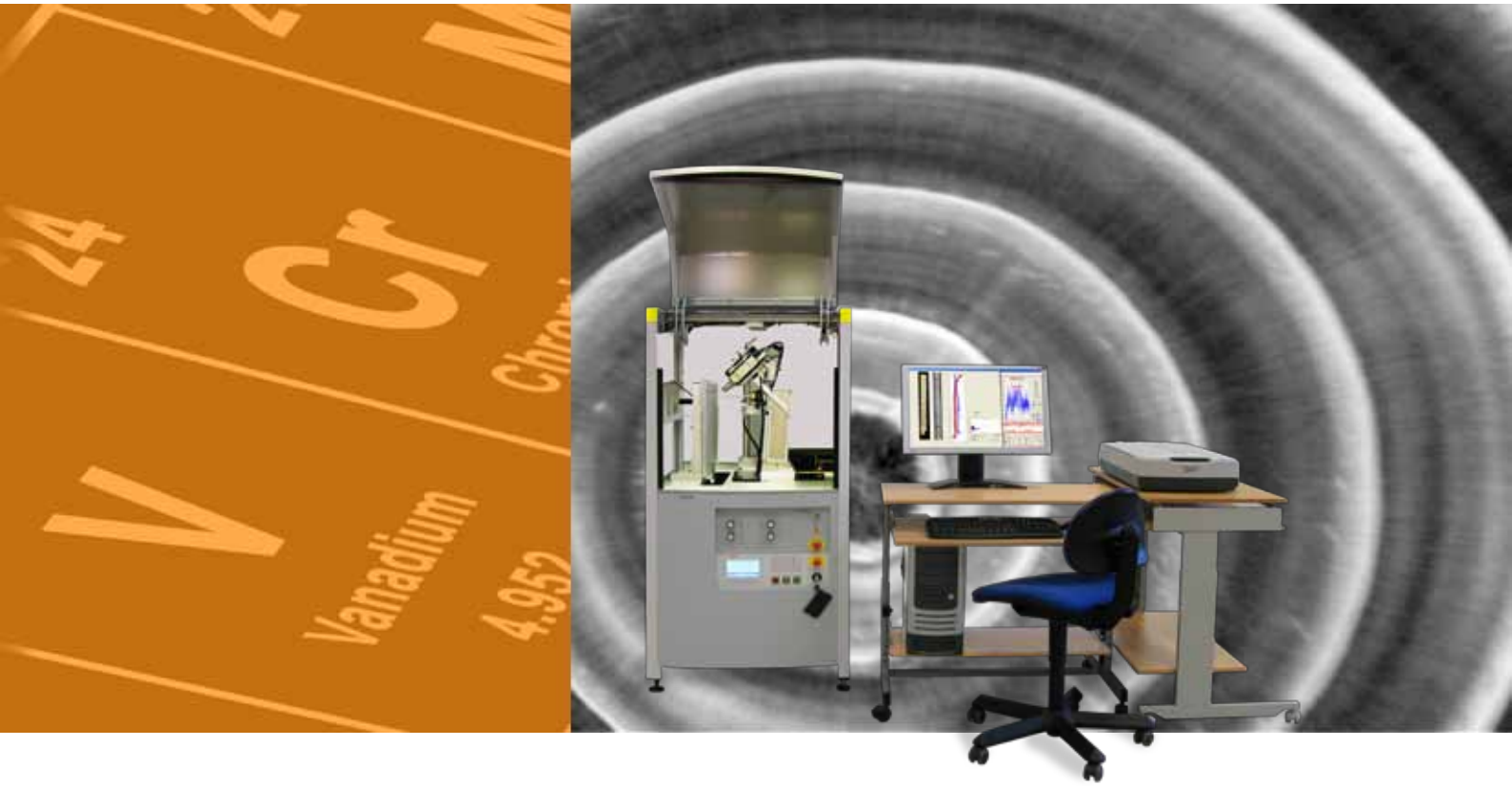
Scanner for wood density and multi element analysis

