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A SILICIFIED SHELF FUNGUS FROM THE LOWER CRETACEOUS OF MONTANA

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In petrified vegetal structures of varied type, from the simplest of vascular plants up to the highest, and from Devonian times down, fungus threads or hyphae are often noted. Penetrating the tissues of woods of varied type, these parasitic cells may be quite well outlined, following either calcification or silicification. Remarkably well defined fungi are found in the cherts of Middle Old Red Sandstone age at Rhynie, Scotland, now so famous for the beauty of the utterly primitive vascular plants there found silicified in abundance.

Also, there are often seen on fossil leaves traces of fungi, and occasionally casts suggesting fungus forms. But true fossils of the higher types of fungi, or the "toadstools," may hardly be said to exist as well defined forms, unless in exceeding rarity. Nevertheless the fungi are believed to include either actually or in the main mostly very old and unchanged forms, "immortal types." We picture the higher types as present back through the ages, and ascribe the meagerness of the record to the small likelihood of fossilization. But amongst fossils the unawaited or infinitely rare type may at last be found.

Such an unexpected "find" is that of a small but beautifully silicified shelf or bracket fungus found by Mr. Barnum Brown lately while collecting armored dinosaurs in the Cloverly horizon of the Lower Cretaceous along Beauvais Creek on the Crow Indian Reservation, about 40 miles south of Billings, Montana. The locality is near the "Bill Cashen ranch" and yielded some twelve skeletons of dinosaurs of varied form and remarkable type. It is indeed curious to thus see with certainty a mushroom very much as it grew in life on the trees of the forests of those remote dinosaur times. We may assume that the climate was warm, that ancestors of the fig and magnolia were there, and that this fungus grew on the bark of such trees, or perhaps on some conifer.

The common genus *Polyporus* includes the bracket or shelf fungi generally, which are familiar to every one who strolls through the woods.

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Adhering to stem or bark, the types vary from lobes an inch or two across and perhaps a half inch in thickness (often thinner) up to larger masses several feet across. Many of these types close up their pores with hyphal growth, becoming tough and woody so that they may persist for many years. After all, it may not prove so strange that such a plant could persist and be petrified, and Brown thinks he should be able to find more examples.

The first example of a silicified polypore is in the form of an oval-shaped lobe 5 centimeters long by 3.5 centimeters across and one thick. It is mainly what students of the fungi call in a polypore the "hymenium" or mass of pore-traversed spore-bearing tissue,—the upper cap, pileus or "subiculum" of the original fungus being here either eroded away or not silicified. As a photograph of this small fossil anywhere near natural size would show little of feature, photomicrographs are mainly relied on for illustration and description; except that there is included the much enlarged camera lucida drawing of a single pore in transverse thin section, done by the scientific illustrator, Lisbeth Krause.

Naming a fossil such as is now before us presents certain peculiar difficulties. Firstly, it is not exactly the best form to declare that the type may be included in a living genus, *Polyporus,* since that might mean too much of an extension of the original generic significance; and secondly, it is rather better to use for fossil plants the ending *ites* where there are near resemblances to living types, especially so where the fossil type is of great age. Hence, were there no difficulties of synonymy in the way, the proper generic term would unquestionably be *Polyporites.* Can this generic name be used? *Porites* is a coral.

Now it so happens that just one hundred years ago Lindley and Hutton in their 'Fossil Flora of Great Britain' (Plate 65) described from the shale of a coal pit near the entrance of the vale of Llangollen, Wales, a fossil which they admit may be the scale of a fish but deem more likely to be a *Polyporus*-like fungus. And their argument is rather clever. They point out just such concentric and radiating surface lines as one might well find in some shelf fungus in the vale of Llangollen (which I know) today. Above is seen the "pileus" with the radiating and sub-concentric lineation, while here and there over the surface are dottings which may be "parts of the *hymenium porosum*" as exposed by tears through the smooth upper surface or pileus. Nevertheless, Schimper (Cf. Zittel II) placed the fossil as a fish, *Holoptychius Hibberti* Agassiz, and added that the *Polyporites Sequoiae* Heer from the Miocene of Greenland "may be a true *Polyporus*."[1]

