ORIENTATION OF QUARTZ GRAINS IN SOME INDIAN SILICIFIED WOODS

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ABSTRACT

The quartz fabric of some underformed Indian silicified woods has been studied. All the fabric diagrams show girdles — preferred orientation — girdling round the longitudinal axis of the tree trunks. The diagrams are of growth fabric determined by the anisotropy of the wood itself. The main principle involved is that the symmetry of the original wood structure should be preserved in the symmetry of the dimensional and the lattice patterns of the quartz fabric.

The dissolved silicates enter the original wood through pore solution. They possibly crystallize by some sort of 'mimetic' crystallization.

INTRODUCTION

IT has been found by applying the X-ray diffraction technique (MITRA & SEN) that quartz is the dominant mineral in the silicified wood of *Dadoxylon* sp. In two other silicified species of wood also quartz appears to be similarly predominant. Since the 'orientation of individual elements forms the final court of appeal in a fabric[1] investigation', and as quartz is by far the most predominant mineral in petrified woods under investigation, the orientation of quartz grains in such specimens has been considered.

The idea of employing this technique following the universal stage procedure, which has never been applied for studying palaeobotanical material, is to explore in a general way the possibility of the survival of original organic texture in petrified wood. The nature of texture in ancient buried wood and coal have been demonstrated and discussed in two other papers of this series (SEN, 1955; SEN & BASAK, 1955). The following brief account is an attempt to study the orientation patterns in petrified wood with reference to the usual textural patterns in typical normal recent secondary wood, with a view to finding out whether the orientation patterns in petrified wood are controlled by pre-existing patterns (which exist in original organic wood). This necessitates the petrofabric analysis of quartz orientation in petrified wood.

It is necessary to justify the employment of the universal stage procedure for studying the mineral orientation in petrified wood in preference to the X-ray diffraction method. Perhaps the principal object in view has been to introduce the use of inexpensive universal stage in such studies, so that the palaeobotanists may be in advantageous position of readily interpreting the nature of the objects of study in their fossil material.

PREVIOUS WORKS ON PETROFABRIC ANALYSIS OF PALAEONTOLOGICAL MATERIAL

The fabric analysis has previously been employed to study the nature of deformed fossils, and the literature on the mineral orientation of composite elements in variously distorted animal fossils has been reviewed by Fairbairn (1949). Similar and other cases have also been cited by Cloos (1949). The study of such fossils of composite elements of premetamorphic origin resulted in interesting conclusions specially with reference to the problems of elongation (SHARPE, 1847; HAUGHTON, 1856; SANDER, 1930; LADURNER, 1933; BILLINGS & SHARP, 1937).

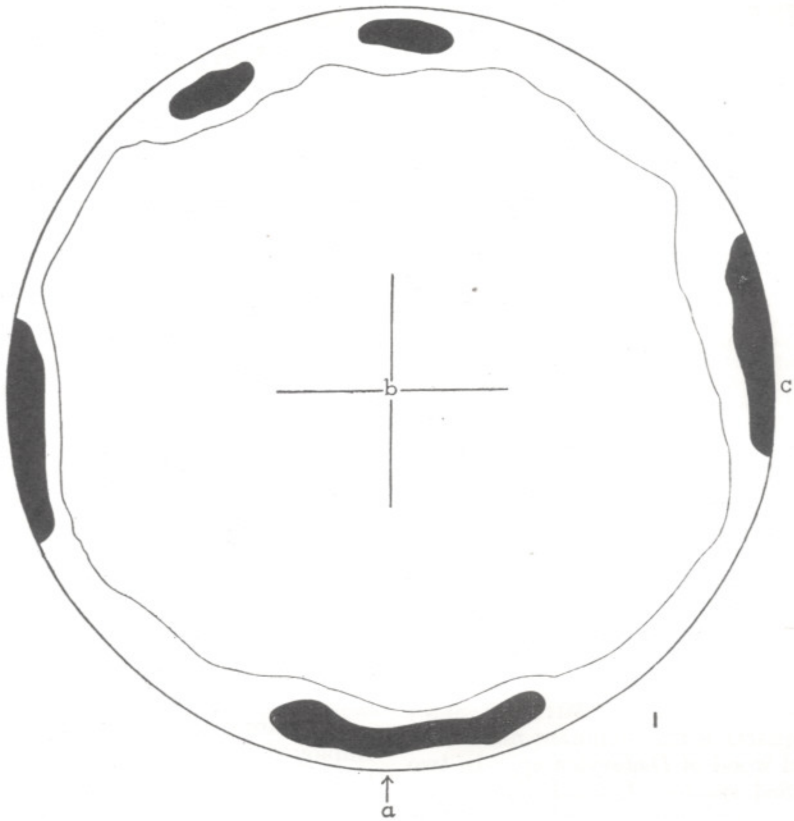
The quartz orientation of only one palaeobotanical material, a sample of *Araucarioxylon schroellianus* Goepp. from Chrzanów in Poland, has so far been studied by Turnau-Morawska and Jahn (1954). These authors prepared fabric diagrams without using a Fedrow or universal stage.