Featuring digital radiography and micro-XRF technology



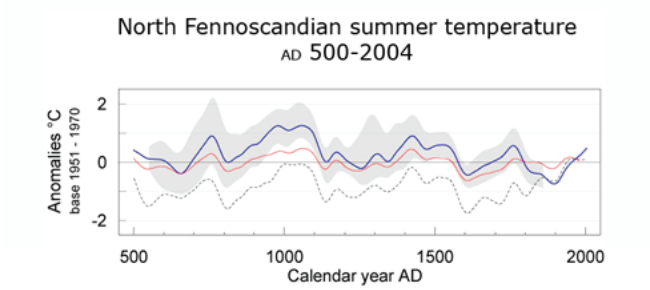
ITRAX MULTISCANNER

COX Analytical Systems

Applications

For a number of fields of research where density and metal content in wood and other flat samples are in focus, the Itrax Multiscanner can do an excellent job. With features like high data quality and repeatability, smooth workflow, short time for analysis and high sample throughput, this workhorse has capacity for wood analysis like no other instrument. A list of scientific articles covering these fields can be downloaded from our homepage www.coxsys.se/downloads.

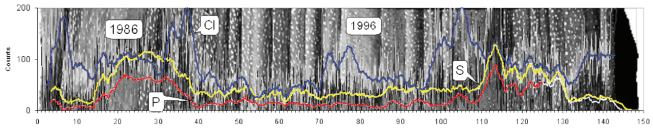
Paleoclimatology is a research field that can benefit from this instrument, where high data precision really is in focus. Aspects like ring width, maximum or average density per year ring etc. can be extracted directly from the digital radiographic images, in an automatic and user supervised way utilizing the evaluation software used (WinDENDRO™). Element signals from XRF analysis, especially Ca, can be used to locate year rings in wood species which do not possess visible rings. Speleothem can be scanned for density as well as other elements.



This diagram shows a climate reconstruction of the north Fennoscandian summer temperature over the last 1500 years, based on data from the Multiscanner. The correlation with instrumental temperature data is 0.84 from that period. Courtesy of Dr. H Grudd, Dendrolab, Stockholm, Sweden.

Forestry studies of aspects of wood include understanding and prediction of wood formation and wood properties and how they are affected by silviculture measures, genetic breeding programs and long term changes in growth conditions such as climate change. The Multiscanner offers possibilities to do analyses on intra-annual ring level and relate them to detailed weather and growth conditions like water and nutrients, incidence of snow and wind damage as well as damages from insects, pathogenic fungi etc.

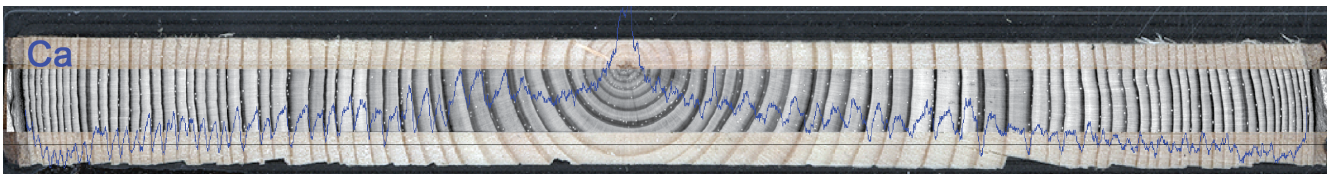
Environmental forensics is a field where uptake of pollutants in wood are of interest, using trees as time records for metals, as well as e.g. chlorinated solvents and oil products that have polluted the environment. Element uptake in wood is mainly confined to the parts of the wood that is formed during uptake, with some variation with species and element.



This image shows a radiographic images of a tree sampling. Overlaid on the radiographic image are three graphs displayed showing Sulphur (yellow), Phosphorous (red) and Clorine (blue) profiles over that sample. Data like these are used as time related pollution records in environmental forensics. Data with courtesy of Dr C. Balouet, Environment International, Orrouy, France, and H. Grudd, Dendrolab, Stockholm, Sweden.

In ecology and anthropogenic historical studies, this instrument has a role for instance when studying the impact of landscape changes and human activities as recorded in wood and other samples.

For wood products like e.g. board, density distribution is of interest. Wood density properties in such products can be studied dynamically during compression with the Multiscanner, to simulate production environment while measuring.