Would it not in the end tend toward better usage and a closer accuracy if the name *Polyporites* were retained for fossils demonstrably like *Polyporus*, and so used for our fossil? Must good names be thrown away forever just because some one has placed them in some inadmissible relation? Can they never again be given scientific status? Here this much may be seen. In texts generally, the references to the fossil fungi, except in the case of the hyphae of the fossil woods as so freely seen, are very short and guarded both as to type and nomenclature. Hence, to sift the literature through for the fungi would be at present a task that would have to be done virtually unaided by text or catalog. This, owing to the exceedingly precarious chance of finding well defined new types, is a poor situation which ought to be rectified in the simplest possible manner. The best course becomes plain enough. It is to begin over again and use the names standing in near relation to existing counterpart genera; or at least to make sure that before casting any name aside it has actually been rendered unusable. In this way, with care in describing fossil fungi, a nomenclature that the authors of texts and catalogs need not doubt may be gradually brought into use.

Accordingly, the name **Polyporites browni** will be used for our fossil, naming it for its discoverer, and with the certainty that this is a very rare and finely silicified polypore.

Polyporites browni, new species

DESCRIPTION

A new species of polypore fungus from the Lower Cretaceous (Cloverly beds) of Montana, collected by Barnum Brown, 1932. One well preserved specimen, 5×37×50 mm., American Museum catalog number 24123, type. One longitudinal section, 24123-A, through hymenium, showing characteristic longitudinal pores and presence of lateral net of pores, or labyrinthine pore-branching. Two transverse sections, one 24123-B, the other 24123-C; compare with the text-figures 1–8, showing photomicrographs, enlarged views and drawing of type.

I have failed to find embedded and well-stained sections of polypores for close comparison. Accordingly, it is more logical to begin with histologic structure taken just as it is seen, and then pass, though but

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[1] 'Flora Fossilis Arctica,' III, Mem. 3, page 7, and Pl. I, Fig. 1. This fossil is from the Miocene of Netluarsuk, Disco Island. It may actually be an imprint of the upper surface of the cap or subiculum of a polypore with radial and concentric lineation. The specimen is of about the same size as the Montana polypore.

