravines, or along the St. Francis and such of its small tributaries as flow from the ridge. It is often penetrated in deep wells, as at Forrest City, and underlies the whole region. The lower exposed portion is fossiliferous, the fossils are marine, and Claibornian in age. The clays are, therefore, Eocene Tertiary.

Slight differences in the section appear in various portions of the ridge, but are not worthy of remark in this connection. The generalized section for the northern portion of the ridge, made at a point seventy-five miles north of St. Francis county, shows the following sequence:

GENERALIZED NORTHERN SECTION NEAR GAINESVILLE, GREENE COUNTY.

1. A humus, largely siliceous, or a soil mainly sand. At the highest hilltops this soil contains gravel or may be entirely replaced by waterworn gravel.
2. Gravel bed, commonly removed by erosion.

3. Sands of Tertiary age, false bedded, party-colored, coarse or fine, banded often with drab, red or white pipe clay, or the last may be in pockets or lenses. These sands are generally loose, but in certain localities they have metamorphosed into a very hard, glassy quartzite. The areas of metamorphism are linearly distributed over many square miles, but are confined chiefly to the west side of the ridge. Silicified woods are found in this member at many localities, but none has yet been discovered in the metamorphosed portions.

4. Drab, blue and black clays of Eocene Tertiary age, horizontally stratified, occasionally fossiliferous, the fossils being chiefly the leaves of deciduous trees. These clays contain rare beds of lignite of small extent and erratic vertical distribution. Moreover, the clays are commonly gypsiferous and are further characterized by abundant small plates of muscovite in the cleavage planes. Silicified wood was seen at a single locality, on Cache River.

The absence of fossils in nearly all the members of the Arkansas Tertiary renders necessary their distinction upon lithological and structural data. The large masses of silicified wood in the upper members of the series are the only organic forms known above the Eocene clays. If in any way these silicified woods may be genetically connected with the lignite beds a means of correlation will not certainly be had, but the fact may sometime possess taxonomic value. Studies made in Eastern Arkansas seem to show that all or nearly all of the silicified woods of the Tertiary sands and gravel beds are derived in some manner from the underlying beds of lignite. In many places whole tree trunks, stumps standing in place, or large fragments of silicified wood occur so related to lignite deposits as to show that they are derived therefrom. In the northwestern portion of Greene county, on the west side of Crowley's Ridge, are masses of wood partly in the form of lignite and partly silicified. The lignitized part is buried in Eocene clays; the silicified ends are buried in Eocene Tertiary sands. It would appear that in this case, before the sands were eroded away, the portion of the trunk which had been buried therein was subjected to the action of waters containing silica in solution and the lignitic matter was replaced by silica.

The silica is, of course, all present as secondary quartz, is often massive but, also, frequently crystallized. Especially is holocrystalline quartz abundant in specimens of wood that were partially decayed when the older lignification process began. In the drusy cavities of such lignite are found large numbers of perfect and rather large quartz crystals. These are often, in some specimens always, characterized by a uniform dark or brownish color which is due to inclusions of limonite.*

Prof. F. H. Knowlton, of the United States Geological Survey, has studied microscopically both the lignite and silicified woods found in Eastern Arkansas. The results of his work may be found in Vol. II. of the Arkansas Geological Survey Reports for 1889. His studies have developed the interesting fact that the woods belong to both dicotyledonous and coniferous types. This occurrence is the first known dicotyledonous wood found in this country in rocks older than Pleistocene and is the first dicotyledonous form determined by internal structure. If, therefore, examinations of both lignites and silicified woods are made and it results that the same form or forms are represented in both, a strong reason exists for genetically connecting the silicified woods with the lignites.

