What can we measure?

What can we measure?

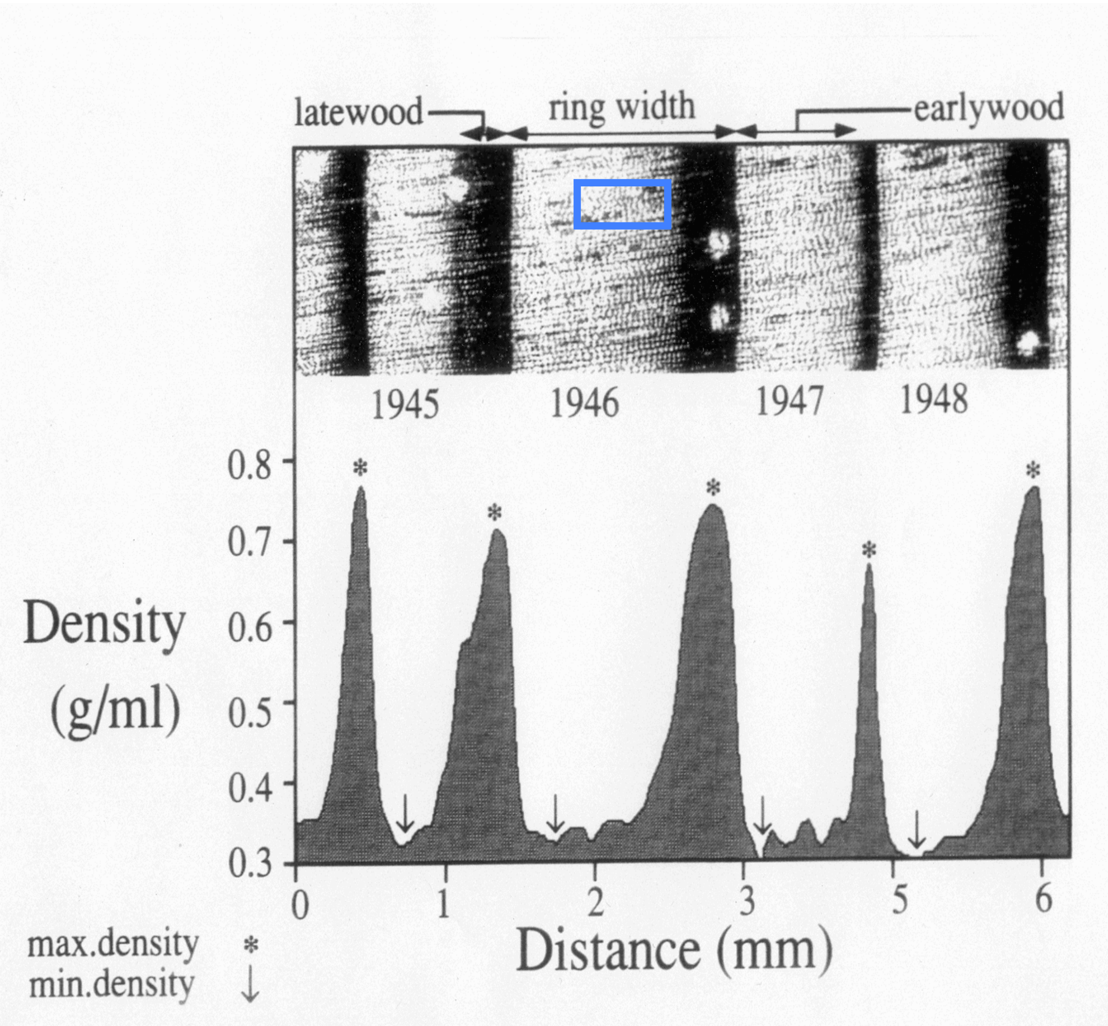
Structural:

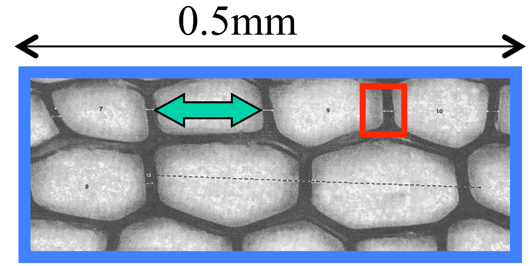
- Macro features seen with dissecting microscope – ring width, earlywood width, latewood width
- Anomalies –light rings; micro rings; frost rings, resin ducts, false rings, etc.
- Micro features needing compound microscope: conifers – tracheid dimensions; angiosperms – cell dimensions and shapes
- Integrative features – densitometry

Chemical:

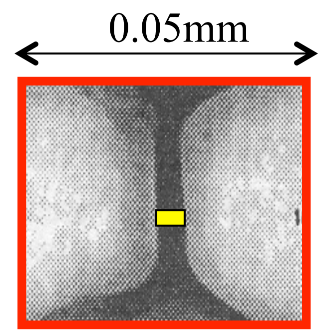
- Organic; inorganic; isotopic – in other lectures

Structure – macro and micro - conifers



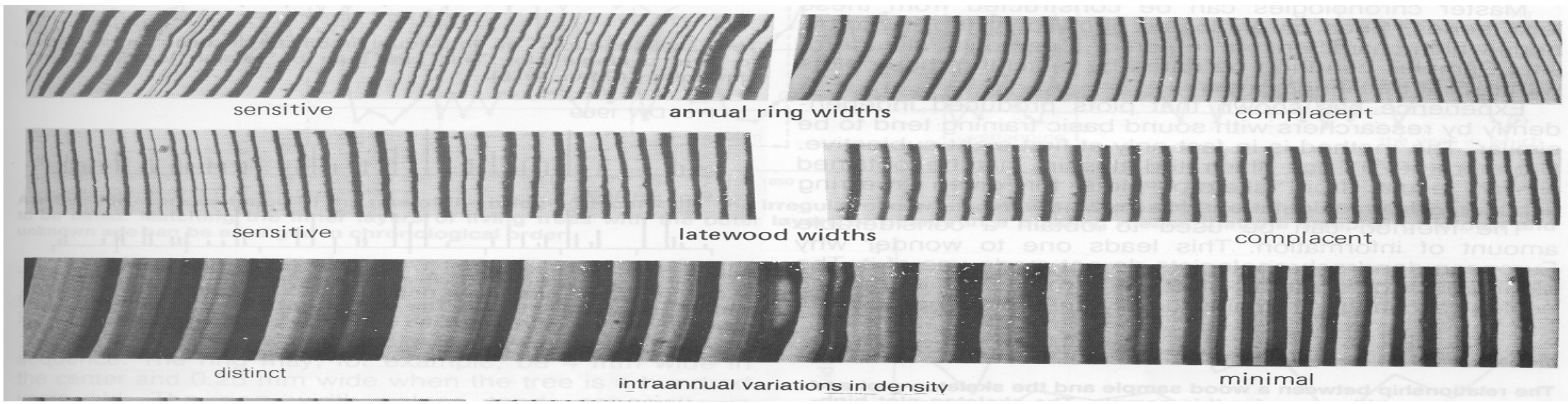


Cell size



Double cell wall thickness

Macro-structure in conifers.

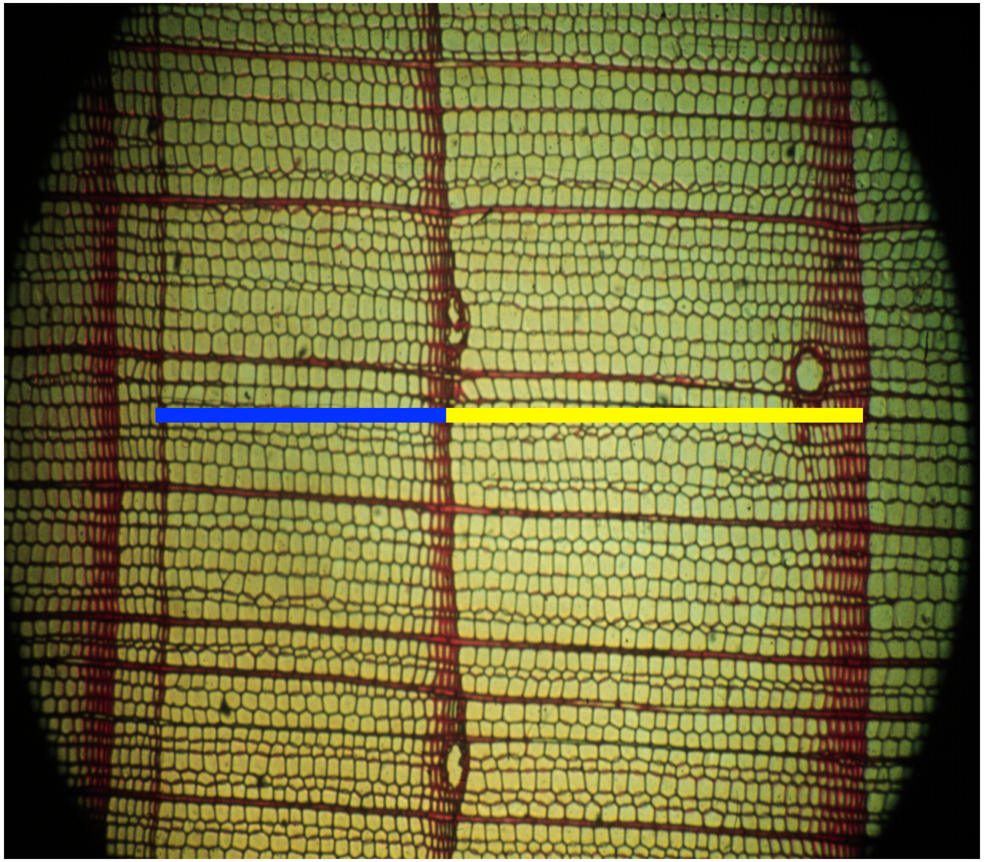


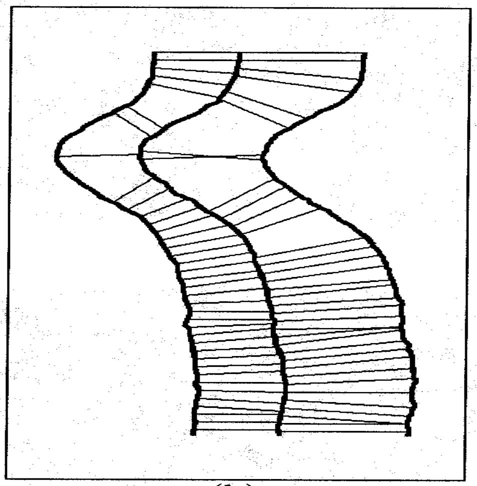
Schweingruber, 1989

Sensitivity can be seen in all these variables under certain circumstances.

Measuring ring-width

Usually done by working along a line more or less at 90 degrees to ring boundary, using cross-hairs to locate intersection of line and ring boundary.