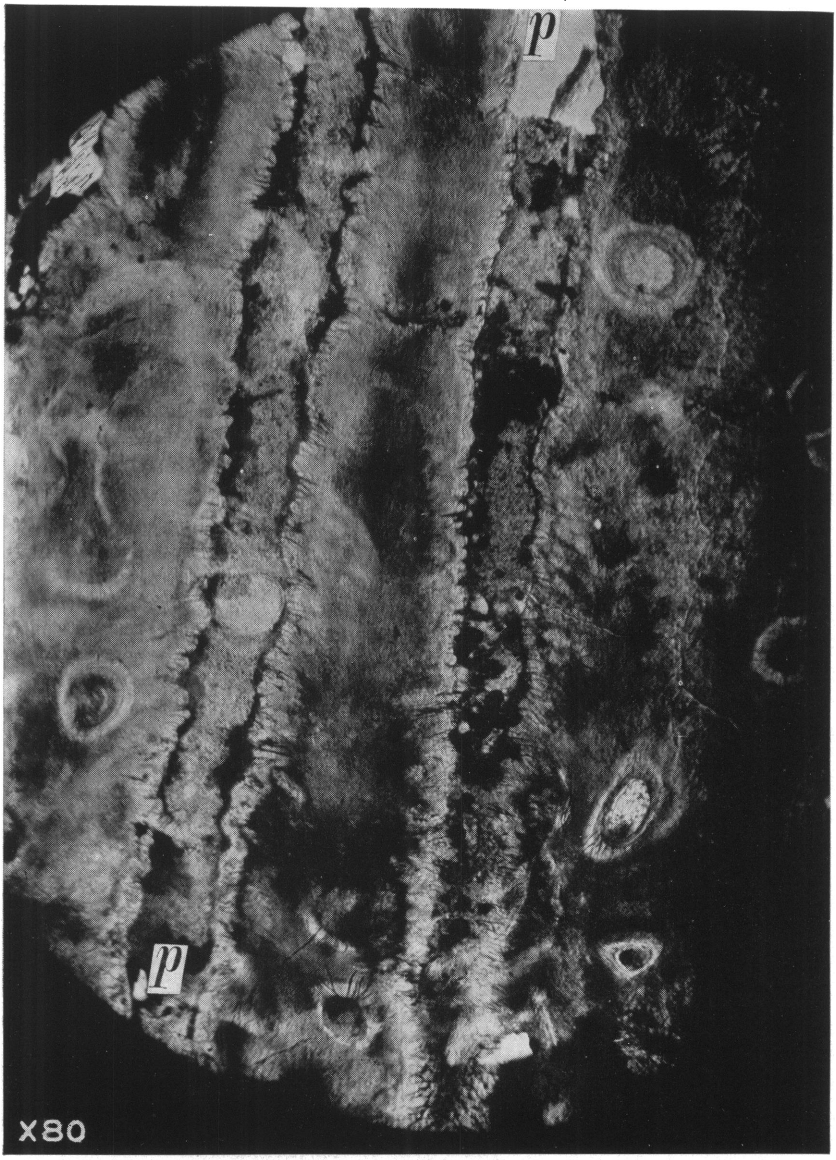


Fig. 1. *Polyporites browni*, n. sp. Type. Amer. Mus. No. 24123-A. Photomicrograph of longitudinal thin section through hymenium, showing characteristic longitudinal pores (*p*, *p*) and also presence of lateral net of pores, or labyrinthine pore branching. × 80.

briefly, to outer form and feature. Figure 1 shows the longitudinal section through the hymenium, enlarged about 80 times. Two of the pores pass quite through with slight evidence of lateral or labyrinthine branching. Only one or two lateral tubes are seen to traverse the broad band of tissue between the pores called the trama (woof). This in polypores is a fine thready or hyphal mat; and in the translucent brown of the thin section itself, as well as in the illustration, a thready mass seems to be present in accord with the definition of the trama.

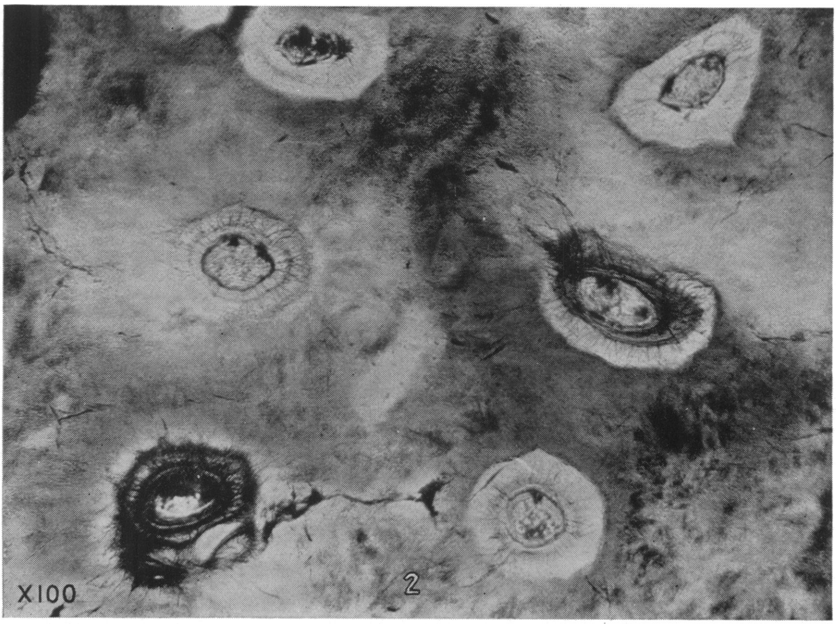


Fig. 2. *Polyporites browni*, n. sp. Type. Photomicrograph showing transverse section through hymenium. Pores unbranched. × 100.

While the pores in the main run parallel as in a polypore like the familiar *Boletus* at first sight, study of the illustration shows the presence of various transversely cut lateral pores; and in the thin section it is soon found that there is a main vertical pore series and a minor labyrinthine series, which branches out from it. These lateral pores do not diminish much in size. They are the most unusual or recondite feature of this fossil.