Unfortunately for taxonomic purposes all the forms described by Prof. Knowlton are new, but some otherwise valuable results have been reached. In the first place

* An especially fine example of this nature was taken from a section in Tertiary sands thirteen miles southeast of the town of Camden on the line of the Camden & Alexandria Railroad. Of the many thousands of quartz crystals which this specimen exhibits not one has been seen which is free from inclusions of limonite.

he finds, among the four new species studied, two forms which are clearly dicotyledonous, and two other distinctly coniferous in relationship. The species are:

Coniferous.	Dicotyledonous.
Cupressinoxylon arkansanum,	*Laurinoxylon branneri*,
Cupressinoxylon calli.	*Laurinoxylon lesquereuxiana*.

There was also a single additional specimen whose affinities appeared to be dicotyledonous and to belong to *Laurinoxylon*; the condition of the material would not admit of a closer determination. The specimens found indicate comparatively few species, but these few must have existed in great numbers. One of the most valuable and pertinent facts in this connection is the finding of the dicotyledonous *Laurinoxylon branneri* in the lignite bed of Bolivar Creek, as lignite, deeply buried in Eocene clays in massive form.

Thus far sufficient distributional facts to give a taxonomic value to the fossil woods have not been discovered. Until extensive collections throughout the whole region of the southern Tertiary have been made it will not be possible to use these forms for purposes of differentiation or of correlation. It is believed, however, that since in the Tertiary sands of Arkansas, Louisana, Texas and Mississippi the same relations of silicified woods to lignites have been observed, it may be possible to co-ordinate the divisions recognized in those States by geologists and devise a system of nomenclature that will explain the relationships of the various beds to each other, though it cannot be done at present.

During the progress of the study of the region by the writer it became more and more clear that the silicified wood had some intimate relation to the pockets or beds of lignite which are scattered throughout the ridge. It was early noticed that no lignite occurs in the sands or gravels above the clays, and that no detached masses of silicified wood occur entirely in the clays. As the investigation proceeded it became a favorite hypothesis that the silicified wood was transformed lignite, and that careful microscopic study would probably prove the hypothesis to be correct. Professor Knowlton's investigations appear to verify the hypothesis.

The opinion that the silicified wood was, in some way, to be connected with the lignites of the bed underlying the sands was suggested by Hilgard* many years ago. Speaking of the occurence of fossils in the Orange sands he says: ". . . . The closest scrutiny I have bestowed on hundreds of extensive exposures, has failed to detect any fossil apparently peculiar to the formation as such. This might seem paradoxical enough to anyone acquainted with the frequent occurrence of silicified wood in these strata, but it soon becomes quite obvious to an attentive observer that the regions of the frequent occurrence of this fossil in the Orange sand are coextensive with those in which fossil wood, either silicified—when imbedded in siliceous sands—or lignitized, occurs in the underlying lignitiferous Cretaceous or Tertiary strata. It is not unusual to find trunks of silicified wood imbedded partly in the unchanged lignitic strata, partly in the Orange sand; the portion contained in the latter being nearly or wholly deprived of carbon, while the part imbedded in the lignitic material is, if at all silicified, of an ebony tint and often contains pyrites." Again, "I am convinced that the greater part, if not all of this fossil wood, is derived from the underlying strata and will be represented in their flora."

There can be little question, therefore, that the process of silification has occurred, in some cases at least, since these masses were torn from the underlying beds

*American Journal of Science, II, Vol. XLI, p. 313, 1866.

by the waters which deposited the sands above the clays.* As ordinarily understood the process is purely a chemical one and perhaps very slow. It consists in the replacement, particle by particle, of the carbon of the lignite by silicic acid, or silicon dioxide. It is by no means essential that the organic matter be unchanged when the process begins. If the belief that this wood represents what was once lignite be a correct one, then the process of silicification can occur in the case of organic matter which has already undergone a partial change.

Where found in clays in a silicified condition, it has probably resulted from the same processes that are seen to obtain in the highly siliceous sands or gravels which overlie them. Though the impervious nature of most clays renders the percolation of silica-charged waters a matter of great difficulty such percolation certainly occurs in them. The silicified masses of wood are often far too large to have been removed from the clays and deposited in the overlying gravels by an ordinary wave or current action, for they sometimes weigh tons. In the form of lignite the same masses could have been transported by currents, but since very large pieces have been rarely, if ever, found far from lignite deposits, even that proposition has very little weight.

