

*Archives and Records Association Conference 2015*

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Revealing hidden ~~text~~  
content with modern X-Ray  
imaging.

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@dtl

The Apocalypso Project

What we're doing and why

# Introduction

Sometime in 2006 a question was asked

*“Can you see ink on parchment with your X-Ray scanner?”*

- Tim Wess talking to Graham Davis in a taxi.

The answer turned out to be yes, and more besides.

In mid 2009 the Apocalypto Project was born - a collaboration between Conservators, Scientists and Computer Vision experts.

This presentation is some of what we’ve worked on

Some may know tim, no one knows Graham

Optometrists and dental schools

EPSRC funding

# The nature of imaging

In general, how do we image anything?



We shine light on an object and detect what's reflected.

Light areas reflect more, dark areas less. Coloured areas absorb some colours - we see the colours they don't absorb.

# The nature of imaging

At different wavelengths different things become visible

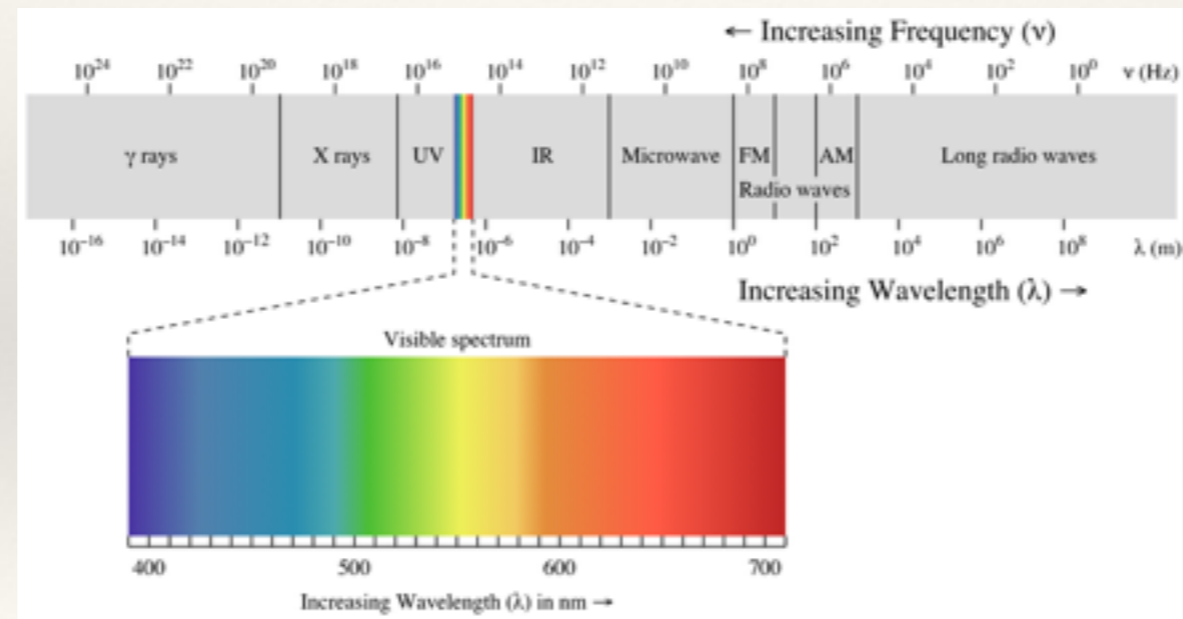


"UV Vis IR Portrait" by Spigget - Own work. Licensed under CC BY-SA 3.0 via Commons - [https://commons.wikimedia.org/wiki/File:UV\\_Vis\\_IR\\_Portrait.jpg#/media/File:UV\\_Vis\\_IR\\_Portrait.jpg](https://commons.wikimedia.org/wiki/File:UV_Vis_IR_Portrait.jpg#/media/File:UV_Vis_IR_Portrait.jpg)

We'd all consider UV, Visible and IR as forms of light. Different materials or features absorb and reflect in different wavelength bands. (might change this to images of magnacarta if I can get permission in time)

# The nature of imaging

X-Rays are just shorter wavelength light



X-Rays are just another form of light.

They are made of the same stuff that the light we're used to is - photons.

# The nature of imaging

Imaging with X-Rays has one major difference...