Turning now to photomicrographs, Figs. 2, 3, showing the transversely cut section of the hymenium somewhat more enlarged than the preceding (× about 100), the appearance and mode of pore preservation may be much better understood, especially the branching feature. Apparently the outer pore wall consists of a setal or hyphal thready mass replaced in the course of silicification as a zone of nearly clear quartz in which the darker hyphae are very distinct. Inside this is a somewhat narrower zone of markedly concentric banding, also traversed by the radial threads. The width of this second zone varies much in the different

Fig. 3. *Polyporites browni*, n. sp. Type. Photomicrograph showing another transverse section through hymenium at nearly same level below unsilicified cap as preceding section, but traversing an area in which initial pore branching occurs. × 100.

pores, and the banding seems to be a feature of petrifaction, rather than due to actual structure.

The filling of the pores inside the banded zone appears merely as a darker mass, or lesser masses set here and there in indistinct granulation of a very uncertain nature; or else there may be a filling in of quite clear light blue silica. Taken feature by feature these naturally stained sections are objects of great beauty. But in the highly magnified camera lucida drawing, Fig. 5, of a transversely cut pore traversing the trama, the artist may have drawn too well! For it is scarcely possible to identify the darker inner bodies there noted with actual structure. In the fossil, nothing like basidia, cystidia or spores, which at × 100 would appear about one millimeter in length, can be noted with certainty. But old sporophores due to leathery texture might last for years, and it

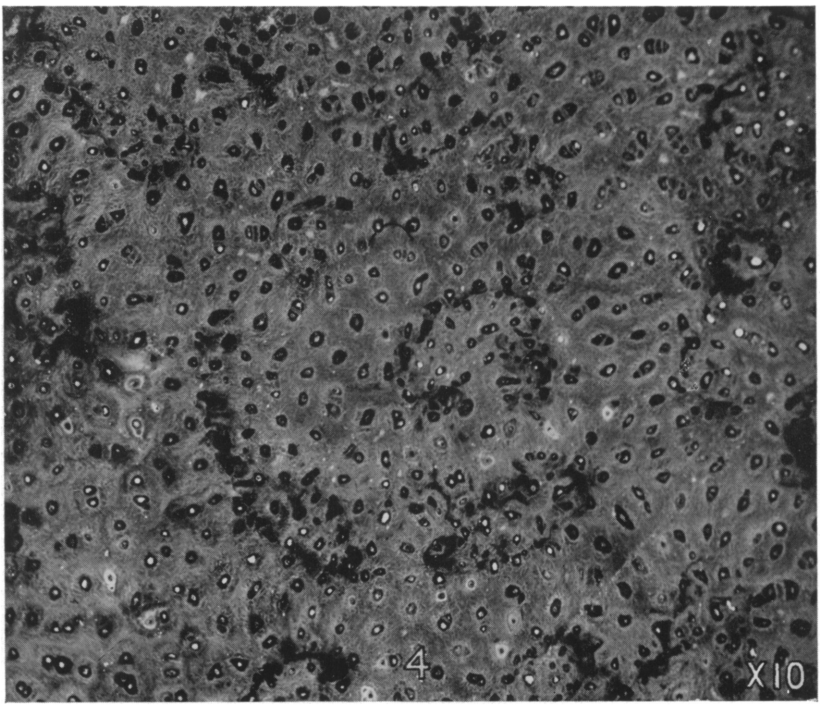


Fig. 4. *Polyporites browni*, n. sp. Type. Photomicrograph showing polished transverse section through hymenium showing manner of pore branching. × 10.

may be that some of the features recorded by the artist are due to such sporophores.

That the silicification nevertheless bears a remarkable relation to the original structures is further brought out by comparison of the polished transverse section, photomicrograph, Fig. 4, with the same surface after etching in a 5% solution of hydrofluoric acid as shown by photomicrograph, Fig. 6. On the etched surface the pores are more clearly outlined as the main structures in the hymenium.