The vertical distribution of the silicified woods of the Arkansas Tertiary is limited by the line of contact between the sands and clays which constitute the Arkansas series. Below this line the silicified wood never occurs, with the single exception above,† so far as observations have yet extended. Above it no lignites have ever been found. The vertical range is therefore limited by the thickness of the sand and gravel bed which is commonly, in Arkansas, between fifty and eighty feet.

There is a marked difference in the vertical range of this fossil in the Tertiary of Arkansas and the Tertiary of California. In the latter State the vertical range is often many hundreds, even several thousands, of feet. Whitney says:‡ "It will be proper to add some of the most important facts gathered during the investigation of the gravel deposits in regard to the mode of occurrence of the fossil plants of the Pliocene epoch. The vertical range of these has been alluded to, and it may

* Dr. R. A. F. Penrose, Jr. (*op cit.*, pp. 24, 26, 50, *et seq.*), has placed on record the numerous occurrences of silicified wood in the Tertiary of Texas; he finds it in both sands and clays. In his description of the Sabine River beds he says: "Silicified wood is of very frequent occurrence in these strata; sometimes occurring as small fragments; and at other times as large trunks of trees. On the Brazos River, in the northern part of Milam county, was seen a trunk one and a half feet in diameter, protruding from a clay bed. Ten feet of it were exposed, while the rest was imbedded in the clay. In many places such fragments are collected in great quantities, but it is especially plentiful in the lower part of the Fayette beds. It is generally dark brown or black inside, and weathers gray or buff color on the outside. Sometimes it occurs partly lignitized and partly silicified. It freqently shows shrinkage cracks which are filled with quartz or chalcedony, and are often lined with quartz crystals."

In this case stratification was but partial or was still in progress, and since there is exposed in the face of the bluff a log which was partially lignitized and partly silicified it proves all but conclusively that, even in the Texan Tertiaries, the lignitic precedes the siliceous condition of these woods.

† In this case the stumps are still standing, the roots, also silicified, ramifying in all directions in Eocene blue clays. Less than one hundred feet east, however, the line of contact between the sand beds and the clays was disclosed in a vertical cut in a hillside. This line was at or near the elevation of the stumps. It was clear that, if the stumps did not actually project into the overlying sands, they were but a short distance below and under conditions to favor silicification from waters percolating through the clay to them.

‡ Auriferous Gravels of the Sierra Nevada, pp. 235, 236. See also American Journal of Science, II, Vol. XLI, p. 359, 1866.

be more distinctly stated that either fossil wood or leaves have been found at every elevation, from the lowest to the highest, where gravels occur. Even as high as Silver Mountain City, at 7,000 feet of elevation, large masses of fossil wood are found in the volcanic deposits; and in Plumas county the same occurrence has been noted on several of the highest mountains in the region, as Penman's Peak and Clermont, peaks from 7,000 to 8,000 feet high . . . . . Fragments and often large masses of wood are found, both in the gravels and the associated clayey and tufaceous beds. In the gravel they frequently bear the marks of transportation from a distance, as would be expected."

In the California Tertiary the most completely silicified and best preserved specimens of wood occur in connection with deposits of a volcanic character, sometimes a rhyolitic ash.* It is suggested by Whitney that these relationships have something to do with the process of silicification. For that region Whitney believes that not only were the woods silicified after their imbedding in white pulverulent volcanic ash but "the lava itself exhibits signs of having been acted on by silicifying agents after its deposition." That the greater part of the series of beds included in the gravel formation has been thoroughly permeated with waters holding silica in solution and that chemical changes induced thereby are sufficient to explain the phenomena appears quite probable. The relations which the phenomena sustain to the facts of volcanism so abundant in that region are set forth and the conclusion is drawn that that relation explains silicification in these woods. In California it becomes a subordinate problem under volcanism.