It might be better to take the mean of many lines:

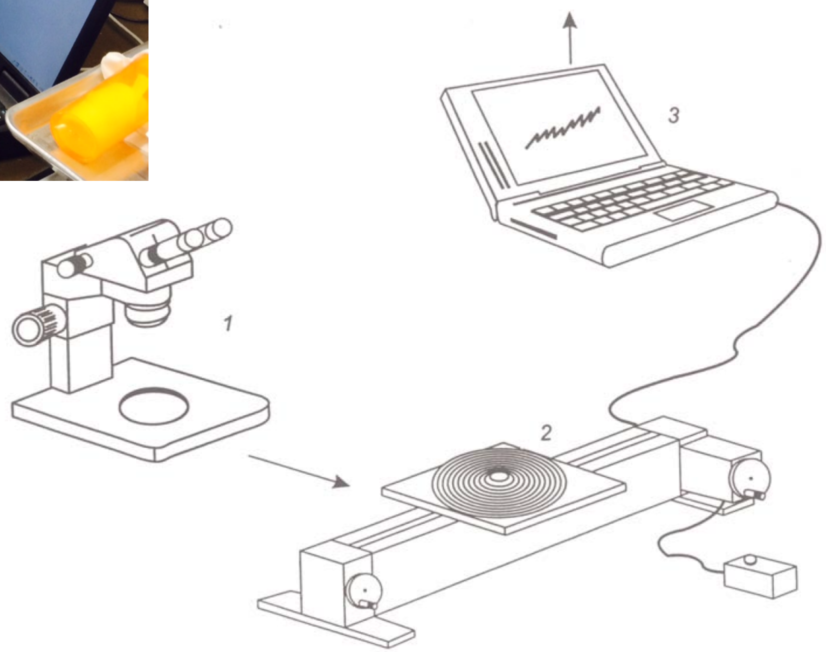
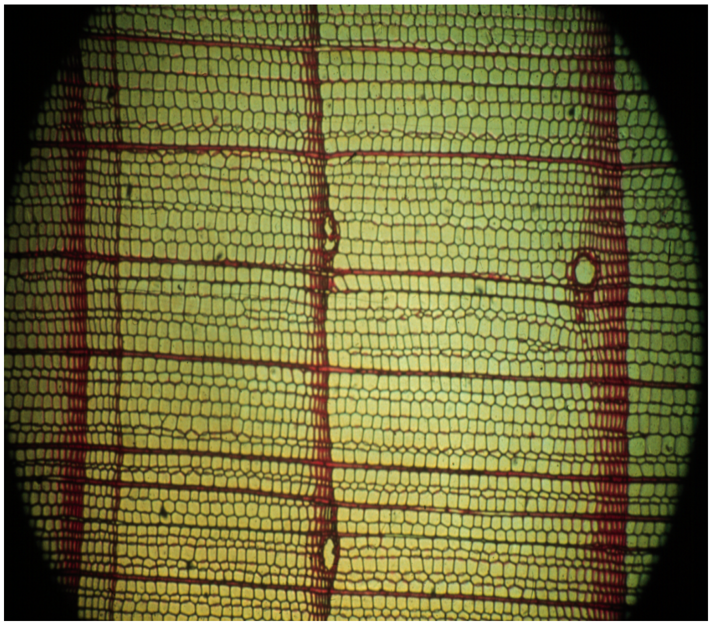


Fig. 2.2. Device for measuring and processing tree-ring width data: *1* stereomicroscope, *2* a specimen table with precision feed providing a linear sample displacement to 0.001 mm, *3* computer for compiling and processing data

Measuring earlywood and latewood width.



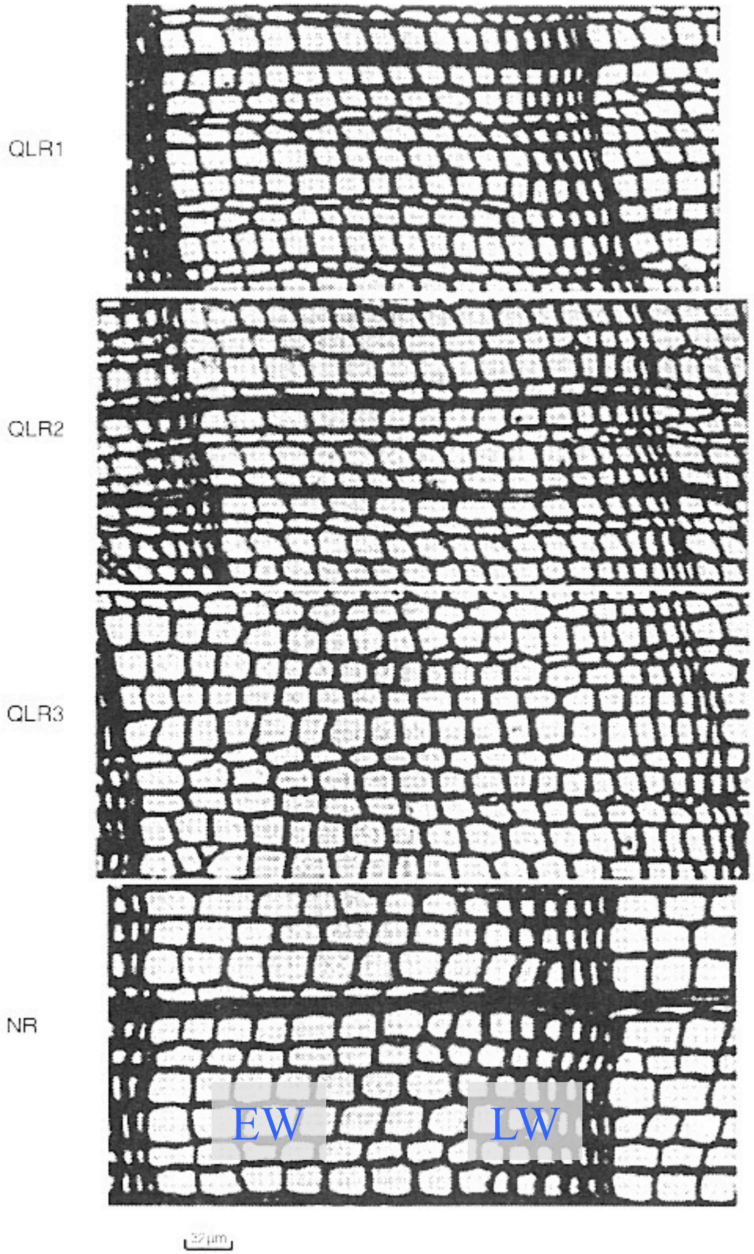
In this case the boundary is relatively clear, but there are species where it is not

It is good to check whether several observers put the boundary in the same place.

Record anomalies and their frequency

Anomalies

- light rings;
- micro rings;
- frost rings;
- resin ducts;
- false rings and density variations.



Light rings

Upper three panels – light rings of black spruce from the northern treeline in Quebec.
Bottom panel – normal ring from the same place.

Light rings in black spruce are 'characterized by pale-colored latewood (LW) made of single or very few latewood cell layers with thin-walled cells' Wang et al, 2000.