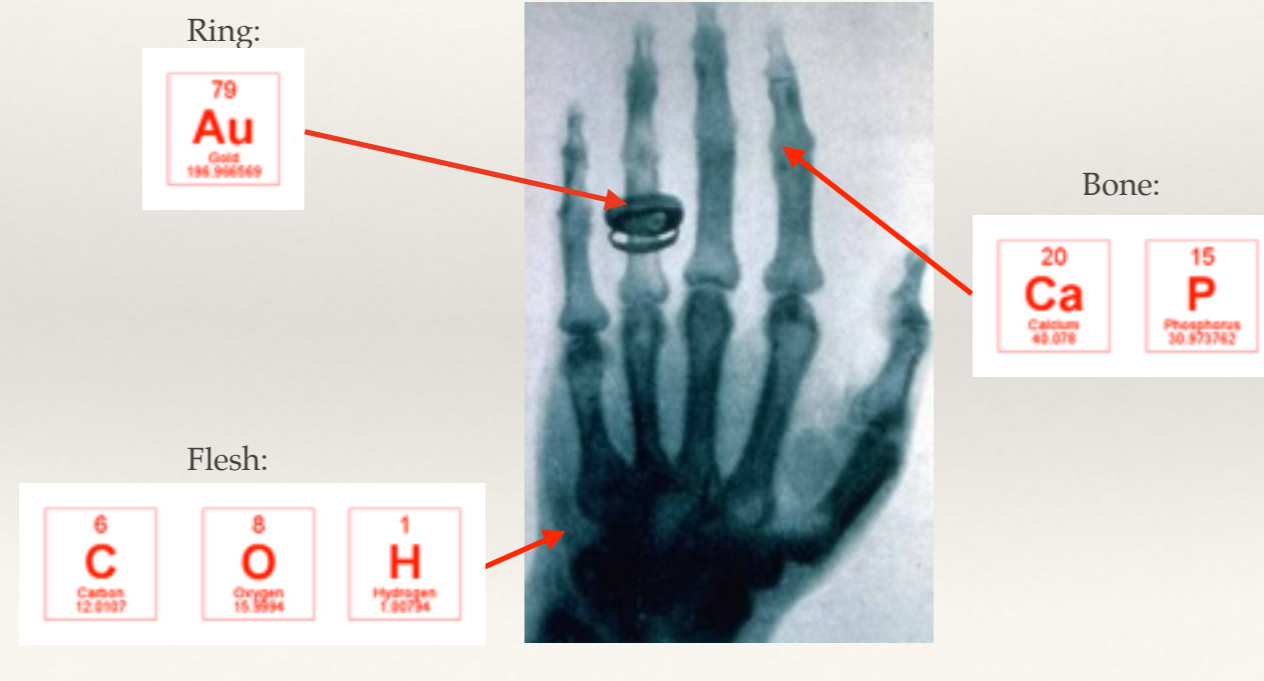


You detect X-Rays that pass through the object,  
not reflected ones.

X-Rays are usually detected in transmission mode - you shine them through an object and detect what gets through. First medical X-Ray, etc

# The nature of imaging

What's the contrast mechanism?



In this image we see flesh, bone and gold. Contrast comes from the stuff - elements the object is made from. Metals show up better than non-metals, but non metals can still be imaged.

# The nature of imaging

## Heavy and light elements

[illegible]

The common elements in materials and inks are shown in the periodic table.

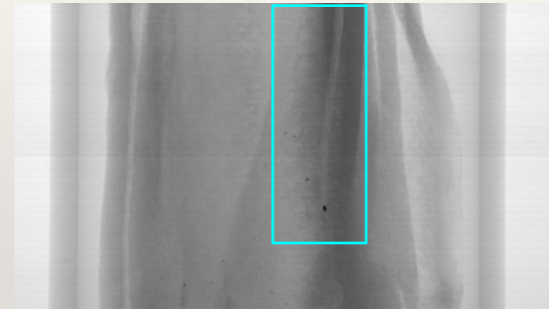
Paper, parchment, organic materials are essentially made of the Orange elements - they don't image well unless there is a great thickness of them, blue is medium and pink is everything else.