The chemical processes which obtained in the case of the Arkansas gravels were not co-ordinate with those in California, for there is no evidence of volcanism or any similar phenomena associated with their silicification. The silica in the eastern locality must be sought in the accompanying sand beds and was probably brought into solution by the action upon it of organic acids.

The study of the Arkansas Tertiary silicified woods appears to justify the following conclusions:

1. The silicified woods of Eastern Arkansas are all of Tertiary age.
2. They are derived from the beds of Eocene clays that underlie the sands and gravels in which they commonly occur.
3. They are silicified lignite; the process of silicification has occurred either while they were still in the clays or most often after they were removed and buried in the sands and gravels.
4. They possess as yet no taxonomic value in determining the relative ages of the members of the Tertiary series.

ADDITIONAL NOTE ON SILICIFIED WOOD IN IOWA.

Nearly all who have had occasion to make any extended study of the Pleistocene strata or deposits in Iowa have found, somewhat rarely it is true, specimens of silicified wood which occur under varying conditions. Most of those which the writer has seen have been found in rearranged Pleistocene strata and bear evidence of having been rather roughly handled since silicification. The generic position of most of these examples is uncertain since there have been no careful microscopical examinations, save in a single instance, of any of these specimens. Professor F. H. Knowlton, of the United States Geological Survey, has studied very carefully† a single example of these woods, basing his investigation upon a

* Op. cit., pp. 327-329.

† Proceedings United States National Museum, Volume II, 1888, p. 5-6.

specimen taken in Emmet county. He found the material to represent a species new to science and gave it the name of *Cupressinoxylon glasgowi*, after its discoverer. He concludes that it represents a horizon which is Cretaceous in age. In the absence of any information to the contrary it is fair to assume that the specimen came from the rocks *in situ* but, if so, it is the only case on record of the occurrence of silicified wood so situated in the limits of the State. It would be interesting to institute studies of these woods in connection with the great masses of silicified woods found so abundantly along the upper Missouri; such study might serve to indicate the real origin of these straggled specimens.

In the Pleistocene of this State occasional large examples of silicified wood have been found; the ones examined by Professor Knowlton were small. The writer has noted two or three, in and about the city of Des Moines, that would weigh an hundred pounds or more; the largest of these was little water-worn.

Throughout the central and east-central portions of the State, and occasionally, in other parts of the commonwealth, large trunks of coniferous trees are reached in well and coal borings. These belong, without question, to that earlier, Pleistocene stratum which many geologists denominate "the forest bed." In the debris which was thrown out of the famous Belle Plaine artesian well, when water was found, there came from this stratum large masses of coniferous woods, sometimes quite large logs, mingled with sands and gravel. They constituted one of the features which made the well famous.

Similar woods have occured in deep wells within the city of Des Moines, even when the highest lands within the city were penetrated. The writer has now in his possession fine examples of such wood taken from a well thirty-six feet in depth in the heart of the city. They are much crushed and twisted, one end of one piece being broken or crushed into fibers by some heavy grinding weight, and give clear evidence of the harsh treatment which they have received. In no case have these fossil woods been compared with those which are silicified; so that identity in generic relation cannot be postulated. It is fair to remark, however, that no member of the forest bed proper has yet furnished a single example of silicified wood; that is no specimen of wood which became silicified since burial in that particular stratum. It would appear, therefore, that the real origin of the silicified woods found in the Pleistocene of this state must be sought outside of its imits.

THE FISHES OF THE DES MOINES BASIN.

BY R. ELLSWORTH CALL.

To one familiar with so much of the literature of science as pertains to the natural history of the State of Iowa it is surprising that so little has been done in relation to its fishes. A list designed to stand for the icthyic fauna of the State has yet to be compiled. There have appeared but three papers devoted to Iowa fishes. Of these three one was published under the auspices of the United States