EW - earlywood

Micro-ring in larch in northern Siberia

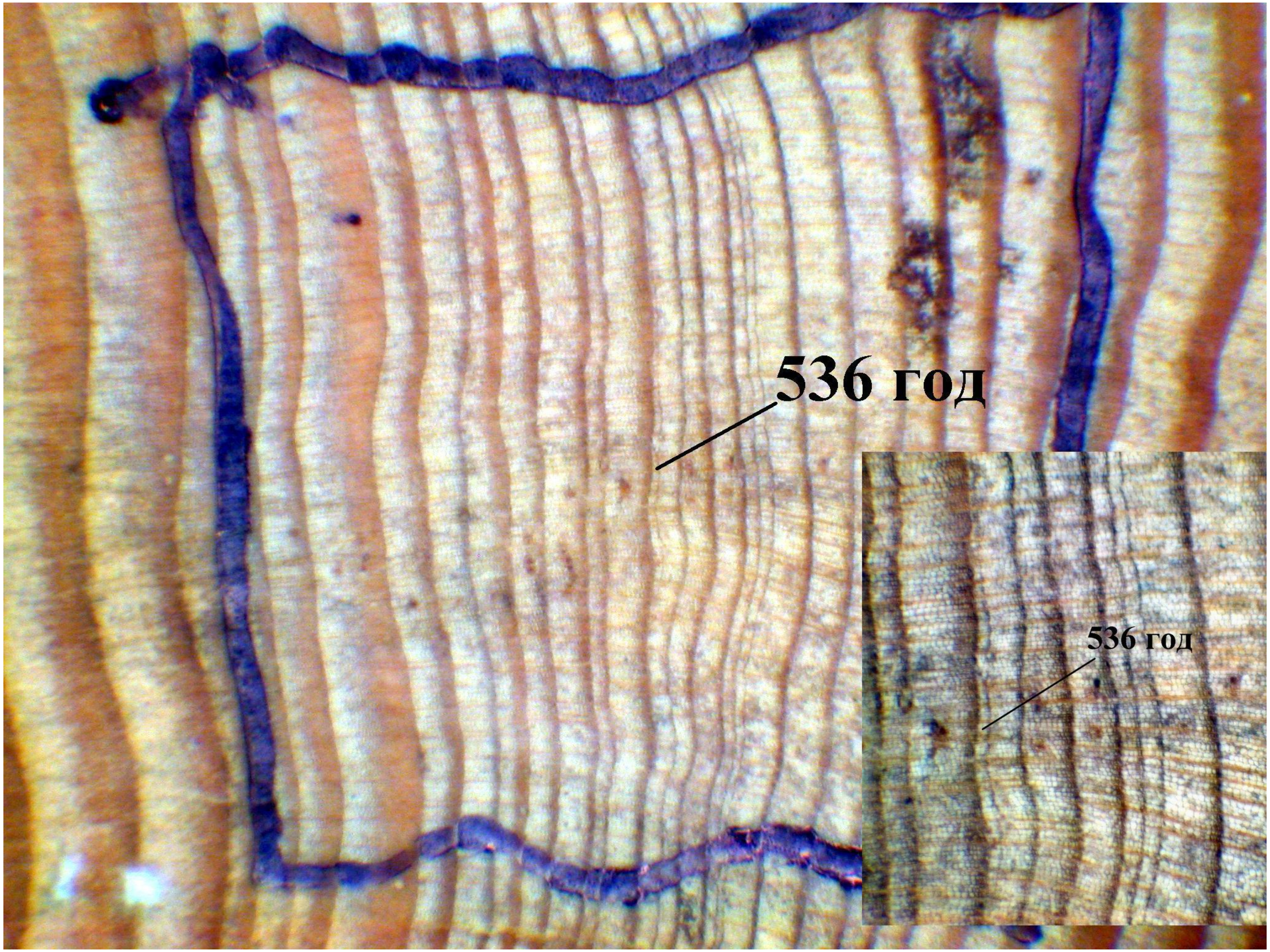


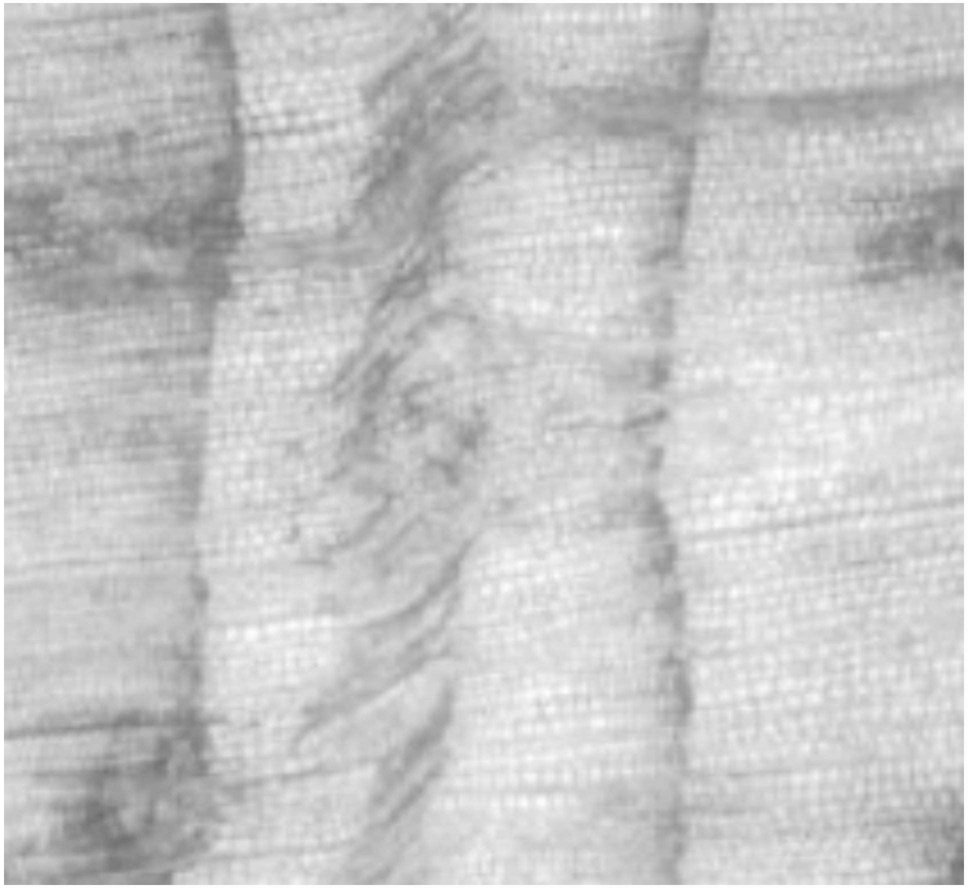
Photo thanks to Mukhtar Naurzbaev

Frost ring in pine from Mongolia

Gordon Jacoby collected this sample of tree rings from a Siberian pine in Mongolia, which records the years AD 534-539 (left to right). The narrow, distorted rings for **536 and 537** indicate a drastic cooling that froze sap in the cells during the growing season. Photo by Dee Breger. Lamont-Doherty Earth Observatory, Columbia University

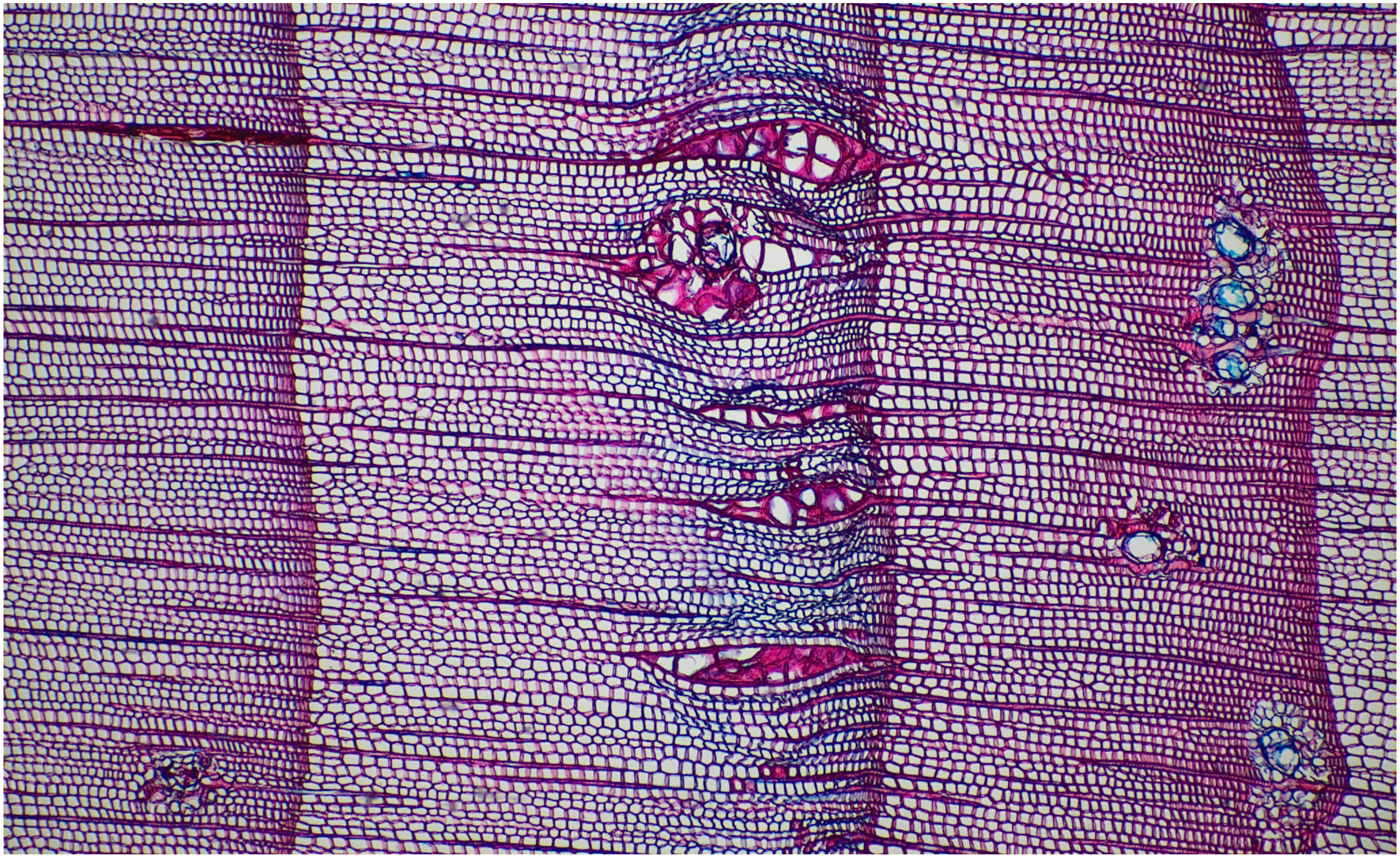
AD 536 – the same year as the micro-ring in Siberia!)

Frost rings in bristlecone pine, White Mts, California



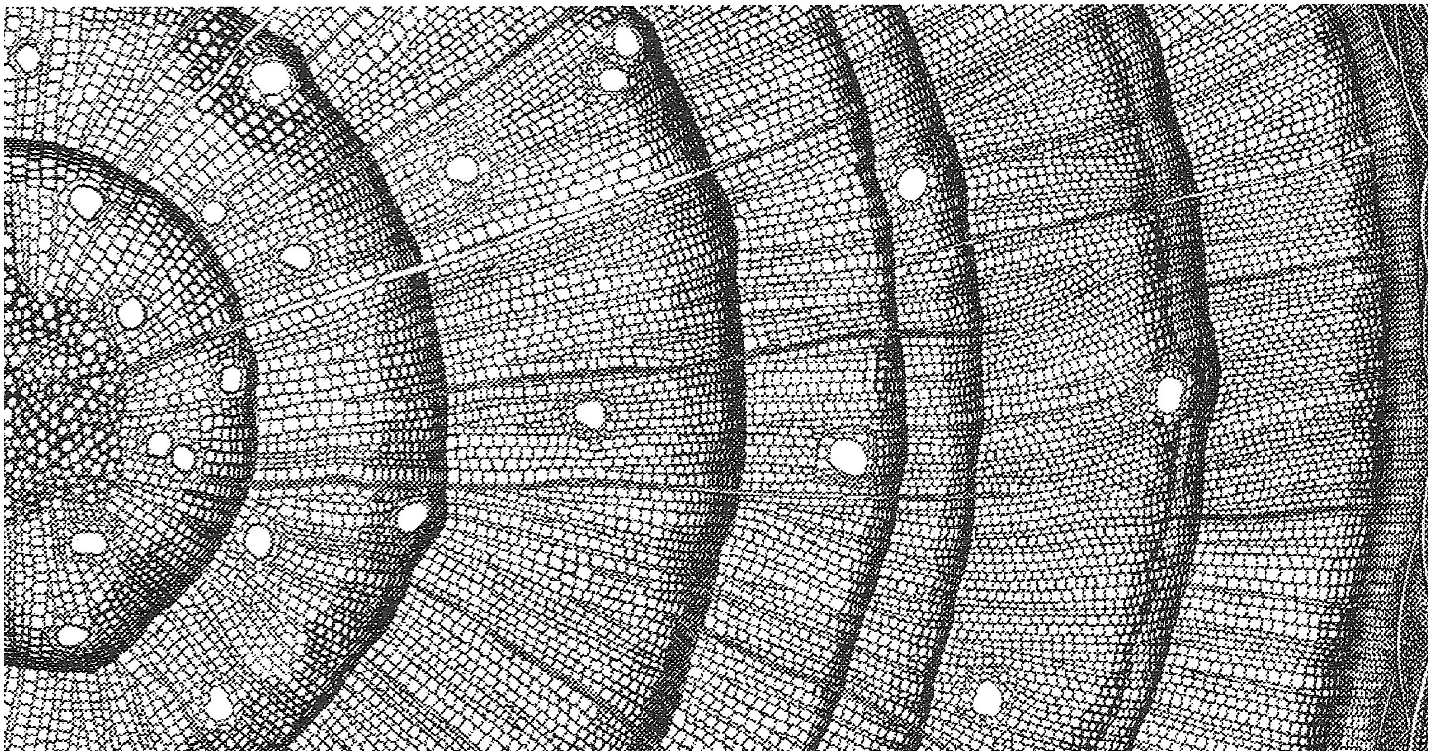
LaMarche and Hirschboeck, 1984

AD 1965 frost ring PRL3A



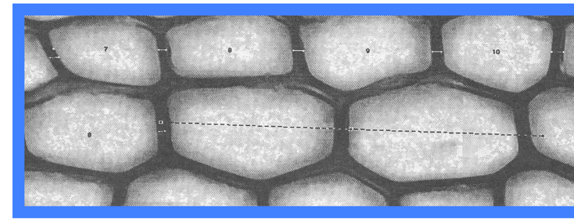
At upper tree limit in Ruby Range, northern Nevada.

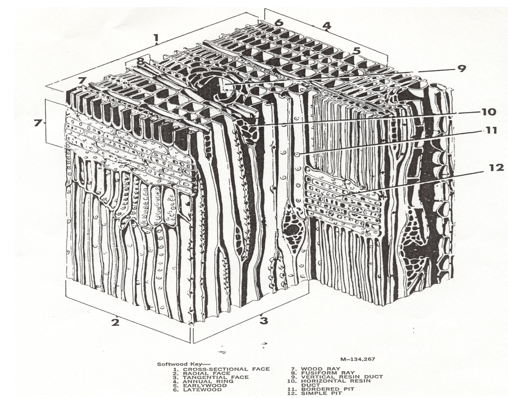
False ring

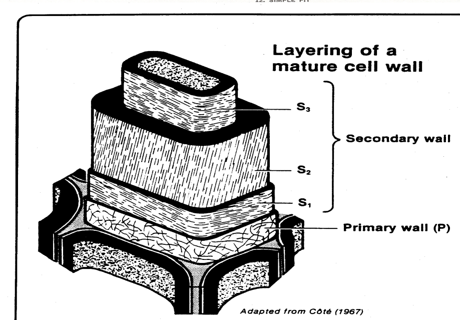


Microstructures in conifers

- Cell sizes and wall thickness in transverse section;
- Fiber lengths;
- Other geometry – for example, length of taper;
- Microfibril orientations;
- Extent of lignification
- Number and disposition of pits.