## What does this mean?

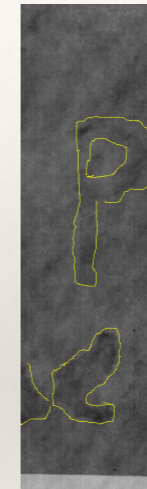
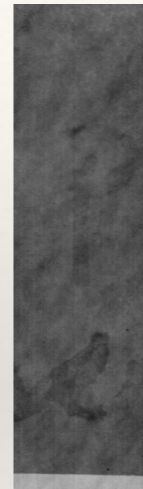
- ❖ If you want to use X-Ray imaging to look inside an object for obscured writing or images
  - ❖ The substrate needs to be material that doesn't show up too strongly (paper, parchment, wood, bark, etc)
  - ❖ The ink should contain heavier elements (iron, copper, gold, silver, mercury, etc)
  - ❖ You're very unlikely to be able to see carbon ink or graphite on paper

Come back to last point on the birchbark sample

# What do you see if you X-Ray parchment?



SA-1855/EC1 : A Scottish employment contract c1855.



Single image, 6s exposure 25kV X-Rays

Take a standard X-Ray

Ink is visible in this flat X-Ray image, but the text isn't really readable.

Proves that high contrast TDI imaging can see ink.

# Damage?

Does X-Raying parchment cause any detectable damage?

We know high doses of X-Rays are not good for living things, what about ex-living things?

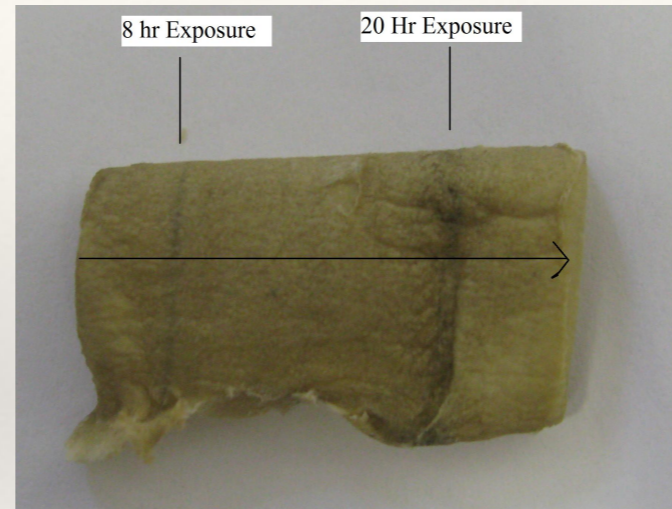
Scans take upwards of a day, so that's a lot of X-Rays

Take a standard X-Ray

Ink is visible in this flat X-Ray image, but the text isn't really readable.

Proves that high contrast TDI imaging can see ink.

# Damage?



This was soaking wet parchment - not the type of material we'd usually scan anyway

Take a standard X-Ray

Ink is visible in this flat X-Ray image, but the text isn't really readable.

Proves that high contrast TDI imaging can see ink.

# Damage?

Is there evidence for change to collagen within parchment samples after exposure to an X-ray dose during high contrast X-ray microtomography? a multi technique investigation

Article in Heritage Science 1(22) · January 2013

DOI: 10.1186/2050-7445-1-22

## Conclusions

*“Our overall impression from the techniques used shows that we cannot detect a systematic change to the collagen chemistry or structure that is an effect of XMT radiation we are using to read documents.”*

Take a standard X-Ray

Ink is visible in this flat X-Ray image, but the text isn't really readable.

Proves that high contrast TDI imaging can see ink.

