SILICIFIED WOOD IN DOLOMITE

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INTRODUCTION

There is exposed on the west side of the Sonoma Range, south of Winnemucca, Nevada, a series of folded and faulted sedimentary rocks of Triassic age. The general geology of the area has been studied for several summers by members of the Stanford University field course in geology, and a preliminary report dealing with the structure and stratigraphy is now in preparation.

The youngest Triassic formational unit exposed in the Range consists of a series of interbedded buff, red and green shales, buff sandstones and gray to black limestones and dolomite beds. A shallow water pelecypod fauna, including *Alectryonia sp.*, and *Myophoria whatleae* is closely related to a Mediterranean-Alpine assemblage of Upper Triassic age. Pieces of a jet black siliceous rock were found scattered over the surface of the formational outcrop during the field mapping. Dr. Siemon W. Muller first recognized this material as organic in origin. Subsequently a number of specimens were collected from this and other carbonate beds in the series. The largest piece of wood found was approximately six feet long and eighteen inches in diameter. Most of the preserved specimens are stems or small logs that floated out in the shallow sea, became waterlogged and sank into the carbonate ooze.

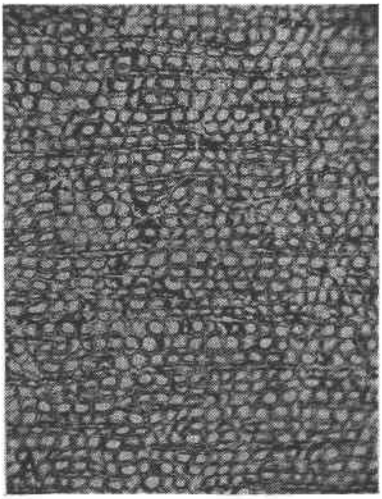
Adams[1] has described a piece of wood picked up as float in which the replacing mineral is in part dolomite, but he knew nothing of the origin of the specimen, beyond the fact that it was found in the Midway oil field, Kern County, California. Wieland[2] mentions the occurrence of beautifully preserved calcified wood from the Genundewa limestone, lower upper Devonian, of western New York. The occurrence of silicified fossils in carbonate rocks is not exceptionally rare, but the occurrence of silicified wood in dolomite is unique insofar as the author has been able to ascertain from a search of the literature.

DESCRIPTION OF SILICIFIED WOOD

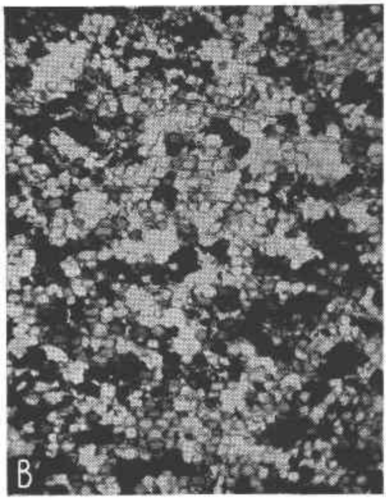
Some of the petrified wood, in hand specimen, is very fine grained, although not cherty in appearance. Other specimens resemble a medium grained black quartzite. The preserving medium in all specimens is predominantly granular quartz; some sections show minor amounts of the chalcedonic variety. The crystal growth in the fine grained material

[1] Adams, S. F., A replacement of wood by dolomite: *Jour. Geol.*, **28**, 356–365 (1920).

[2] Wieland, G. R., The Cerro Cuadrado petrified forest: *Carnegie Institution of Washington*, Publication No. **449**, 62 (1935).

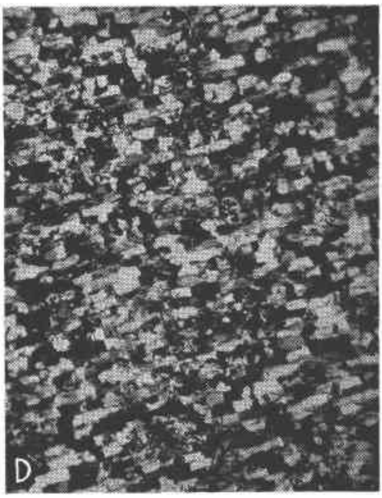


1*a*



1*b*

2*a*



2*b*

FIG. 1*a*. Transverse section of silicified *Araucarioxylon sp.* ×31.

FIG. 1*b*. Crossed nicols. Illustrating the predominantly hyperblastic structure of the preserving quartz. ×27.

FIG. 2*a*. Almost true radial section from same specimen as shown in 1*a*, showing preservation of bordered pits on the tracheid walls. ×31.