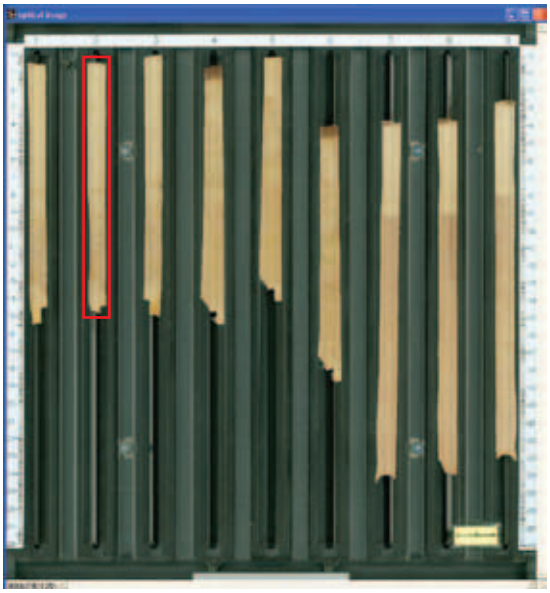


The wood lath shown in color in this image was scanned with the optical scanner of the Multiscanner, and shows a Pine lath mounted in the sample holder. Overlaid on that, in the central part is a radiographic image in grey-scale, and on top of that a Ca concentration profile in blue, recorded utilizing the XRF device. Please note how the Calcium varies within each year ring. All data were recorded with the Multiscanner. The quality of this image does not fully reflect that of the original image.

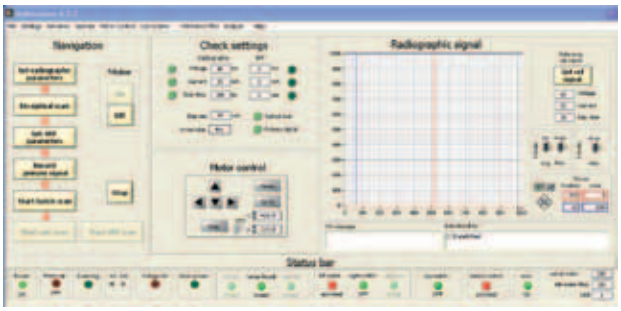
Using the Multiscanner

Several features of the Multiscanner help to make the workflow smooth and labor input at a minimum. The standard sample holder for thin wood laths is removable so that the laths can be mounted easily. It can hold up to nine samples each up to 28 centimeters long. A density ladder can also be placed in the sample holder for calibration purposes. Wood laths is the recommended sample type for wood, since laths allow for highest quality of data for both density and XRF measurements. A range of other sample types can be analyzed too, including drill cores, wood blocks, discs, etc. More than wood, also e.g. flat speleothem samples and resin embedded sediment samples can be analyzed, further contributing to the versatility of this instrument.

Samples for analysis are selected by defining the areas for analysis from an optical image of the sample holder with samples mounted, see photo below. Settings like lateral resolution, elements of interest etc. can be done separately for each sample, or by applying user defined, stored standard values. The path for XRF scanning can be selected either as a straight line, or as a user defined, non straight line. This features facilitates analysis of samples with complicated structures. Since all samples can be analyzed unattended, the required time at the instrument is minimized and a high throughput can be maintained at the same time. Data quality is in focus in every aspect of this instrument. Since data are produced digitally, all the information is instantly available and no film or chemicals are used.



The photo shows the sample holder for batch analyses of wood laths, here with nine samples mounted of which one is marked for analysis. The user defines the job by scanning the sample holder with samples mounted. The areas for analysis are then marked on the monitor.



Part of the Navigator user interface is shown above. It makes the analysis straightforward by offering overview and a logical workflow.

Software

The Multiscanner is computer operated with a graphical interface that makes operation easy by using an intuitive workflow scheme. The features include:

- All work from scanning the sample holder and onwards is done at the instrument computer.

- Setting analytical parameters like resolution and exposure time can be done from stored standard settings in order to facilitate standard analyses, or manually when other settings are required.

- Batch jobs are supported in order to allow for minimized user time at the instrument. This also extends the instrument capacity since jobs can be started e.g. when leaving for the day, letting the Multiscanner work through a filled sample holder unattended. The instrument automatically goes to an idle state when the job is completed

- The wood density data extraction software (WinDENDRO™) is fully featured and user friendly.