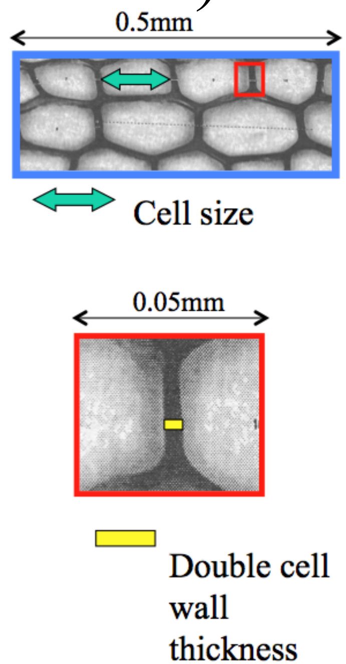


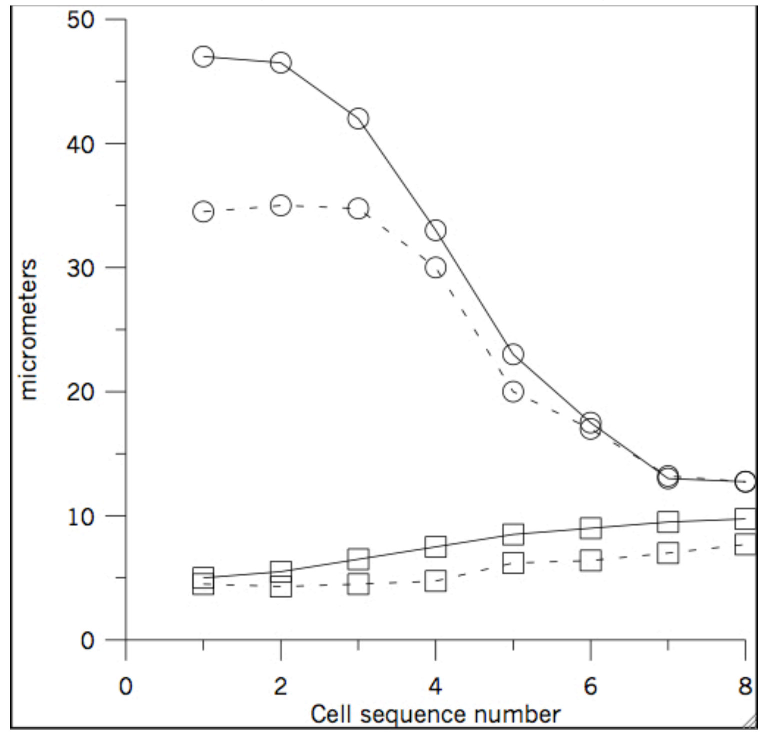




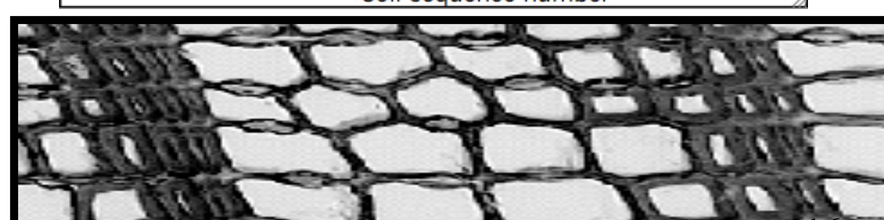
What is a tracheidogram?

Cell measurements from tree rings can tell about different parts of the growing season. For example, cell size (circles) and double cell-wall thickness (squares) for years of early growth start (solid line) and late start (broken line).

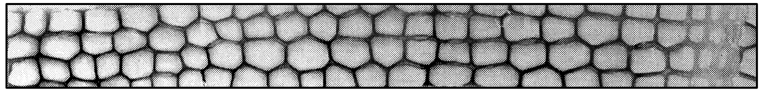




What does this graph of larch tracheidograms tell us?



Tracheidograms of rings from giant sequoia



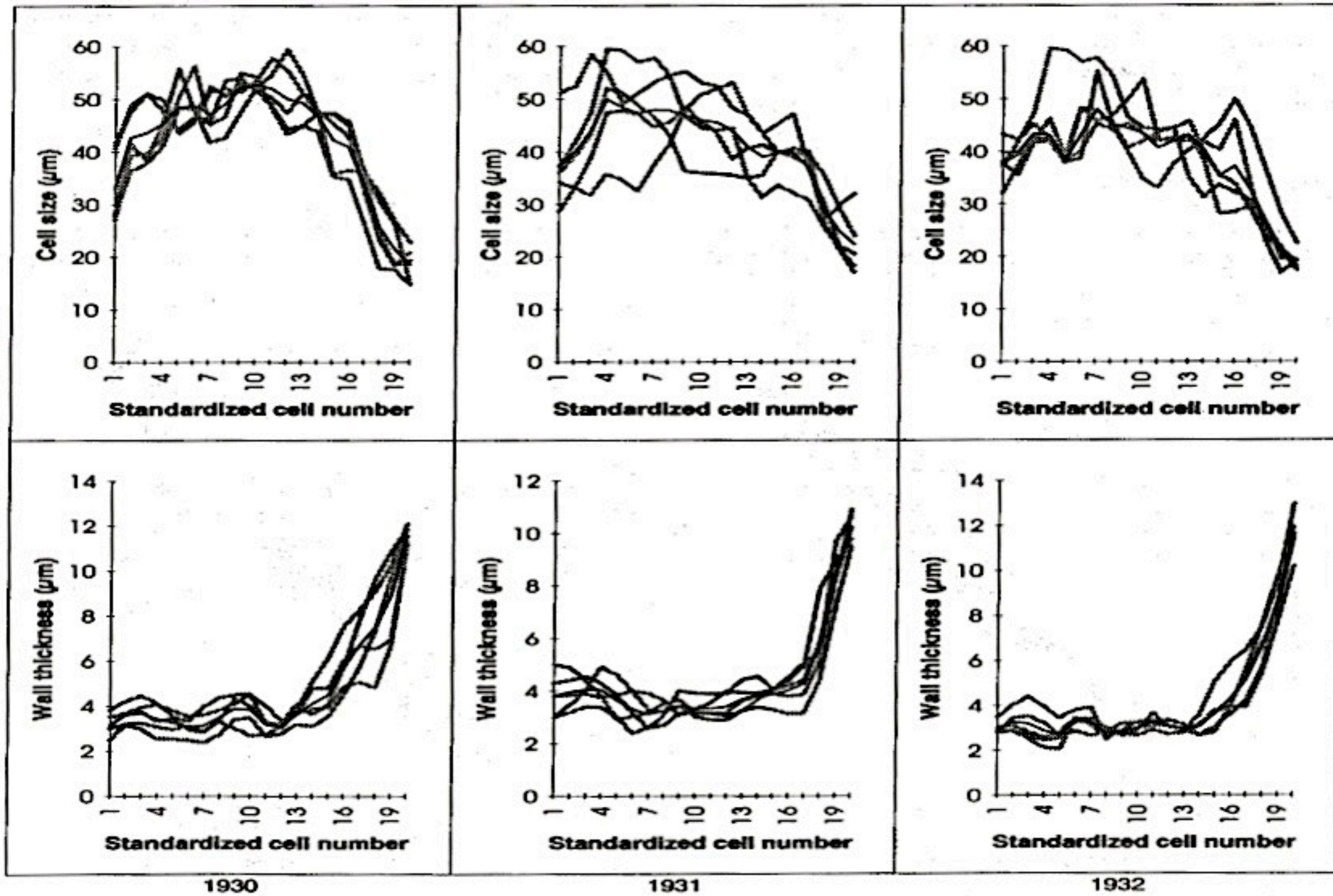


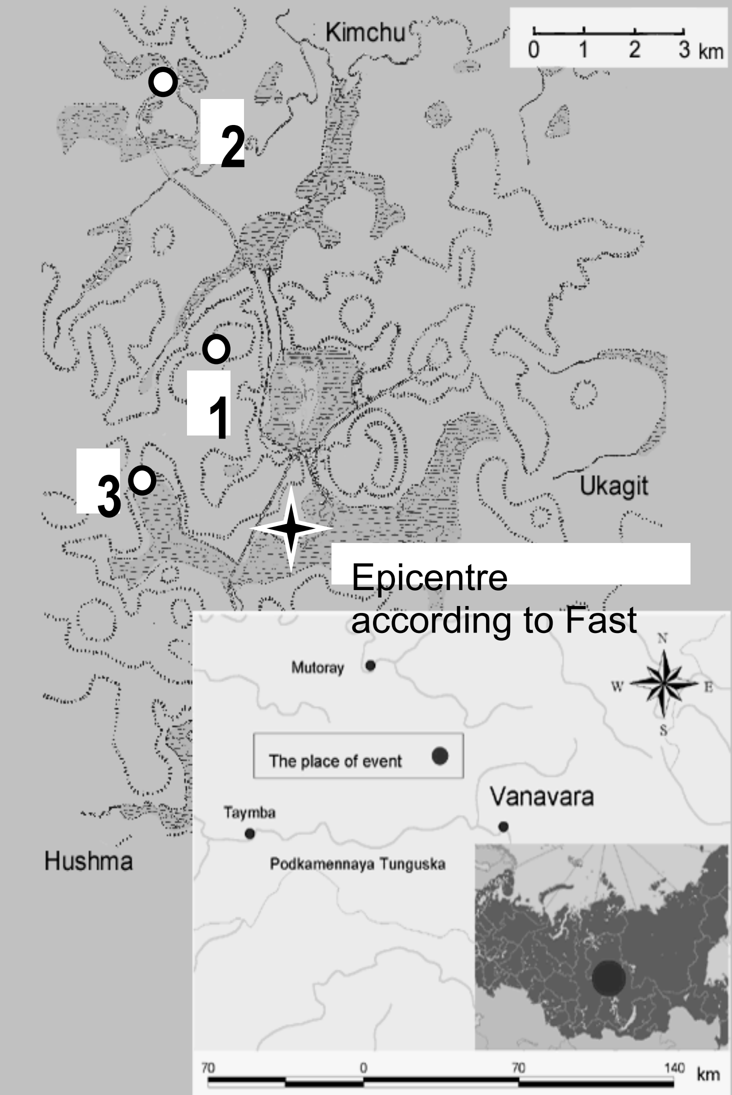
Fig. 3. Examples of standard tracheidograms measured (*Sequoiadendron giganteum* from the Giant Forest in Sequoia National Park, AD 1930–1932). The black lines are the cell size and wall thickness means, the gray lines are the measurements of the five radial files used to produce the mean. The tracheidograms are standardized to a length of 20 cells.

Munro et al, 1996

Chelyabinsk, Russia, February 15, 2013

A meteor (17 meters diameter) crashes through the atmosphere

Tunguska, Russia, June 30, 1908, an even bigger meteor (estimated 40 m diameter) explodes ~8.5 km above ground. Millions of trees blown over, but some at the epicenter survived, but with needles and branches stripped off.



