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NOTES ON THE TECHNIQUE OF TREE-RING ANALYSIS, III.

A. E. Douglass

CHARCOAL TREATMENT*

(Continued from Vol. 7, No. 1, July, 1940, pp. 5-8.)

Care of Charcoal Fragments. In charcoal work no prepared surface is necessarily the final one, for there is always some detail that may require study in other parts of the tree. For example, faint or microscopic rings as well as false or locally absent rings should be examined throughout their entire available presentation. Since most charcoal specimens are small and irregular in shape, the first policy in charcoal technique is to preserve with special care the entire outside of the specimen. Thus at the moment of discovery the pieces need to be dipped briefly in a weak solution of paraffin in gasoline or some similar binding solution. This is followed by attaching firmly in place if possible all loose fragments and tying the whole in cotton with string.

In the laboratory the first need is to determine the direction of growth and the alignment of the cells. Thus we find the beginning and the end of the sequence and can secure any parts that are partially loosened and sometimes glue on in their proper place fragments that are actually broken off.

Uncovering the Ring Sequence. This is begun on its sides, not at its ends. Shallow cuts with the razor blade may be made at an angle of some 35 degrees with the grain; the blade should be sharp or it will not give a readable surface. Chipping is done by a firm but slow tearing pressure of a razor blade in the direction of the ring circuit. The combination of these two minor surgical operations usually uncovers the full sequence exhibited by the specimen. If the sequence is good the piece may be set aside with a group of preferred pieces. Unless the dating is almost immediately recognized, it will pay to let it go until extensive crossdating between specimens has been done, and a definite local sequence secured. A sequence derived from a good examination of all the specimens is of more value than a few scattered dates; for the dating of any new site is best sustained by a full presentation of its local chronology derived from many different trees.

This makes inadvisable the cutting of a charcoal piece into flat sections until after the ring series is fully identified for only then can one have a

*These are generally the methods we are using; not necessarily the best that can be devised.

clear idea of the value of the sequence and the need for photographs of it. This excludes completely the use of a sand blast, or other violent method intended to render rings visible for counting or identification, for such treatment completely obliterates faint rings and renders invisible the cellular structure upon which depends the recognition of the non-annual rings. An important part of the whole treatment of charcoal is the preservation of its features so that other students can give it proper examination.

Charcoal Classification. Great numbers of charcoal pieces are so fragmentary that true outside or bark rings cannot be identified or even estimated as to presence. However if there are large numbers of dated fragments, these may be arranged to give close value of construction dates by statistical methods. This requires a careful examination of each piece and its classification with respect to probable loss on its outside. The following classes are perhaps sufficient.

Class 1 includes those pieces in which true outside appears to be present. Such outside is characterized by a smooth tangential surface often with slight ridges in the direction of the grain as seen commonly under the bark; if the rings are large enough to be traced in circuit the same ring may be followed around the outside for a considerable part of the circuit.

One has to be careful not to mistake for the true outside a latewood surface of a strong ring which in rare cases is laid bare by vertical cleavage within the specimen. This judgment of nearness to outside by surface character is often checked and confirmed by the crowding of the rings nearby. Rings in trees normally are smaller, that is, thinner, as the age of the tree becomes greater. An additional factor in the desert area is the soil in which the trees grow; it is apt to be shallow and sometimes unstable or even subject to complete removal. So as the tree grows too big for its soil there comes a time when the outer rings rapidly diminish, even to microscopic size on account of diminishing food supply. That rapid change in size becomes therefore a sign of considerable age and of nearness to the true outside.

Class 2 includes those pieces of charcoal whose location in the tree is clearly very near to the true outside or bark ring, but does not quite reach it. This location is usually indicated by rapidly diminishing ring size near the apparent outside, as referred to in the last paragraph, but circuit continuity at the outside is so lacking that no certain identity of the true outside can be made. There are usually present some outer rings showing a near agreement in date.

Class 3 of the charcoal pieces includes those that give no indication of distance from the real outside. The great majority of fragments come in this class. They show large disagreements in outer rings and no rapid change in ring size. The outside loss on individual pieces may be 20 to 100 rings or more. The only hint lies in the average size of other sections from the same location, obviously complete or nearly so. One must keep in mind that in some areas the pit houses had four to six or more vertical posts as roof supports. These often were very large and sometimes show several hundred more rings than the smaller beams or poles of the roofs in the same houses. It is often easy to distinguish between these two types of logs.