Finally, the upper surface of the fossil is shown in Fig. 7, and the lower surface in Fig. 8, magnified ten and five times respectively. It is thus certain that none of the pileus is present, though it should be as

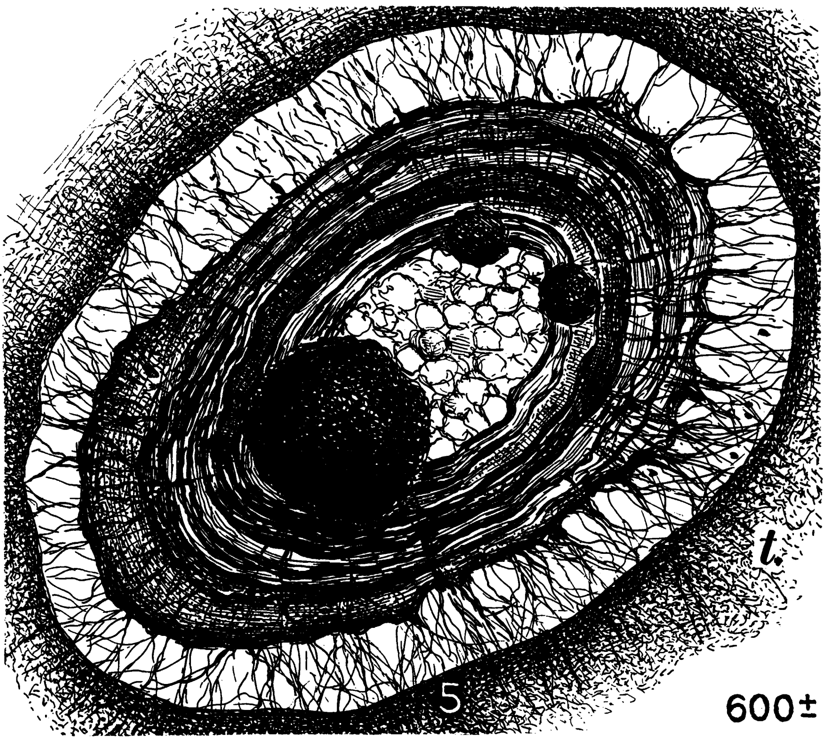


Fig. 5. *Polyporites browni*, n. sp. Type. Camera lucida drawing of transverse section through single pore greatly enlarged. Outside the transparent layer is the tissue of the trama (t). The concentric banding of the inner pore wall is partly due to the manner in which siliceous replacement proceeded. The lighter central granulation appears to be a feature of the siliceous replacement, and the larger dark bodies are not understood as features of the pore. × 600.

readily replaced and as resistant to decay as the hymenium. It is possible that the pores aided the infiltration of the solutions which brought on silicification, and that the upper portion of the fossil was more granular and easily eroded.

SILICIFICATION

Each new instance of the replacement of plant tissues by silica gives an added interest to a process which has gone on in nature throughout geologic time and yet has never been quite satisfactorily reproduced in the laboratory. We see in a fossil like that here illustrated, or in the