FIG. 2*b*. Crossed nicols. Illustrating the influence of the cell walls on the crystallization of many of the quartz grains. ×27.

was influenced by the cell walls as shown in Fig. 2*b*. Single anhedrons may occupy one cell or may include several. In some portions of the slides one can see the primary wall still preserved; in others most of the middle lamella has disappeared, and its place is taken by quartz deposited in optical continuity with the tracheid cell filling. Storz,[3] in his description of Egyptian petrified woods, classifies this type of silicification as *durchkieselung*, simple tracheid filling as *einkieselung*. Where one crystal occupies a single cell the structure is called *oligoblastic;* where the anhedron takes in several cells and cell walls it is called *hyperblastic* (Fig. 1*b*).

There are small areas in some of the thin sections of the coarse grained material showing preservation very similar to that just described for the fine grained material. However, most of these thin sections show a different type of petrifaction. A crude cellular structure has been formed in the coarse grained material where crystallizing subhedral grains of quartz have attempted to clear themselves of the carbonaceous cellular material of the original wood along definite crystallographic directions, and have concentrated the black material just inside their borders. Some of the areas show the original cells to have been distorted by the force of the growing crystals. Other places in the section show well preserved fragments of cellular wood inclosed within a singular anhedral crystal. Some of the cleared areas are single anhedrons; others are made up of several wedge-shaped individuals which have grown outward from centers. Each wedge has forced the carbonaceous material outward to meet or almost meet the black material being forced away from the center of an adjoining grain or group of grains. The result is a crudely hexagonal pseudo-cellular structure (Fig. 3).

A study of the thin sections of the wood shows that there are no resin canals and no apparent annual rings present (Fig. 1). The uniserial medullary rays are as many as twenty cells deep. There are one or two rows of bordered pits on the radial walls of the tracheids, contiguous, alternate and often slightly flattened. This identifies the wood generically as *Araucarioxylon*, a primitive coniferous type comparable to that found in the Arizona Triassic sandstones.

Nature of Wood during Silicification

The condition of wood at the time of its petrifaction and the nature of the petrifying solutions have long been subjects of discussion. St. John[4]

[3] Stromer, E., Kraut, H. und Storz, M., Ergebnisse der Forschungsreisen Prof. E. Stromers in den Wusten Ägyptens. IV. Die fossilen Floren Ägyptens: *Abh. der Bay. Ak. der Wiss., Math.-natur. Abth.*, Neue Folge, **16,** 28, 42 (1933).

[4] St. John, Ruth N., Replacement vs. impregnation in petrified wood: *Econ. Geol.*, **22,** 730 (1927).

believes that wood may be either fairly fresh at the time of petrifaction, or it may be partly decayed.

Wieland[5] suggests that much wood is probably partly lignitized before petrifaction, but he will not agree that vegetable matter has gone beyond

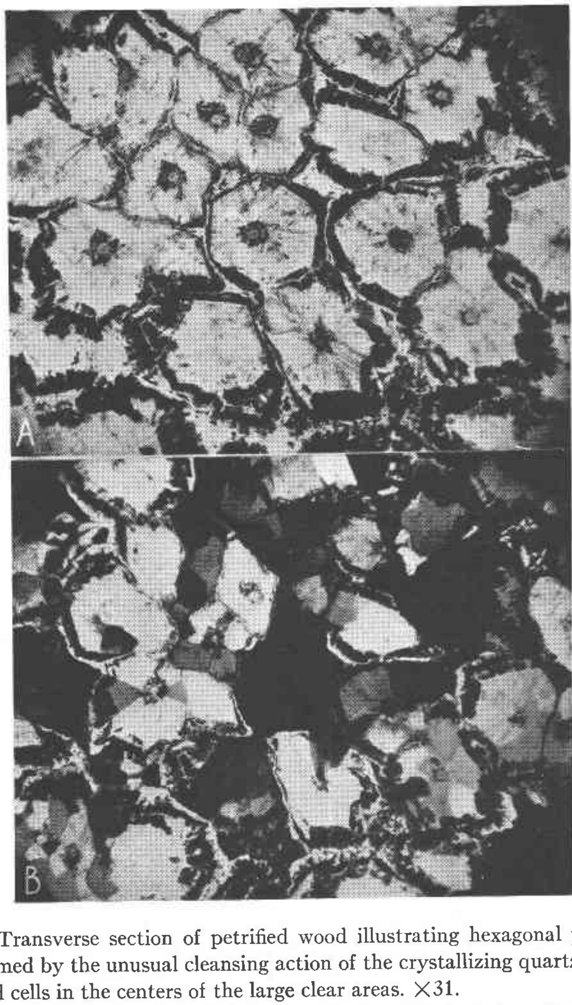


FIG. 3a. Transverse section of petrified wood illustrating hexagonal pseudo-cellular structure formed by the unusual cleansing action of the crystallizing quartz. Note the unharmed wood cells in the centers of the large clear areas. ×31.