Method of Expressing Loss or Uncertainty. There may be two kinds of deficiencies on the outside of charcoal fragments as indeed to a less degree on wood specimens. The first is a normal uncertainty as to the date of the outside ring on a dated specimen whose rings become compressed or microscopic on the outside and present a chance for many absences. In this case one estimates the earliest possible date for the outside ring, the latest possible date, quotes the midpoint between these two as the date and adds "plus or minus" half the difference between the two to indicate the uncertainty. Thus if the earliest and latest possible dates are 737 and 747, the date to be quoted is 742±5 (case a). The other deficiency is in an estimated number of rings lost altogether from the specimen. Here again one estimates the greatest and least possible loss and expresses the loss as the mean of the two, plus or minus half of the difference between them. For example suppose the least is 0 and the greatest estimated loss is 40. Then one expresses the loss as 20±20 (case b). If the least is 20 and the greatest 50, then it may be put 35±15 (case c).

Now in case each form of deficiency exists, the two uncertainties may be combined. For example in combining (a) and (b) we see that the possible final dates are 737 and 747; in adding 0 to 40 we get a range from 737 to 787, which is expressed as 762±25, which is simply the sum of the several parts. Similarly the sum of (a) and (c) is 777±20.

Of course these large uncertainties do not always help much by being stated in detail. They are often abbreviated +x or +X. In the case of wood much help comes from the use of the sap-heart contact as given in Tree-Ring Bulletin, Vol. 6, No. 1, July, 1939, pages 3 to 8.

Time Pattern for Charcoal Fragments. The sap-heart contact is not available in charcoal but from the large numbers of fragments a statistical solution becomes possible. This has been referred to in previous notes in the Bulletin, Vol. 7, No. 1, July, 1940, page 6. It was the method used in studying several hundred fragments from Showlow, Arizona, for a publication in 1935.

In making the time-pattern the plots of all dated pieces are arranged in order of the final dates actually identified on each one, beginning with the earliest one. The location and extent of each in time is now plotted as a horizontal black line on a time scale marked left to right on coordinate paper. The earliest ending sequence may be placed at the bottom and the others above this about a centimeter apart. This forms a pattern in which one or more construction dates or periods are indicated closely by obvious approach of groups of lines to apparent limits which become the desired dates or periods. This has been called an "asymptotic" method by Schulman.

Ring Qualities. In considering whether any given specimen is worthy of measurement and photograph one needs to know its sensitivity and species. In the case of wood specimens it is easy to make a small cut with a razor blade and uncover a sample of the ring sequence and judge of the specimen's value. But such quick estimate is not easy or safe in charcoal collections; the pieces are smaller and far more numerous and very fragile; in the large numbers there may be only one or two that point directly to the year in which the ruin was built or that present a valuable climatic record, and these must be found if possible.

In our years of work we recognized at an early date gradations of dating qualities in the sequences found and certain preference as to species. It gradually became apparent that the best ring records were in pines and Douglas firs growing in high specialized sites such as that at Mesa Verde as discussed in previous articles. Edmund Schulman of this Laboratory has effectively brought out the specially high quality of the best Douglas fir records and he has been very successful in identifying their best sites for chronology purposes. In judging charcoal fragments for these two qualities of sensitivity and species, the first is usually recognized at once by those who have really examined rings but the second is less easy and needs some special notes as given in the following paragraphs:—

Species Identification. Distinguishing characters in the wood or charcoal of the common southwestern species are named and described below; this refers specially to charcoal.

Douglas Fir *(Pseudotsuga taxifolia).*

(1) Very prominent latewood; (2) apparent rarity of resin ducts; rare occurrence of short, ring-like rows of ducts as in frost effects; (3) in diagonal cuts the cells form prominent and regular radial rows; (4) central rings are commonly small and show good sensitivity; (5) decisive identification is made under a microscope power of X 80 or more; this shows the highly characteristic spiral reinforcement on the cells of this species in the form of hair-like lines across the cells;* (6) size of cells averages about 0.035 mm; (7) complete omission of rings is very rare; doubles are rather characteristic and easily recognized.