- Full software support for XRF analysis, with spectra view, spectra overlay for comparison, semi-automatic spectra evaluation, batch job support for multiple spectra evaluation and choice of peak areas or concentration output (The XRF is an optional add-on).

- Data post processing includes software for graph production of element profiles as well as element ratio profiles. It also features overlaying graphs on radiographic and optical images.

Technical

X-ray source

The Multiscanner uses a 1.9 kW x-ray source for density and XRF measurements. With this powerful source, high x-ray intensity can be used to give quick and very precise data. An innovative x-ray optical unit and analytical setup allow for optimal conditions over the whole sample. The x-ray beam axis is kept perpendicular to the sample surface in all parts of the sample, allowing for optimized imaging of wood structures by collecting data from one line of the sample at the time while stepping line by line to collect data. Samples with a length of up to 28 centimetres, and width up to 20 millimetres can be scanned in batch mode. Wider samples can be scanned one by one.

Density measurements

X-rays that are transmitted through a sample are registered in a digital radiographic camera connected to the computer, and results can be displayed immediately. This x-ray camera has about 1.000 measuring pixels in one line, where each pixel registers the density in that sample point and together they make up one image line. The camera has a dynamic range of 15 bits and an image format of 16 bits, which exceeds that of film media by far, so re-exposure due to under- or oversaturation is usually not needed. At the same time, this allows for high precision based on registration of high photon numbers. The density precision is down to well below the 1% level in each data pixel. The exposure time is variable, and thereby allows for optimization of speed/performance as well as analytical precision, based on requirements and time available. The x-ray beam of the Multiscanner is somewhat divergent in one direction, which is a feature that reduces the sensitivity to sample fiber orientation when determining calibrated density values.

XRF

Multi element analysis with high lateral resolution and high sensitivity can be performed, based on XRF (X-Ray Fluorescence). With this add-on, a wide range of elements can be determined, most of them down to the trace level. The elements usually found in wood include Al, Si, P, S, Cl, K, Ca, Ti, V, Fe, Ni, Cu, Zn, As, Rb, and Sr. Also e.g. Pb is found sometimes. A variable exposure time allows for optimization of speed and performance. The analytical stability and reproducibility of this add-on is high. Having density measurement and element analysis in the same instrument gives correct positioning of every measuring point in relation to wood structures, which is the best way to ensure that the points for analysis is correct. XRF scanning can be performed along straight as well as along non-linear, user defined lines in order to follow sample structures.

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Lateral resolution

The Multiscanner offers variable lateral resolution. For the density measurements this is selectable down to 10 micrometers in the sample length direction. The width of the radiographic image can be from a few millimeters up to a maximum of 20 depending on the samples. For XRF, the lateral resolution of the analytical footprint is down to 50 micrometers in the sample length direction, and 2 millimeters perpendicular to that.

Data and processing

The radiographic information is available as 16bit TIFF images. By calibrating the software using an image of the density ladder, post processing software (WinDENDRO™) can convert radiographic data to density data.

For each point of analysis, an XRF spectrum is generated and stored on the computer. After analysis, all the recorded spectra are evaluated in an automatic, user supervised batch mode. The resulting information is stored in spreadsheet format, where the amount of each selected element is listed for each point. Since spectra are stored, data can be re-analyzed e.g. in order to search for more elements. Data can also be exported to Excel and other software.

Scan time examples

Scan time to digital image at different lateral resolutions:
- 17 minutes per 10 centimeters at 10 micrometers
- 8 minutes per 10 centimeters at 20 micrometers
- 3 minutes per 10 centimeters at 50 micrometers

XRF analysis: 110 minutes per 10 centimeters at 50 micrometers resolution and 3 seconds exposure time per point, (standard time for analysis).

Detection limits (PPM)

Al	960	Ca	12	Zn	18
Si	390	Ti	9	As	26
P	237	V	37	Rb	24
S	160	Fe	40	Sr	21
Cl	99	Ni	19	Pb	48
K	25	Cu	18	Hg	41

These XRF Detection Limits of 3 S.D. accuracy are based on a 100 s. analysis of NIST 610 reference glass using a Cr x-ray tube. The detection limits in wood are at least as good. For Ti and heavier elements, improvements can be made by using a Molybdenum anode x-ray tube instead of the standard Cr tube.