MATERIAL AND METHODS

The material consists of some species of Indian[2] silicified woods, none of which were found *in situ*. They are (1) *Dadoxylon* sp., with no organic substance preserved, and original cellular structure greatly destroyed

1. Fabric refers to the 'shape and arrangement of the crystalline and non-crystalline parts of a structure'.

2. The word 'Indian' is used here in a generalized sense denoting the Indian Subcontinent.



TEXT-FIG. 1 — Quartz fabric in a transverse section of the peripheral zone of *Dadoxylon* sp. Contour interval 0-0·5-15.

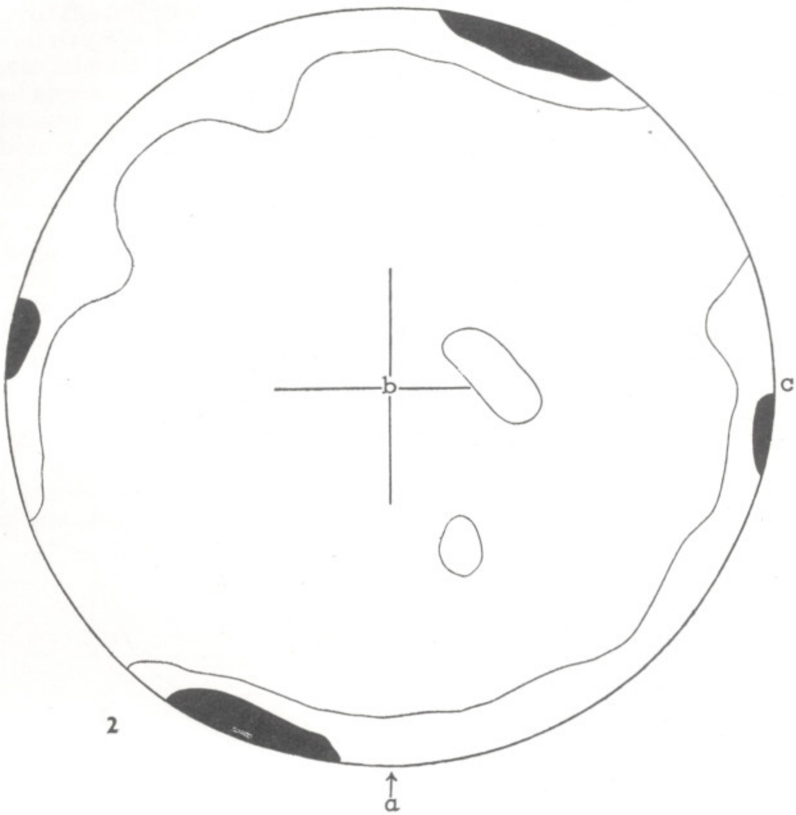
from Telimucha (near Mohuda), Ranigunj Stage (Permian, Lower Gondwana), India; (2) *Glutoxylon* sp., with organic substances persistent in the cell walls, and original cellular structure preserved nicely; from Mainamati Hills, East Pakistan (Tertiary), and (3) an undetermined species of dicotyledonous silicified wood, with traces of organic substances persistent in the cell walls, and original cellular structure preserved to some extent from Garbetta, West Bengal (age not known), India.

The specimens were strewn in open fields or under superficial deposits, and are not related to any larger structural feature. Therefore, there has been no occasion for collecting specially orientated samples in the field.

Thin sections of silicified wood were prepared transverse to the axis of the fossil. The axes a, b and c, at right angles to each other, were chosen for reference of fabric symmetry in space as shown in the fabric diagrams (TEXT-FIGS. 1-4). The fabric has been studied by keeping the slide strictly parallel. With the help of the improved 5 axis (EMMONS) universal stage, the orientation of the optic axes of the quartz grains with respect to the thin sections have been accurately determined. The poles of the optic axes have been plotted on a Schmidt's net, and ultimately converted into contour diagrams, following the conventional procedure.