Western Yellow Pine *(Pinus ponderosa).*

(1) Latewood strong but not prominent, often wide with gradual increase of density on early side; (2) a few scattered resin ducts visible; (3) cell rows in diagonal cuts irregular; (4) central rings large and usually complacent; (5) under microscope power X 80 bordered pits prominent and broad surfaces of cells show luminous reflection; (6) size of cells about 0.035 mm; (7) locally absent and false rings seem more common than in Douglas fir.

Pinyon *(Pinus edulis).*

(1) Latewood narrow; (2) resin ducts very numerous; (3) cell rows inconspicuous; (4) central rings small and look like ponderosa pine rings; (5) bordered pits strong; (6) cells somewhat covered and appear small but show the same number per mm as yellow pine; (7) doubles almost completely absent.

Junipers *(J. pachyphloea, J. utahensis, J. monosperma and J. scopulorum.)*

For all: (1) latewood narrow; (2) no resin ducts; (3) cell rows inconspicuous; (4) central rings somewhat large; (5) bordered pits conspicuous; (6) cells about 0.02 mm. in size. They can be convincingly identified by direct comparison with pine or fir cells, side by side on a glass plate under the microscope; (7) in general ring characters the species differ: pachyphloea, complacent; utahensis and monosperma have many doubles and generally are difficult; scopulorum in good sites shows datable rings, slightly complacent, doubles mostly confined to central rings.

Note: The characters named above have been derived from thousands of specimens from the Pueblo Area of the Southwest and are subject to correction especially in such brief statements; fir, pine, pinyon and scopulorum are illustrated in figures 4, 5, 6 and 7—a suggestion is evident here that special attention to sites might produce more readable juniper sequences; I. F. Flora of Durango, Colorado, has called special attention to the scopulorum. We have used a superb scopulorum and an equally good utahensis (?) in chronology building.

PHOTOGRAPHY OF CHARCOAL

Charred Wood. In the examination of charred wood, the diagonal cut, some 35 degrees from the direction of the grain, is the most efficient treatment because it is easier and quicker and less liable to crumble the wood or charcoal and gives by far the best view of the desired details of the rings for our purposes.

Charcoal. In genuine charcoal the cell reflection, emphasized in dealing with wood, is much less important; the brightening of the early wood can be seen but the latewood is not dark enough to give contrast. Hence the rings of charcoal are best seen by "specular" reflection on the surface which renders the earlywood dark and the latewood light, the reverse of their appearance on wood.

Different Surfaces on Charcoal. The best quick surface for first examination is obtained by chipping the charcoal in favorable places and using

*We make the "DF" test in a few moments by cutting with a sharp razor blade many very minute shavings from a radial-vertical surface, dropping them onto a glass plate and placing them under a microscope. Figure 3 shows an enlargement X 170 of these criss-cross reinforcement lines which we sometimes call "fur," shown by reflected light; transmitted light is preferable but not essential on thin shavings.