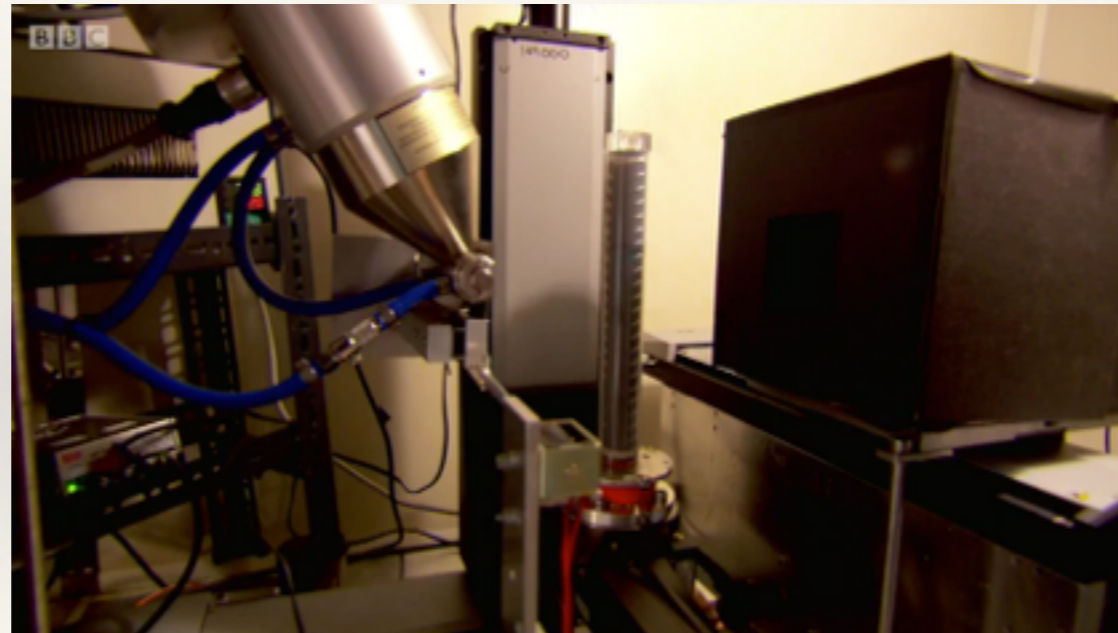
# Let's use a machine built for the job



MuCAT - 2 at Queen Mary University of London

This is one of our three machines, imaginatively named MuCAT 1 to 3. It's a CT scanner rather like you get in hospitals, but aimed at scanning smaller objects at much higher resolution with much better contrast.

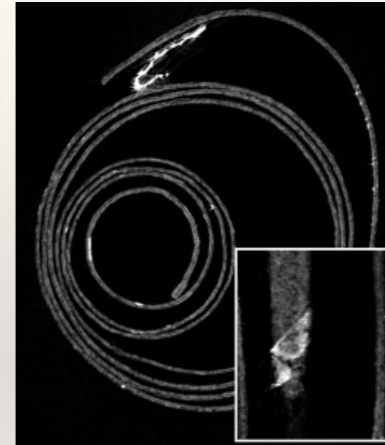
# Let's use a machine built for the job



MuCAT - 2 at Queen Mary University of London

This was filmed by the BBC for The One Show. It shows a greatly speeded up scanning process.

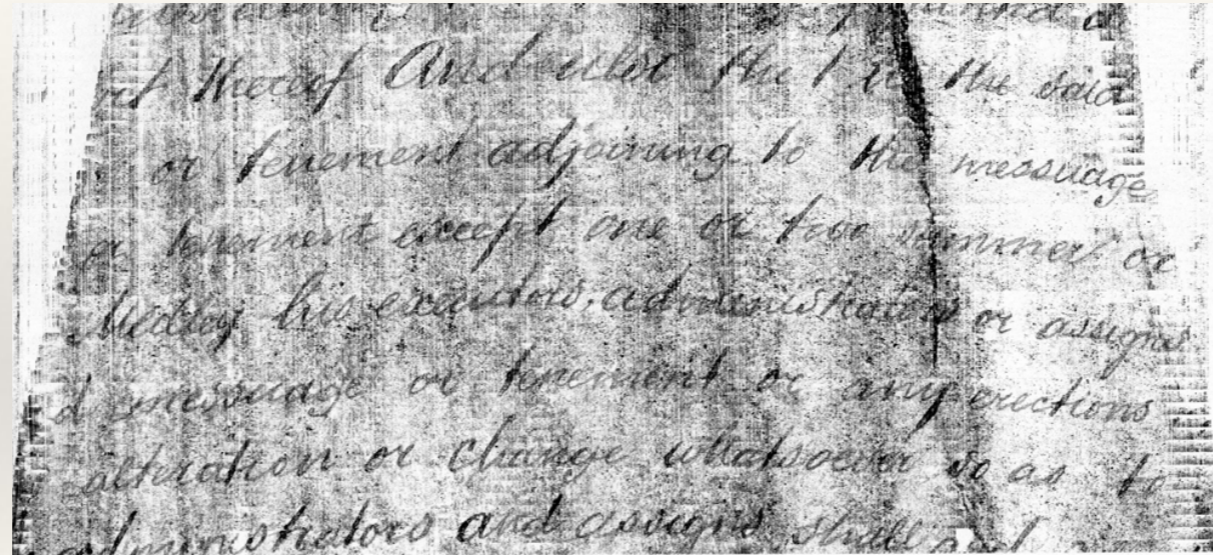
## An initial result



The small scroll was obtained from the Norfolk Archives teaching collection. It was very stiff, difficult to unroll without causing damage and the textual content was unknown.