OBSERVATIONS AND INTERPRETATION

The transverse sections of the trunk of *Dadoxylon* sp. have been prepared from a small portion of the periphery (along a growth ring) as shown (TEXT-FIG. 1). Similar preparations from other peripheral zones do not give additonal information; and composite diagram out of all the data cannot be prepared for a fuller picture the one dia-

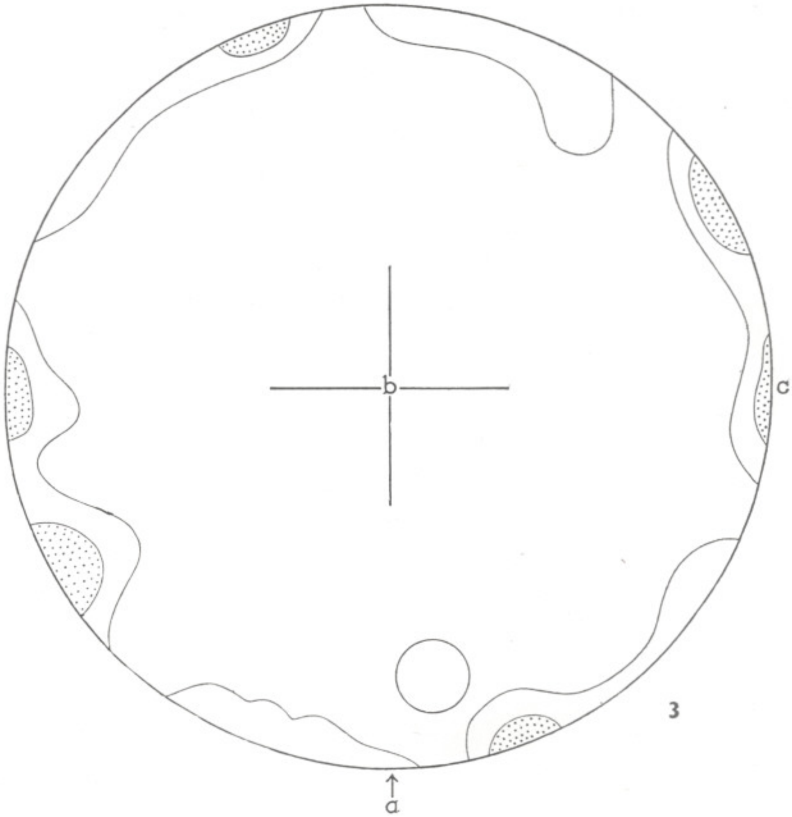


TEXT-FIG. 2 — Quartz fabric in a transverse section of the peripheral zone of *Glutoxylon* sp. Contour interval 0·5-10.

gram, because all the diagrams show similar girdles. Hence a representative diagram has been presented (TEXT-FIG. 1). The transverse sections of *Glutoxylon* sp. and those of the unidentified dicotyledonous wood have also been prepared from the periphery of the samples. In these cases also the diagrams (TEXT-FIGS. 2-4) show similar girdles (or like appearance). They suggest the possibility of the flow directions of the mineral solution travelling more or less centripetally from the periphery of the wood samples. This can be reasonably expected.

Both the diagrams of *Dadoxylon* sp. and *Glutoxylon* sp. (TEXT-FIGS. 1, 2) show girdle diagrams within which the poles of the measured optical axes are variously concentrated, with a few negligible exceptions, and exhibiting preferred orientations. In one of the samples of the fossil wood (TEXT-FIG. 4) from Garbetta the girdle is relatively less complete. The girdles are of *c* axes of quartz, the girdle axes being parallel to the long axes of the fossil trunks. Such a pattern could possibly develop if fibres of quartz elongated at right angle to the *c* axes crystallized parallel to the length of the stem. This type of crystal elongation is known in the quartz of veins and of other growth fabrics. The *c* axes of quartz are normal to the long axes of the cells.

It may be suggested that the orientation is restricted to the plane (of the girdle) transverse to the long axes of the cells. Since no such planes exist (in the sense of bedding plane), and that the girdle is usually found at every point on the transverse plane, there is a greater possibility that the orientation has been controlled by a pre-existing spatial structural organization of the cells in the original wood. The fabric thus obtained is a growth fabric, determined by the anisotropy of the wood itself. The main principle involved is that the symmetry of the original



TEXT-FIG. 3 — Quartz fabric in a transverse section of the peripheral zone of an unidentified dicotyledonous wood. Contour interval 0-1-2 above. Max. 4 per cent.

wood structure should be preserved in the symmetry of the dimensional and the lattice patterns of the quartz fabric.