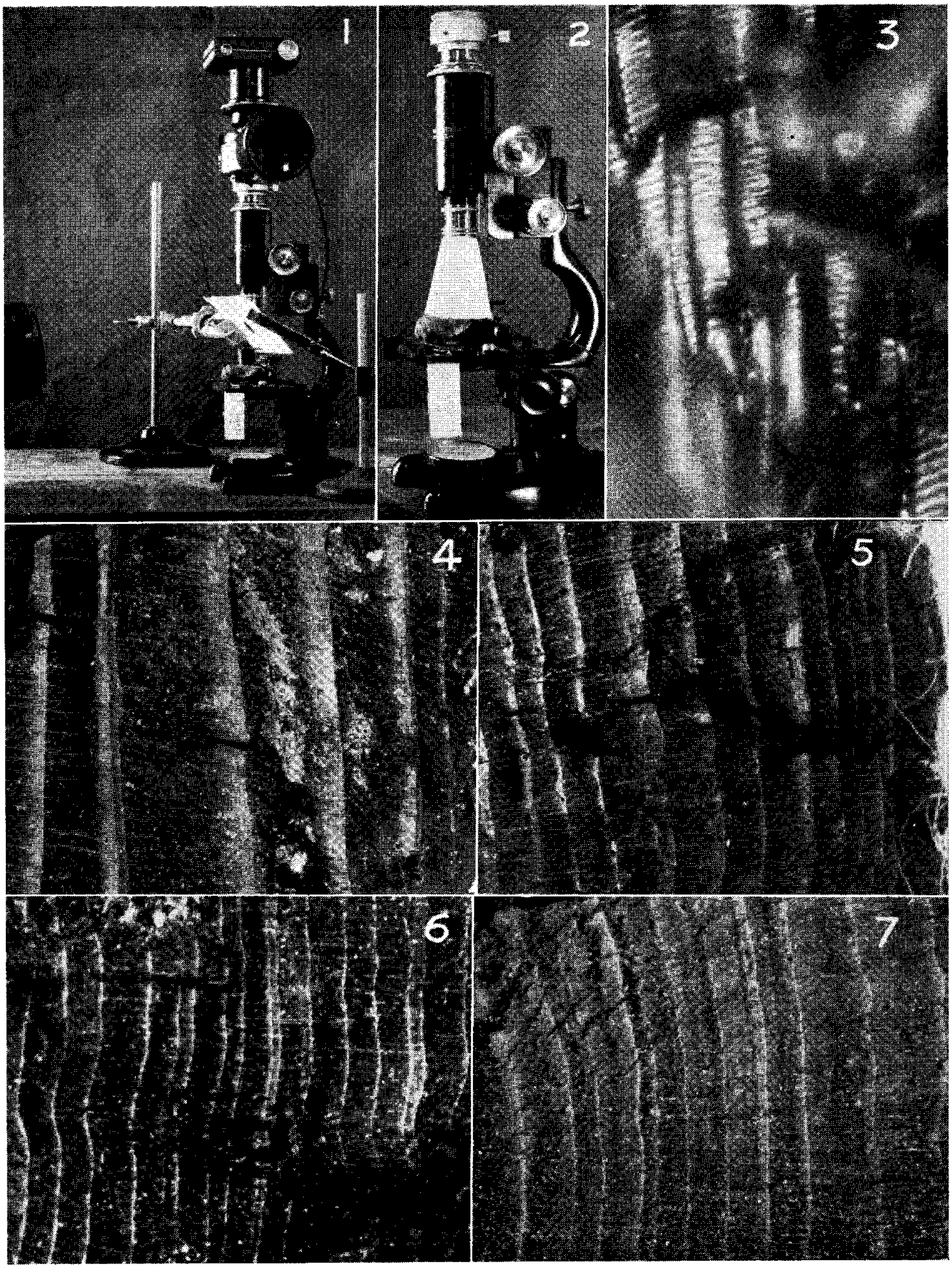

Photo setup for charcoal and specific ring appearance in charcoal of Southwestern dating woods (See species characters in text).

1. Microscope—camera setup for photography of charcoal with slant diffusion screen. 2. Microscope with cone diffusion screen. 3. Douglas fir cells showing spiral reinforcement lines crossing the cells; enlargement about X 170; photo from opaque charcoal surface. 4. Douglas fir rings in charcoal; A.D. 268 shows partly on left, 270 small, 274 micro; collected by Morris and Flora at Durango, Colo. 5. Pine sequence, A.D. 653 to 665, showing 660 microscopic, followed by four smallish rings. Collected by E. W. Haury and party at Forestdale, Ariz., 1939. 6. J. scopulorum ring sequence A.D. 265 (part) at left, 270, 272, 274, and 279 small; collected by Flora at Durango. 7. Pinyon sequence, A.D. 656 to 666, with 660 small followed by 4 smallish rings; collected by C. F. Miller of F. H. H. Roberts party at Allentown, Ariz., 1932.

diffused light so that a bright specular reflection even on irregular surfaces gives a good display of the desired details. From this one can judge of the importance of the ring record.

Classifying Specimens. Large groups of poorer specimens are best saved for later examination. Somewhat better ones are chipped so that the record can receive a "skeleton-count." If the specimen seems worth placing on record in a photograph it may be chipped to a rough but brilliant surface that under diffused light may be photographed with very slight enlargement (or in favorable cases it may even be reduced in size) and a very small aperture, preferably not beyond *f*100 using the computed value as described below.