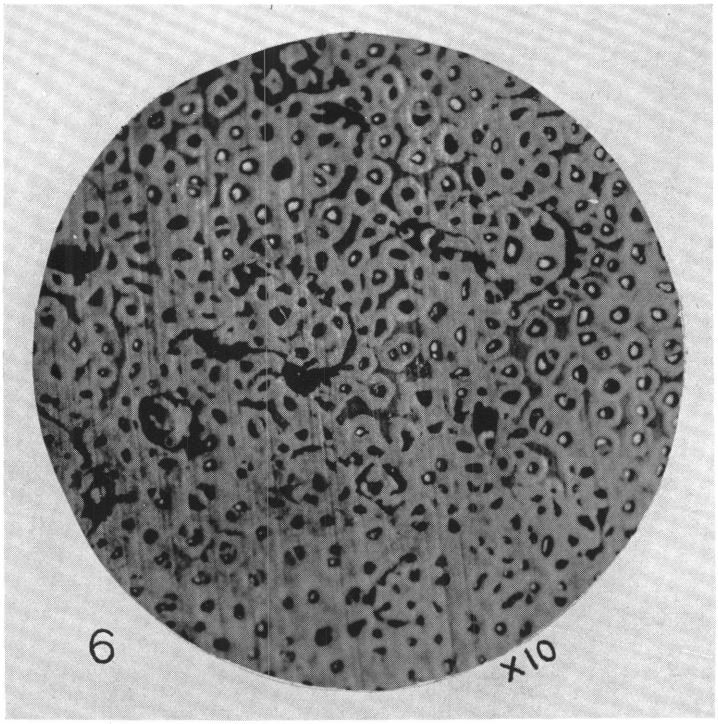


Fig. 6. *Polyporites browni*, n. sp. Type. Amer. Mus. No. 24123-C. Photomicrograph showing etched transverse section through hymenium for comparison with polished section, Fig. 3. This section lies parallel to and about three millimeters beneath the upper hymenial surface as shown in the succeeding Fig. 7. × 10.

stem of a petrified oak, or again in a petrified seed or pollen grain or flower, the end result of a chemical reaction as well defined as that which ends in a quartz crystal. It is a result, too, which if it could be hastened and controlled until the opaline stage was reached would have high value in the laboratory, in botanical teaching and demonstration, and in the arts. The initial stages of this process are seen in the kettles about the Yellowstone. Over thirty years ago I collected there bits of partly mineralized wood and also replaced pine needles. But what is seen is far from analysis and controlled reactions which again and again result in the replacement of logs even ten feet in diameter.

Obviously chemists have not studied this field more closely because the silicification process has not yet touched the arts, no great industries

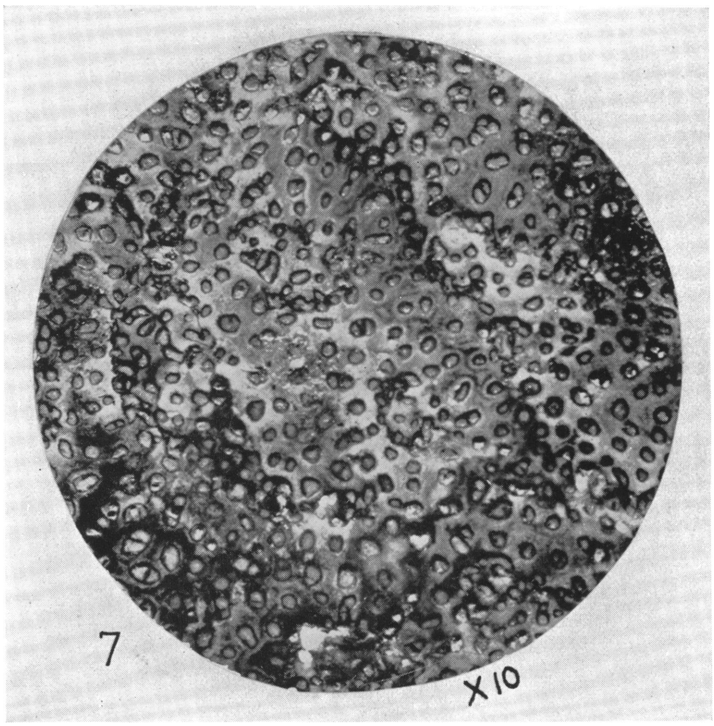


Fig. 7. *Polyporites browni*, n. sp. Type. Photomicrograph showing upper surface of hymenium near cap insertion. × 10.

being directly based on the silicic acid series as on the carbon series. But recently the fact that orthosilicic acid may be secured in stable form or relatively so, has been shown by the organic chemist Willstaetter. It is at least evident now that orthosilicic acid in penetrant form reacts on cellulose with deposition of opaline silica, as the first stage in silicification. Also carbon dioxide, especially under pressure, has an important solvent action, so that probably with the aid of heat and pressure in the