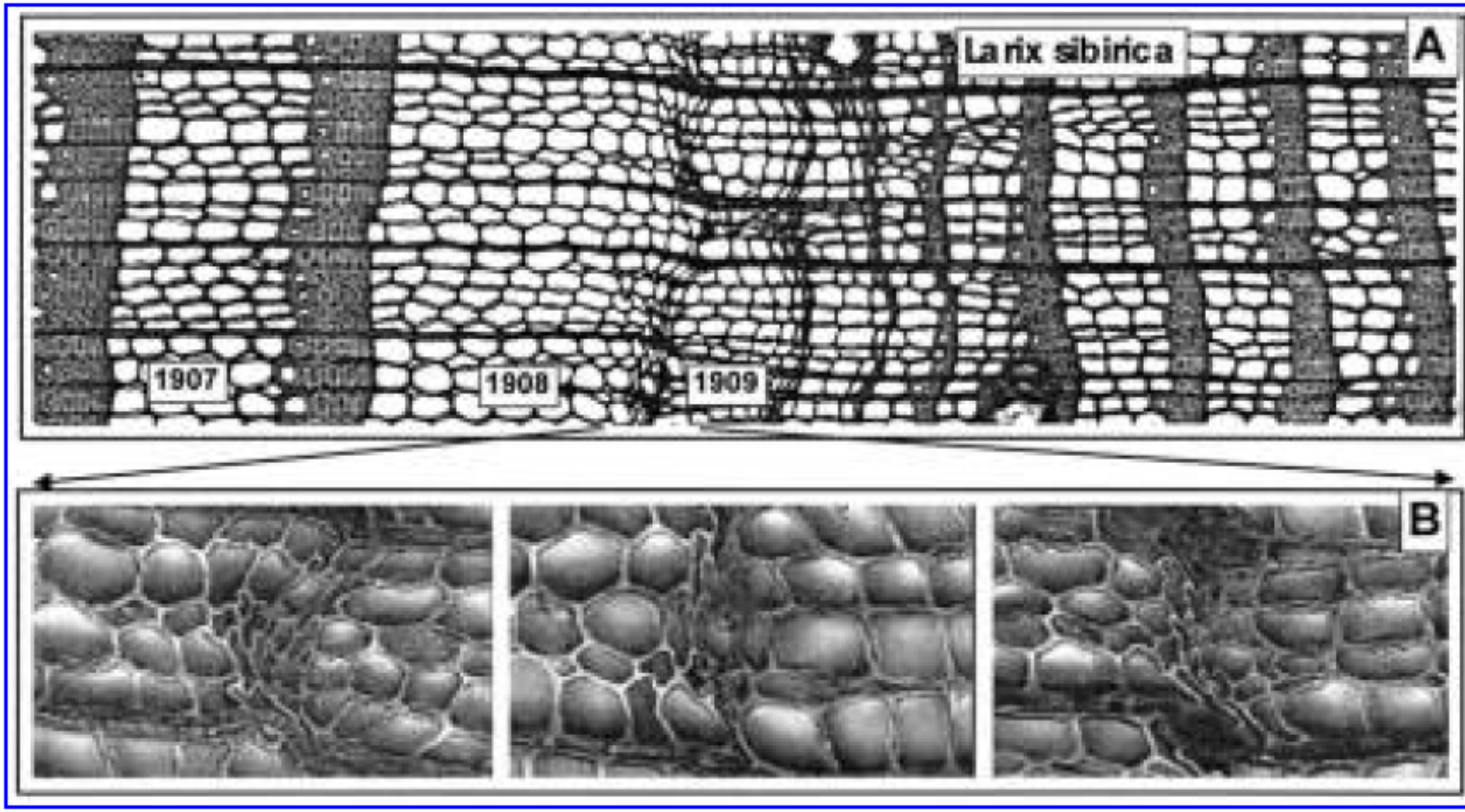


FIG. 6. A: Transverse section of a larch sample showing the rings for 1907–1915. B: Three views of the disrupted tracheids in the 1908 ring. The normal anatomy in the rings formed in the subsequent years can be seen in A.

Vaganov, Hughes, Silkin, Nesvetailo, 2004

Cellular analyses: sizes and numbers of cells affected

394 VAGANOV ET AL.

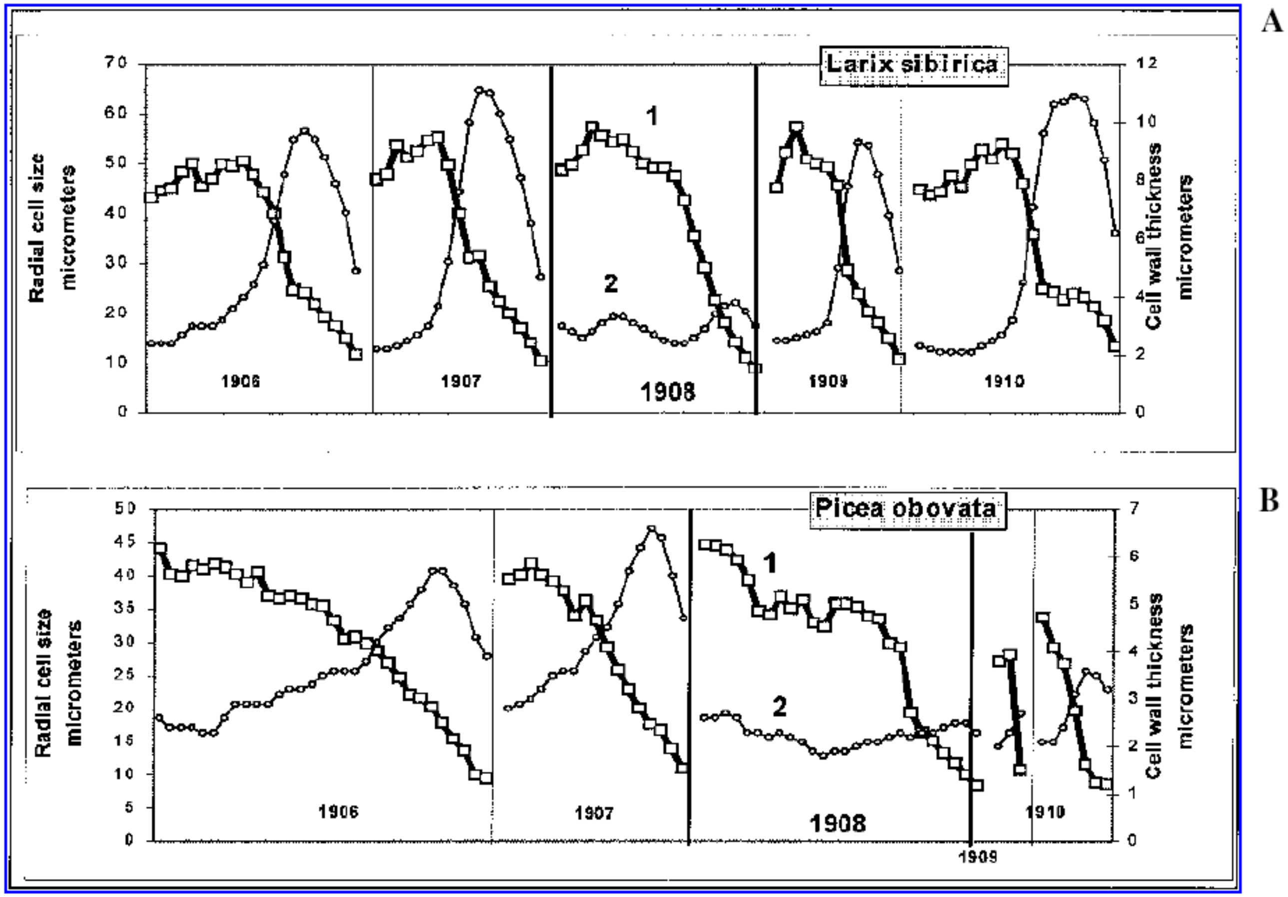
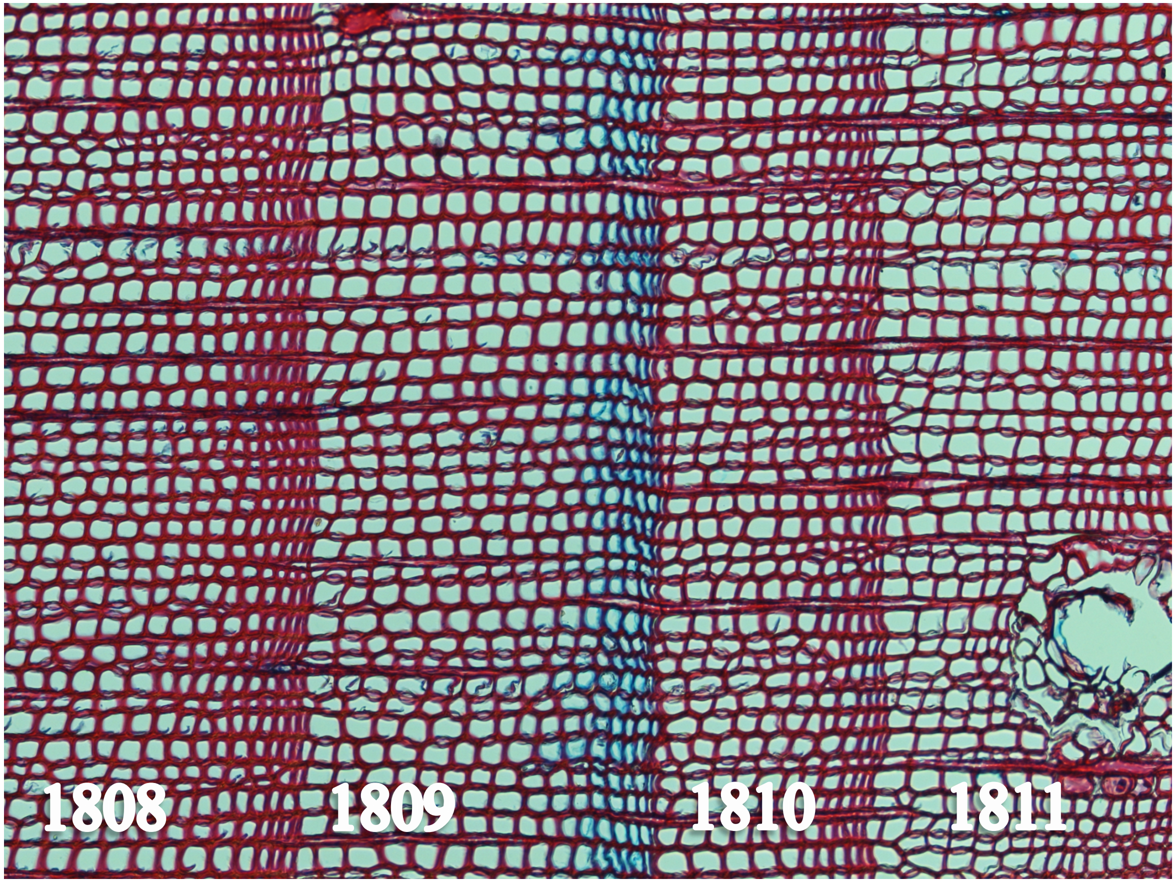


FIG. 3. Tracheid cell dimensions for the rings formed in 1906–1910. A: Radial cell size (line 1) and cell wall thickness (line 2) of each cell in sequence for a larch sample. Note failure of cell walls to thicken in 1908. B: As in A but for a spruce sample. Note the drastically reduced number of cells produced in 1909 and 1910, but the normal thickening of the last formed cells in each of these years.