FIG. 3b. Crossed nicols. Central dark area showing basal section of quartz hexagon. Note composite nature of some of the less perfectly formed hexagons. ×27.

the lightly carbonized stage to that of coaly matter, as suggested by earlier authors. He cites as evidence the lack of notable silicified bands in bituminous or anthracite coals.

[5] Wieland, G. R., Wood opalization: *Sci.*, *N.S.*, **76**, 278 (1932).

There is probably every gradation in condition of wood, just as there is every gradation from encrustation and penetration to complete replacement. Where there has been perfect preservation of the wood structure and form, as in the Nevada fine grained silcified woods, the structure must have been intact. In this investigation it has been found that the outer portions of the logs or stems are the ones preserved by coarse grained quartz with the development of the pseudocellular structure. The inner wood was evidently sound and the siliceous solutions preserved it. The outer wood had probably reached the lightly carbonized stage,* and its weakened cells were disrupted by the growing quartz crystals as they attempted to clear themselves.

Nature of Petrifying Solutions

The nature of siliceous petrifying solutions is a problem not yet solved. The majority of chemists and geologists believe that silica occurs and is transported only in the colloidal state in natural solutions.[6] Lovering,[7] investigating the solubility of silica and silicate minerals, found that cold water solutions of the bicarbonates of calcium and magnesium attacked all silica and silicate minerals, and to about the same degree. He accepted the belief that silica goes into solution as a colloid.

On the other hand Wieland[8] believes that monosilicic acid, thermal in source, must account for certain petrified forests.

Willstatter[9] has recently stated that conditions arise in nature where true silicic acid solutions result from acid action on silicates, and that the commonest solvent is carbonic acid. He presents H. Kraut's method for the production of orthosilicic acid in the laboratory, and discusses the factors that favor stability of the simplest silicic acid, namely its extreme dilution, or a slightly increased pressure to give a stronger carbonic acid and higher hydrogen ion concentration. If Willstatter and Kraut are correct in their assumptions that monosilicic acid can exist, the solutions which penetrated the dolomite beds to silicify the Triassic woods may have been true solutions. Certainly they must have been weak in silica and high in carbonate content. Willstatter makes a general assumption that colloidal silica lacks the ability to penetrate wood and animal mem-

* That the black color of the wood is due to its carbonaceous content was demonstrated by firing several slices, 2–3 mm. thick, in a ceramics furnace at 1500° C. Upon cooling, the slice resembled white bath tile. Under the microscope, faint outlines of the wood structure, apparently due to the residual ash, can be seen.

[6] Weiser, G. B., *The Hydrous Oxides*, McGraw-Hill, N. Y., 178 (1926).

[7] Lovering, T. S., The leaching of iron protores, solution and precipitation of silica in cold water: *Econ. Geol.*, **18**, 523, 525 (1923).

[8] *Loc. cit.*, 279.

[9] Willstatter, Richard, Über Kieselsaurewanderung und Verkieselung in der Natur: *Natur und Museum Sencken. Naturf. Gesell.*, B. **61**, 332–337 (1931).

branes. Therefore, because silica does penetrate it must be in the form of a true molecular solution. This is not a safe assumption.

Bailey[10] has shown that the perforations in the pit membranes of conifers are of such size that aqueous solutions containing finely divided carbon can be made to pass through the membranes of the bordered pits of the sap wood of conifers. He also cites an experiment in which gelatin was passed through the septa of the bordered pits.[11] Bailey[12] also points out that experiments show re-soaked dry woods, in many cases, to be somewhat more pervious to air and presumably to solutions, than unseasoned material. This is probably due to the rupturing of the pit membranes during the process of drying.

Summary and Conclusions

1. The black petrified wood found in Upper Triassic dolomite beds of the Sonoma Range, Nevada, is preserved by the infiltration of siliceous material which crystallized as quartz.
2. Where the wood was sound, the quartz growth was influenced by the cell walls; where there was a weakened cell structure the crystallizing quartz, usually considered far down the crystalloblastic scale, was able to partially, if not completely, clear itself of the carbonaceous material and destroy the true cell structure.
3. The assumption, in proof of the existence to true molecular silicic acid, that coniferous woods act as dialyzers and, therefore, exclude colloidal solutions, is unwarranted in view of the work done by wood technologists and botanists on size of openings in cell walls.

[10] Bailey, Irving W., The structure of the bordered pits of conifers and its bearing upon the tension hypothesis of the ascent of sap in plants: *Bot. Gazette*, **62**, 133–142 (1916).

[11] *Ibid.*, 136.

[12] Bailey, Irving W., Preservative treatment of wood: *Forest Quarterly*, Mar. **1913.** Contrib. from the Lab. of Wood Tech. of Harvard School of For., No. **2**, p. 7.