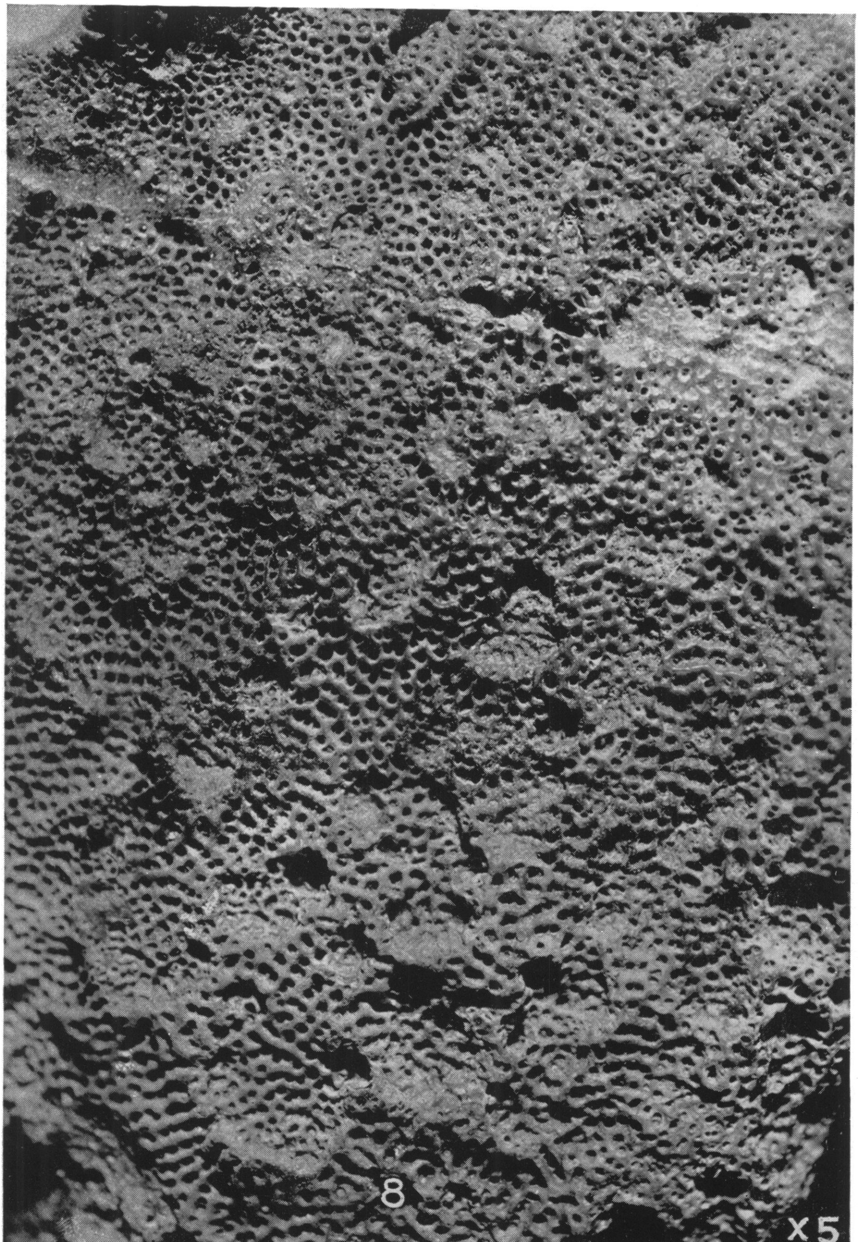
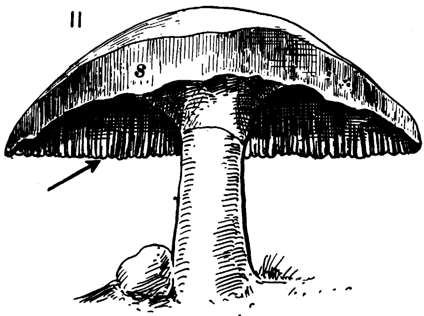


Fig. 8. *Polyporites browni*, n. sp. Type. Photomicrograph showing enlarged view of lower surface of hymenium. There is a highly characteristic mottling due to nodes of hard silica and a series of slight, partly ridge-outlined depressions. The latter feature is just what one may find in a partly desiccated *Boletus* found in the woods any time in the mid- or late summer to-day. Often the pores on one side of a ridge are for a short distance distinctly aligned, showing how easy and simple would be the transition to a gilled fungus type. × 5.

presence of a flow of orthosilicic acid, petrifaction may be brought about. The more stable mono- or orthosilicic acid is produced by dissolving pure sodium silicate in mixed hydrochloric with excess acetic acid. In carrying out experiments looking toward the final solution of the problem of silicification, no more curious plant type could be used than a shelf fungus. Some simple experiments have been begun.