If finally the specimen promises to be highly valuable in chronology or climatic work it will need measurement and the best photography which requires a large flat surface. Then one looks again at the direction of the grain. While chipping is perhaps best done on a surface perpendicular to the grain, a large flat surface is a bit safer (in our present opinion) at a slant to the grain of 30 to 45 degrees; it should be cut first with a hack-saw blade held bare in the fingers, flattened with a big flat file, moistened with a weak paraffin-gasoline solution and the surface sliced gently with a very sharp razor blade held in the fingers while watched under a lens.

Diffuse Illumination. There are two simple ways of producing diffuse illumination either for the chipped surface or the flat surface. For small specimens a beautiful result is obtained by a flat white screen 4 to 6 inches square with a hole in the center. This is mounted at an angle of 45 degrees close to the microscope objective which points through the hole. A bright beam from a photo flood spot light illuminates the screen. In our use such a screen has been found to throw upon the charcoal specimen about 8 percent of the incident light; and from the charcoal we have obtained about one percent of its incident light. This setup is shown in Figure 1. The screen takes up a good deal of room and high powers are hard to operate.

Perhaps the best general method of giving diffused light is the tissue paper cone shown in place in Figure 2. Different sized cones may be kept on hand and two or three lights placed about the one selected. For the best diffusion these lights should be far enough away to avoid concentrated spots of light on the cone.

Camera Setup. Important areas on a specimen may be photographed by a microscope and light arranged as above described and an ordinary camera focused on infinity mounted to look directly into the microscope. The camera should have a long focal length for the enlargement depends on that. Focusing this combination can be done before placing the film in the camera; an indirect method will be given in the next topic. Of course the combination here discussed has more lenses than are necessary and is limited in certain ways for that reason. The satisfactory outfit in the long run is a sturdy camera with long bellows that can use lenses of 1 to 6 inches focus and operate in an upright position which for many reasons proves very convenient.

Indirect Focusing. Focusing is very easy when done on a ground glass or better on a clear glass whose lower side is marked with ink lines which serve as reference marks in setting the focus. But one often has to use a camera with enclosed focal plane that is hard to get at; if this camera is focused on infinity then the microscope can be focused separately by a small telescope carefully focused on infinity. Such telescope must have cross-threads or some object in the focal plane that can be adjusted into its proper position while viewing a very distant object. The telescope with focus thus adjusted is placed over the microscope in the position to be held by the camera, and the microscope is brought to a good focus through it. Now the camera can be replaced and its film will be in focus. This plan of a secondary telescope has much further application which there is no room to describe here.

Exposure Timing. This topic gives some simple hints on timing photographic exposures under some of the special conditions that are met in this work. Use is made of the sensitive exposure meter that gives fractions of one foot-candle of light.

The brightness of the object to be photographed can easily be obtained if the object is large. But many wood pieces are narrow and most charcoal pieces are small and we must have their light-giving power to determine the exposure. In such cases we have used a short black paper cone open at both ends. The large end is placed over the meter and the small end, say one-half inch in diameter, is directed at the object from a close-up position. The correction needed for the reading may be obtained by trying this on a large area of uniform brightness and finding the ratio of change between readings with and without the cone.

Calculating f. The chief correction to the *f* that one has to introduce is for greatly increased length of focus. One remembers that in all cases the *f* is the quotient of the focal length (or equivalent focal length, as used below) divided by the diameter of the aperture actually used to receive light. In enlargements through one lens and long bellows to the film, the *f* is therefore the distance from lens to film divided by the effective diameter of lens used, not the *f* marked on the lens mounting. To avoid certain undesired effects (diffraction) it is well not to use *f* values much over 100.

For a combination microscope and camera one can calculate the equivalent focal length from the enlargement; it is the enlargement times the focal length of the microscope objective. In this combination the aperture is the actual outside diameter of the objective lens facing the specimen. The equivalent focal length divided by this aperture is the required *f*.

If the enlargement is not known it can best be measured in the camera before putting in the film. If that is not convenient an estimate may be made thus:—there are two steps in this combination enlargement, (1) divide the focal length of the objective into the distance from the objective to the nearer lens of the eye-piece, (2) divide the focal length of the eye-piece into the focal length of the camera; multiply these two results together and the product is approximately the enlargement.

Finally the *f* calculated may be far greater than shown on the scale of the meter or table used; in such case we find the *f* that requires one second exposure and then the desired exposure in seconds will be the square of the quotient of the real *f* divided by the *f* for one second.