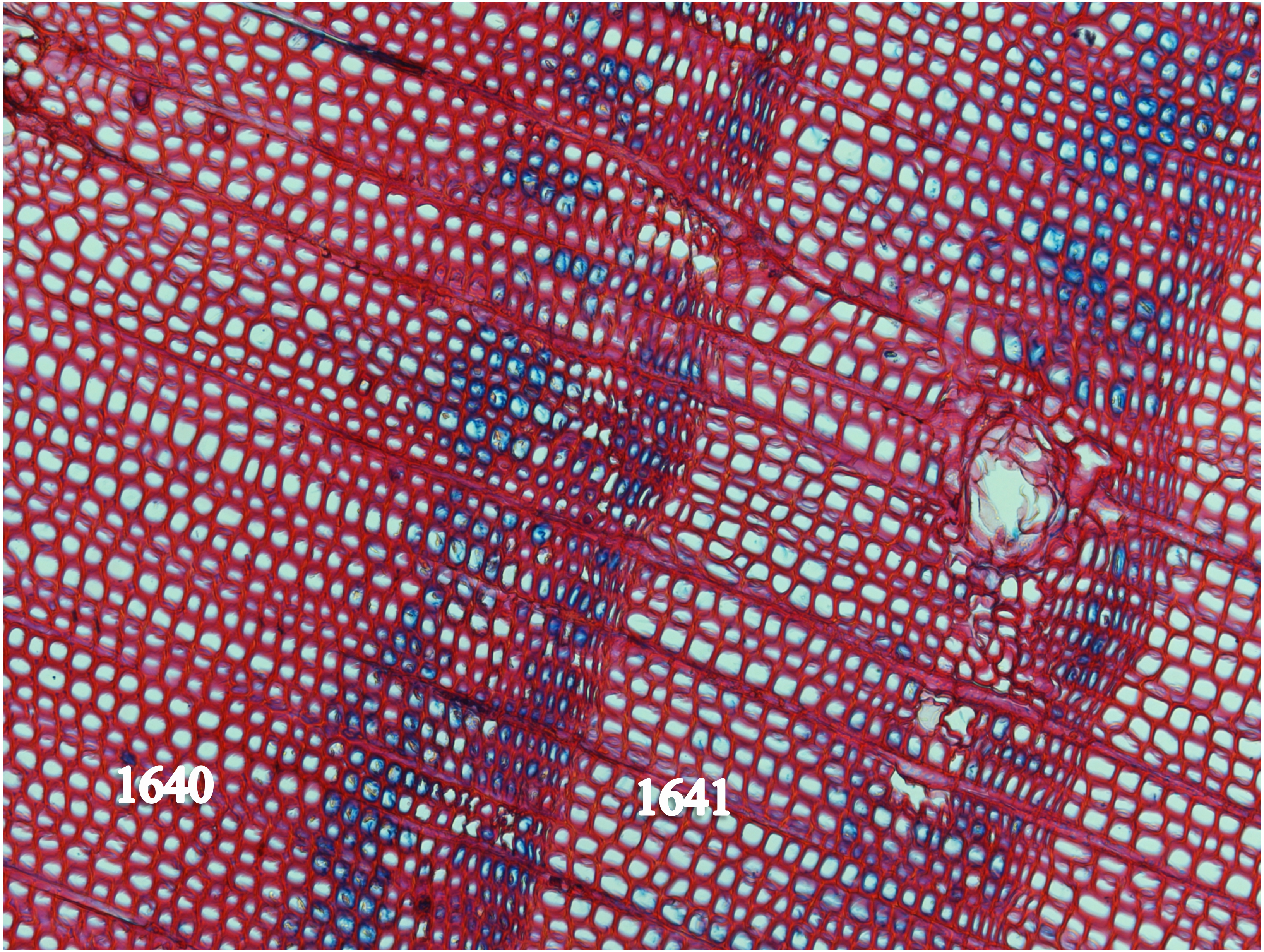
What can we infer from this?

Thin section bristlecone pine tree 5A from Pearl Peak, NV
Double-stained Safranin-Astra blue

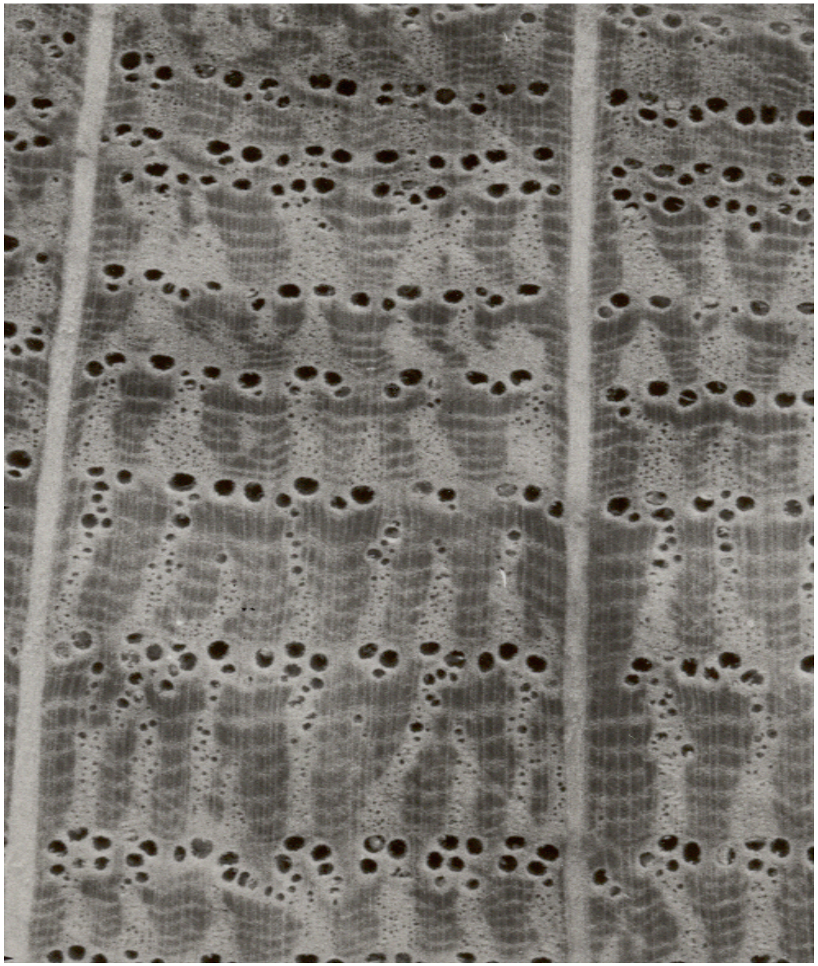


Incomplete lignification

Picture – Alma Piermattei
Sample – Matthew Salzer


1640
1641

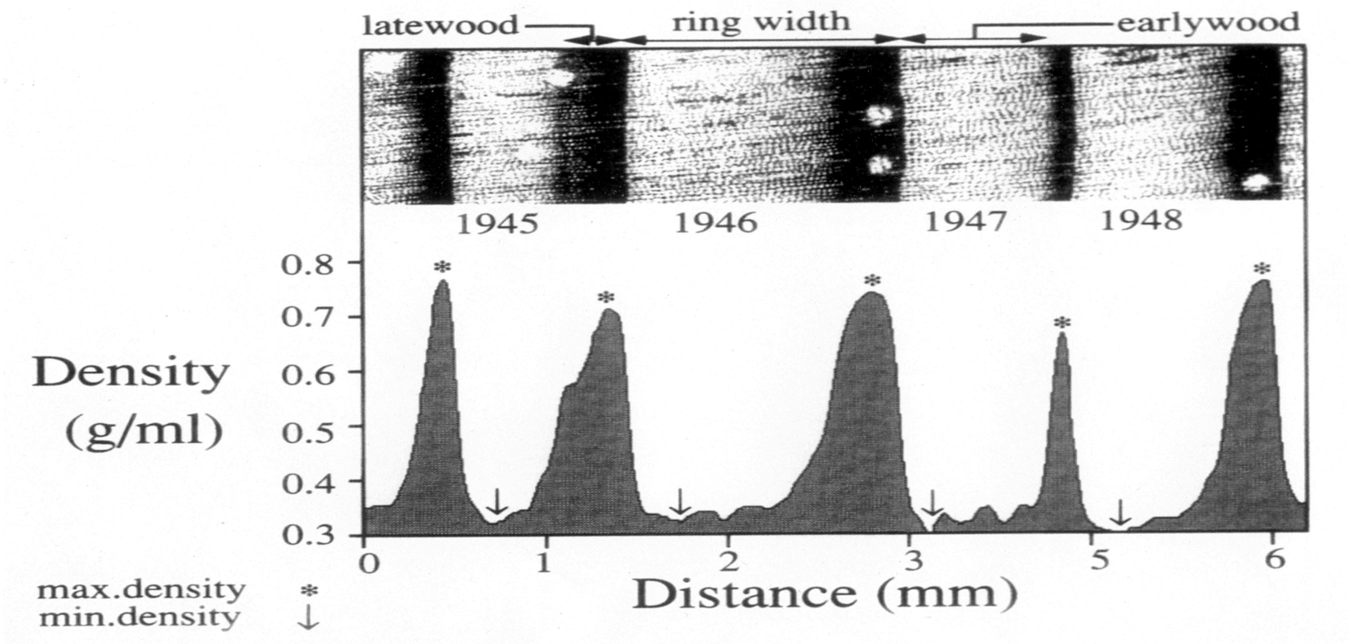
Microstructure in angiosperms



- Proportions of x-section area taken by different cell types;
- Size distribution of each cell type;
- Geometry of cell types – e.g. circularity of vessels;
- Pattern of transition in cell mix across ring.

Malcolm K Hughes, Laboratory of Tree-Ring Research

Integrative structural measures - densitometry



Smaller cells with thicker walls mean greater density in latewood. Packing density of cellulose microfibrils and proportion of lignin in cell wall will also affect this. Note year-to-year changes in shape of density trace, and, especially, in maximum density.

In regions with cool, moist summers maximum latewood density is often a good recorder of growing season temperature.

X-ray microdensitometry

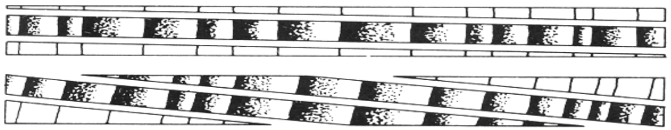
- The most common way to measure these fine variations in density is to make contact prints with X-rays.
- The denser the wood, the smaller the proportion of X-rays that get through the wood to the film.
- This can be calibrated using materials of known density.

Problems

- Wood contains X-ray opaque materials that are mobile, notably water.
- Making a contact print of something with thickness introduces fuzziness in image.
- In addition, wood has structure that can further complicate getting sharp picture – fiber direction must be parallel to X-ray beam.
- Ring boundaries vary in orientation.