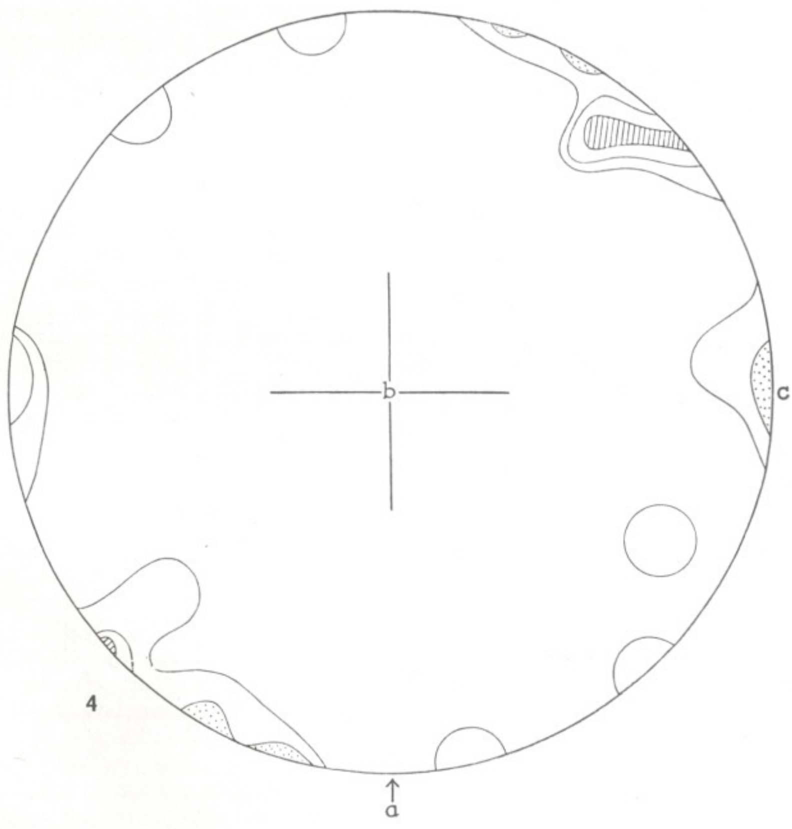
The cases, as the foregoing, clearly demonstrate that a new assemblage of inorganic substances (i.e. quartz as petrifying minerals) and possibly a new fabric have completely or partly replaced the structural organization in the original wood; but the general nature of fabric patterns in both (i.e. original wood and petrified wood) is preferred, the latter formed pattern being influenced by the pre-existing pattern.

In this connection it should be mentioned that a significant nature of arrangement of quartz grains has been found in a silicified trunk of *Araucarioxylon schroellianus* by Turnau-Morawska and Jahn (1954). About 90 per cent of the quartz grains are generally elongated in the direction of the long axis of the tracheids, whereas in the zone of medullary rays they are flattened in the same direction. The orientation of the quartz grains in this material are in conformity with the general nature of orientation of the structural units (i.e. cellulose micelles) in the original wood. In both the cases the structural units (i.e. quartz grains and cellulose micelles) are arranged in the same direction (in a very general way) with reference to the long axis of the cells. The original texture of the wood has thus been generally preserved in the texture of the silicified wood.

The crystallization of the dissolved silicates which have entered the wood through pore solution is obviously an interesting phenomenon. Possibly some sort of effective 'mimetic' crystallization is responsible for the types of inherited orientation present in the silicified wood as discussed in this paper. It has been concluded by Turnau-Morawska and Jahn (loc. cit.) that during crystallization of silica in the organic cells some phenomena of deformation in the crystalline lattice may occur, which appears in the strain shadows of quartz grains. These authors hold that the resistance of the cell membrane produces stresses and strains, the result of which is a preferred optic orientation of quartz grains similar to that appearing in crystalline schists.

The mechanism of petrifaction of plant tissues has been described as a case of metasomatic replacement (BATEMAN, 1950). Accordingly the metasomes need not have a common ion with the original wood. It has been said that the " replacing minerals are carried in solution and the replaced substances are carried away in solution, it is an open circuit, not a closed one .... Consequently, the shape, size, structure, and *texture* may be faithfully preserved in the replacing substance ... even below the visible magnifications of the microscope." Although the hypothesis of complete replacement is now out of date (ARNOLD, 1942, 1947), yet the fact remains that the original organic *texture* often survives in a general way. It is still a wonder how the general pattern of fine texture of wood is preserved at least in some petrifactions even after the original structural units (i.e. cellulose micelles), which form the texture in the original wood, are usually destroyed.

Arnold's (loc. cit.) suggestion regarding infiltration of wood by minerals as a result of which the silicification of wood is effected has been elaborated in an analogy put forward by Turnau-Morawska and Jahn (1954). According to these authors the quartz grains in the transverse sections of *Araucarioxylon schroellianus* in optical behaviour, appears to be similar to those of sandstone-quartzite where the grains are enlarged by secondary growth. It has been suggested that the " phenomenon of the secondary enlargement of quartz grains was an analogous process in



TEXT-FIG. 4 — Quartz fabric in a transverse section of the peripheral zone opposite to the sample in the Fig. 3. Contour interval 0-1-2-3 per cent. Max. concentration 4 per cent.

case of the silicification of the plant and in the diagenesis of sandstones, where silica was infiltrated in place of an older cement of different chemical nature or filled the pores between the grains ". The situation no doubt deserves closer examination. Some experiments on the mechanism of silicification are now being conducted by the present author, which will be published later on.

ACKNOWLEDGEMENTS

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