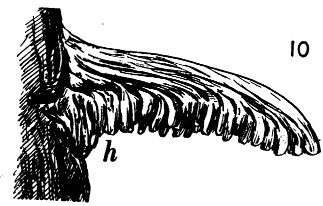


Fig. 9. A common polypore "shelf fungus" of the woods as found growing in abundance on old or fallen trees. Longitudinal view through outer portion of lobe: *h*, hymenium; *s*, subiculum, cap or pileus which is not preserved in the fossil.

Fig. 10. "Shelf fungus" showing tree form of attachment. Longitudinal view, diagrammatic.

Fig. 11. A "stone fungus," *Boletus*. Wholly diagrammatic. The arrow points out the shaded hymenial mass pendant to the upper cap of solid white tissue or subiculum. From the form of the fossil, it is held more likely that it is a "shelf" form rather than one of the stalked "stone" fungi. By way of emphasis, note again that in the fossil it is only the pore-traversed hymenial mass that is preserved, and no part of the cap or subiculum.

Following submission of the foregoing notes to the Editor of *Novitates*, Mr. Brown returned from his field work and further reconnaissance in the Northwest during the past summer. He has learned of what is evidently a second specimen of petrified fungus now amongst the fossils assembled by the famous collector J. B. Hatcher, but not recognized by him as a fungus. This specimen, long in the Carnegie Museum of Pittsburgh, needs therefore to be renoted.

Also, Mr. Brown has now found south of Harlowton, Montana, an additional fungus quite identical with that here described. Associated vertebrates and invertebrates are identical with those of the Cloverly north of the Pryor-Big Horn Mountains. Hence these unusual silicified shelf fungi must be for their horizon far from rare, and may evidently be found along a considerable range of the Cloverly terranes.

Because of this extended interest, a few of the simplest explanatory drawings, Text Figs. 9–11, are appended to show the relation of the fossil hymenium, as recovered, to the complete fungus as in life, and also to show the simple relation to a closely related stalked form like the common *Boletus*. The relation is in fact so close that, as fossils go, it is conceivable that the petrified form could be more closely related to *Boletus* than to the characteristic shelf fungi. This is somewhat evident from Text Figs. 8–10. There, as the views include the vertical longitudinal section, the position of the hymenium with respect to both types is indicated more directly, and it is seen that in a fossil there would be no absolute certainty that the one type or the other was indicated unless defined or complete outlines were present. But it is the shelf fungi mainly that become woody and lasting, and that might eventually be petrified while yet adherent to tree trunks, perhaps themselves destined to petrifaction. The fossil form before us is (though not with absolute certainty) considered to be a shelf fungus.

CONCERNING GENERIC DIAGNOSIS

In the foregoing pages there is described and even adequately illustrated a vegetal type from the forests where fed the dinosaurs. This is so like types of to-day that one might expect to find not only the generic but even the specific characters yet existent. Indeed, such nearness of type is a most arresting fact, adding a whole chapter to the history of the fungi. Nevertheless, from the fossil side, classification is about all that can as yet be expected. Closer generic or specific diagnoses would here be so arbitrary and imperfect that they could not find application. Such an isolated type finds its own classification, but closer diagnosis begins only when more and varying forms are found. Besides, there must be very many related though as yet unidentified living forms. In the case of these, in fact, as I have been told, even to the initiated, what appears like a *Poria* one day may be thought a *Polyporus* the next! Some students of the fungi do not attempt to identify material over twenty-four hours old, so little lasting are some of the more critical diagnostic features. These may thus better be omitted in the case of this new material "fixed" one hundred million years ago!