From Schweingruber, 1989

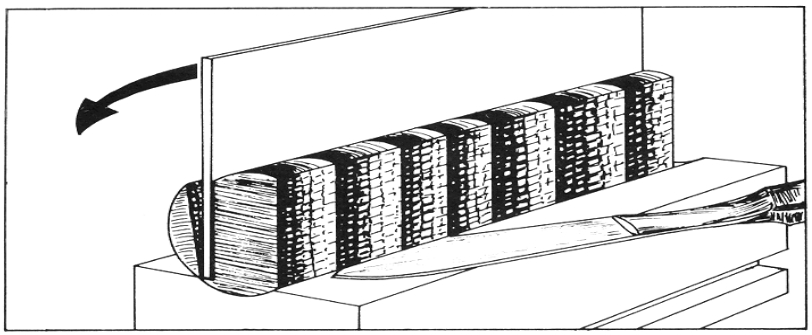
Dealing with varying fiber angle



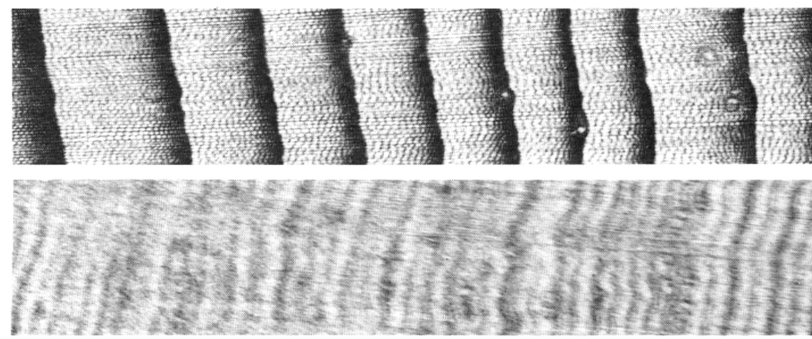
Core orientation in relation to the fibre angle

Well cored sample

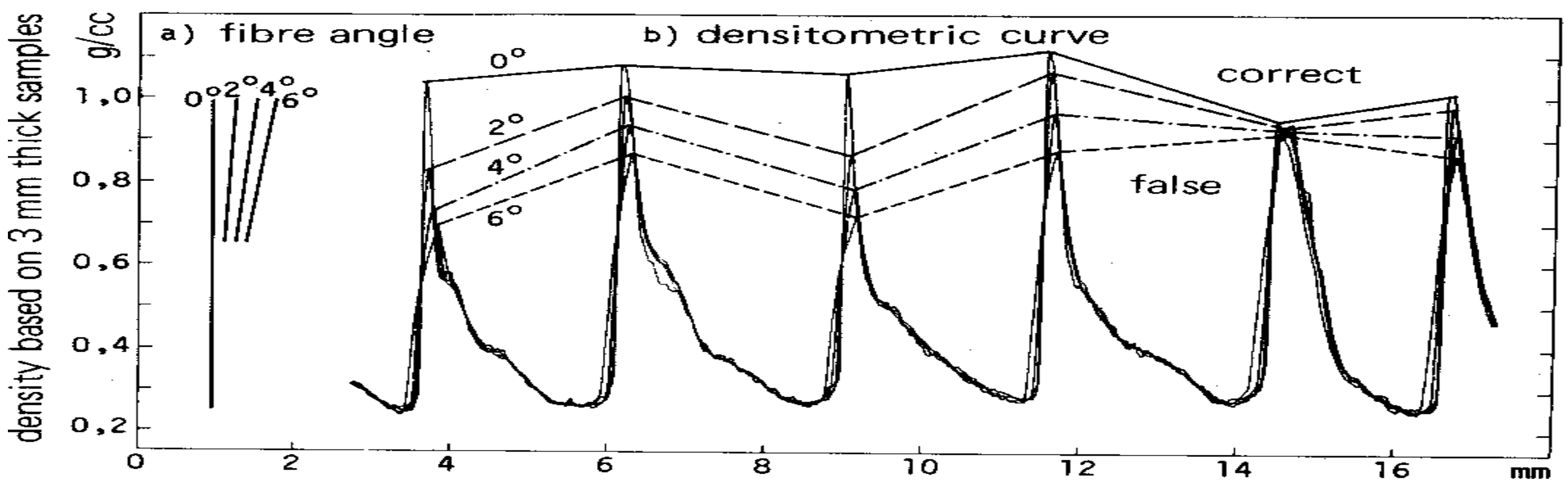
Bad cored sample. Corrections have to be made by overlapping saw cuts.



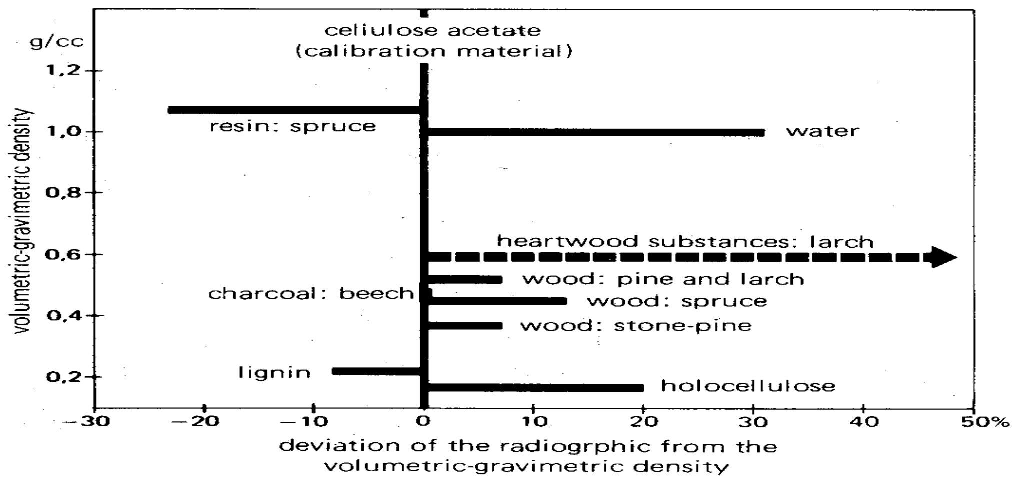
Detaching the cut lath from the support.



The quality of the X-ray picture.
Top: Good — here the structure is clearly visible.
Bottom: Poor — here the structure is blurred.

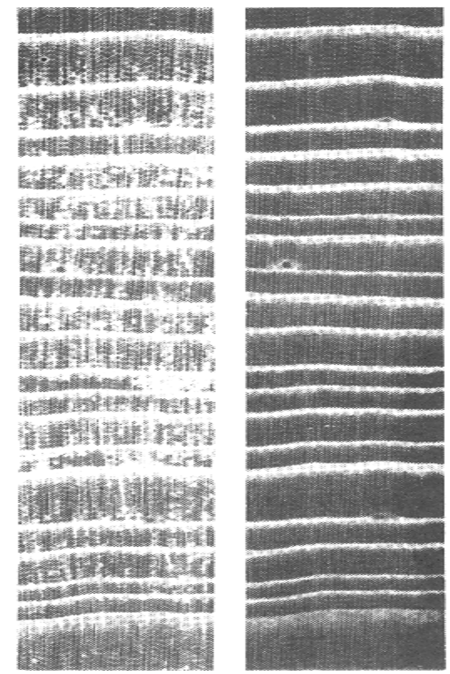


Removing mobile substances



The rates of X-ray absorption for different woods and wood substances in relation to cellulose acetate.

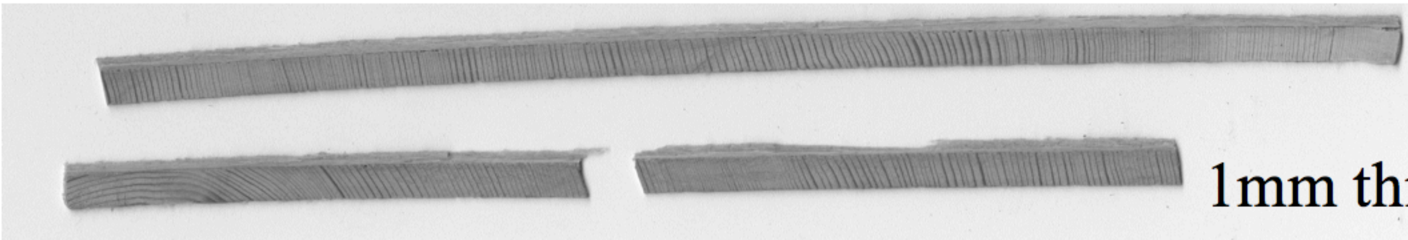
Water is X-ray opaque, need controlled water content. Resins and heartwood substances are mobile – remove chemically.



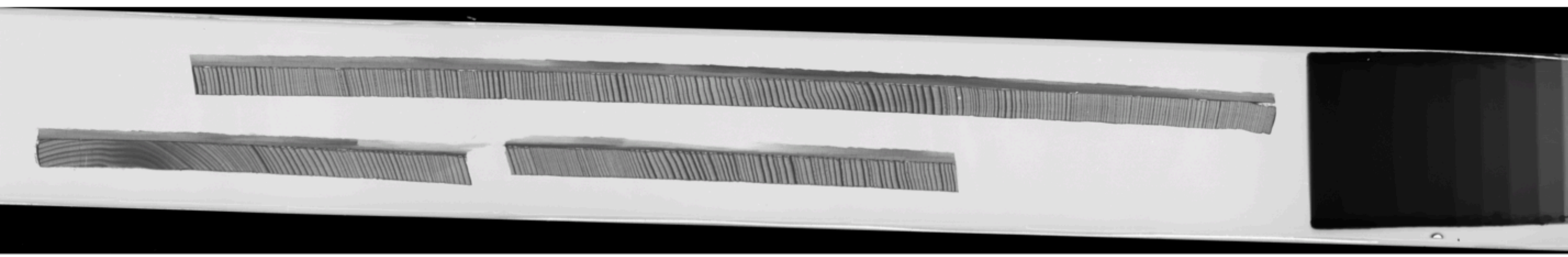
X-ray pictures of larch heartwood; left: before the extraction of heartwood substances; right: after the extraction of these substances.

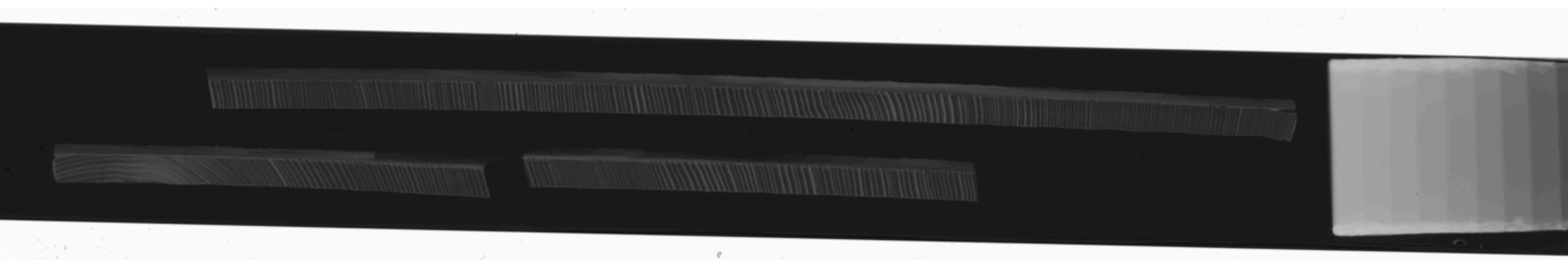
From Schweingruber, 1989

Limber pine, Labarge Creek, Wyoming



1mm thick laths

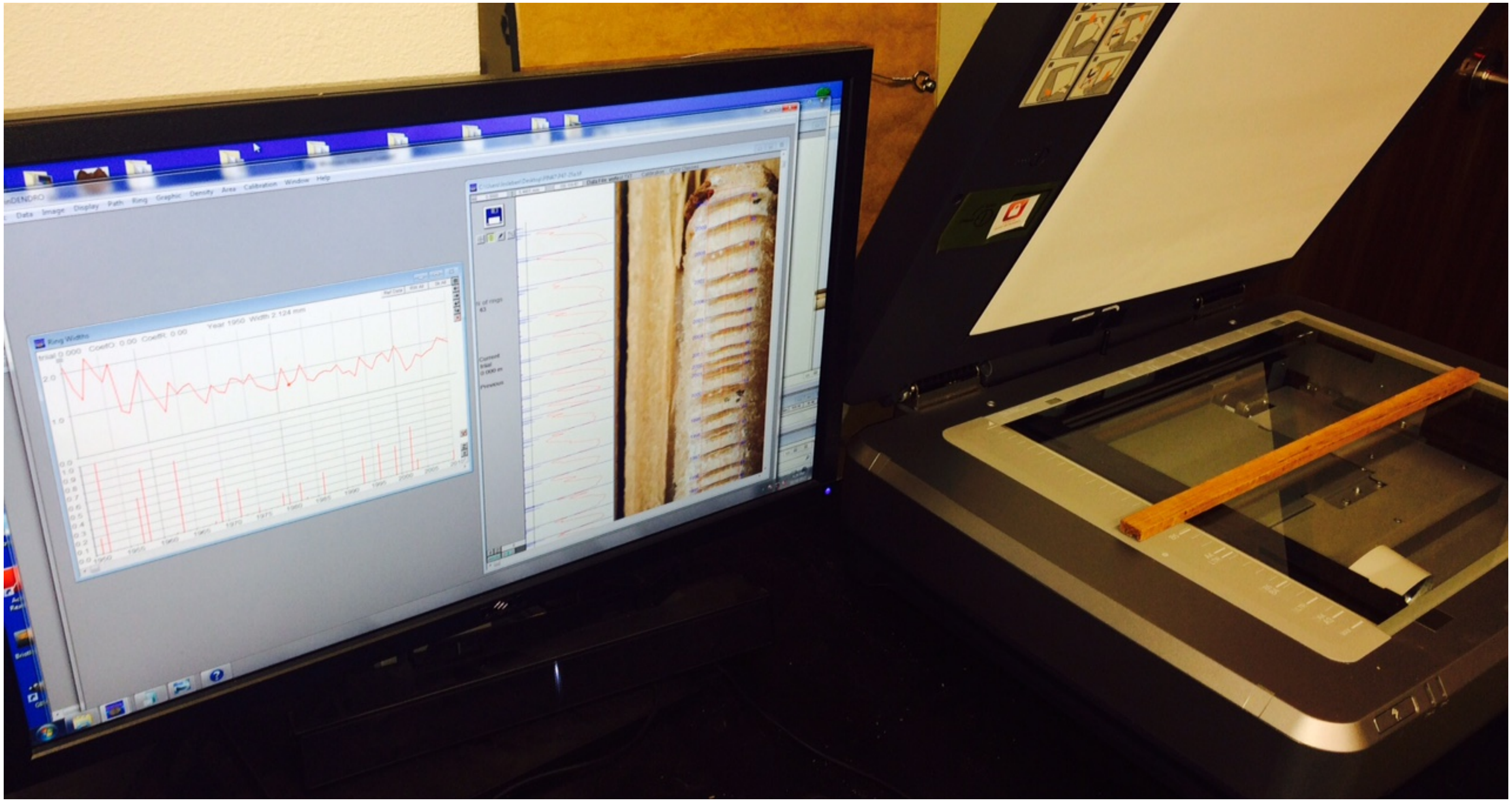




X-radiograph

Alternatives to x-ray densitometry

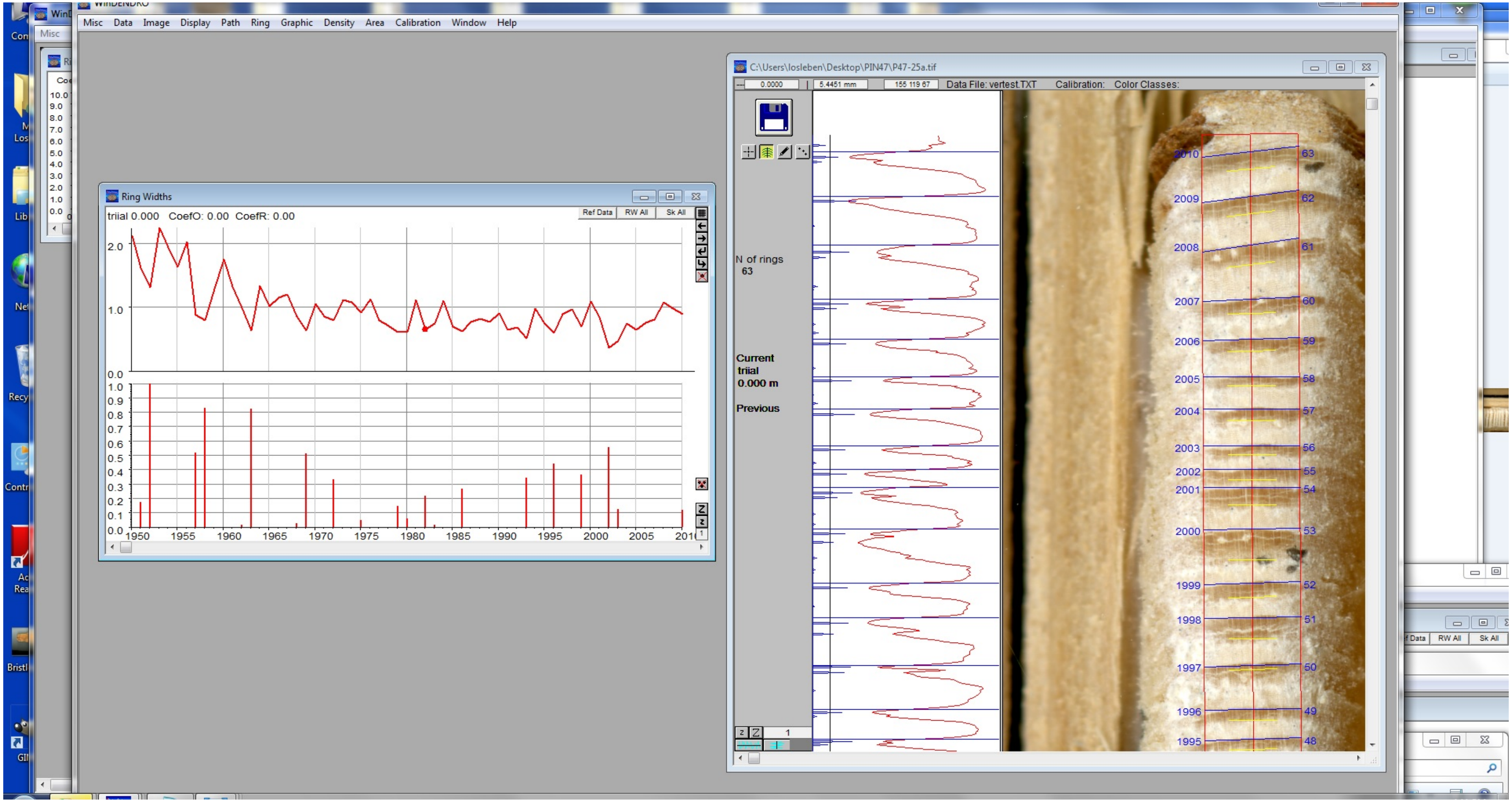
- **Measure of surface brightness (Sheppard et al) – if can remove effect of color, surface brightness is very similar to density, with no problems of parallax or fuzziness and preparation is simpler**
- **Similar to this, measure blue reflectance of the wood surface (Campbell et al)**
- Varying dielectric constant (Schinker et al). Drag electrodes across wood surface – similar advantages, but 30 μm penetration.



Can now use custom software and high-resolution scanner to handle surface brightness, blue reflectance and analyze optical density of radiographs

WinDendro™

Core P47-25a *Pinus sylvestris*
Pinezhsky Biosphere Reserve, Northern European Russia



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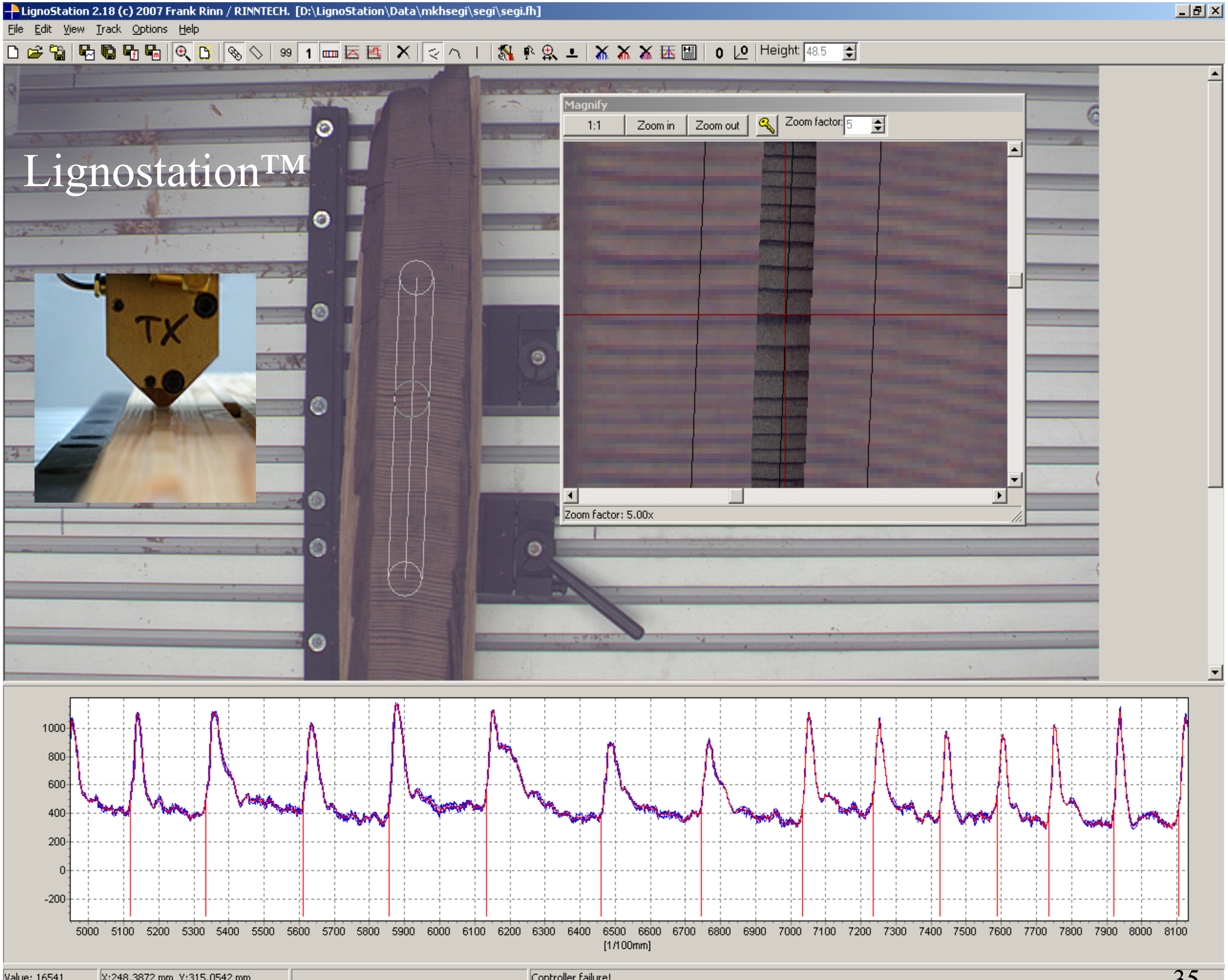

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