Small parchment roll and cross section view

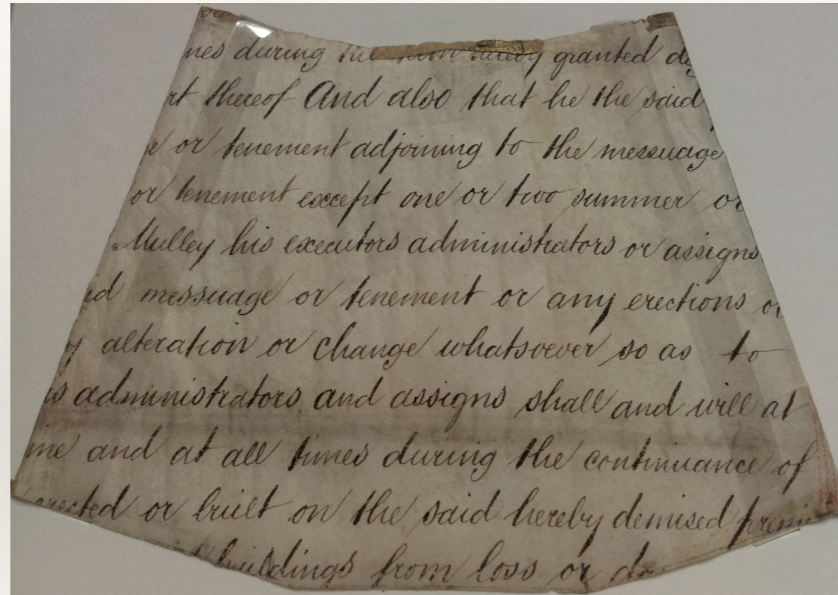
## An initial result



Algorithms developed by colleagues in the school of computer science at Cardiff University, were able to “unroll” the XMT data, making the writing visible

This was filmed by the BBC for The One Show. It shows a greatly speeded up scanning process.

## An initial result



Our conservation consultant on the project, Meagen Smith, was able to unroll the scroll for verification purposes.

Meagen Smith used a combination of humidification and pressing to unroll and flatten the scroll. Was cut to this shape to be used as part of a lamp shade.

# The Bressingham Roll

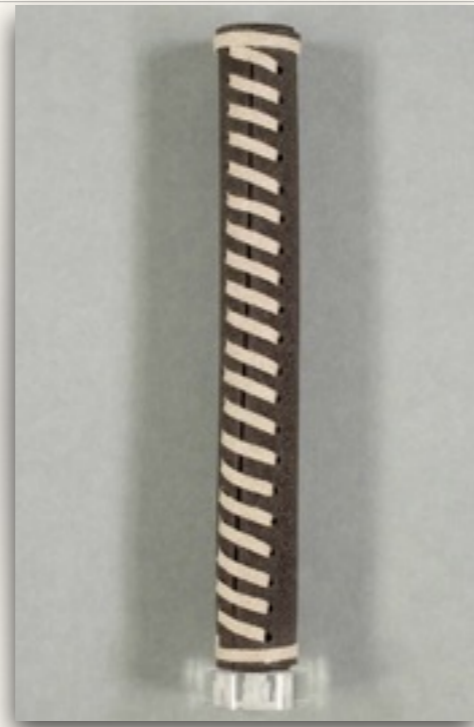


Parchment roll c1409

Detailing annual accounts of the manor of Bressingham in Norfolk UK.

Approximately 70% of the roll is inaccessible due to water damage to the parchment.

# The Bressingham Roll

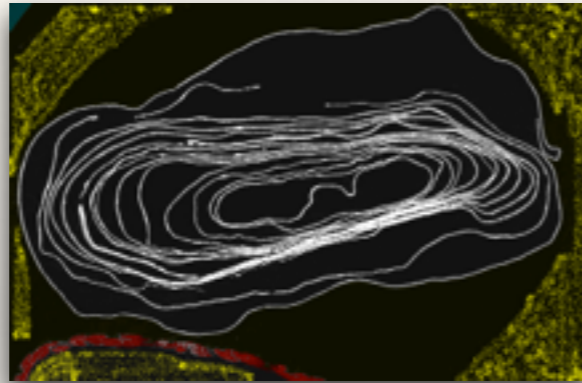


## Ready for scanning

Prior experiments had shown that Plastizote was stable in X-Rays, allowing the roll to be packaged for transport and safe handling by non-conservators

# The Bressingham Roll

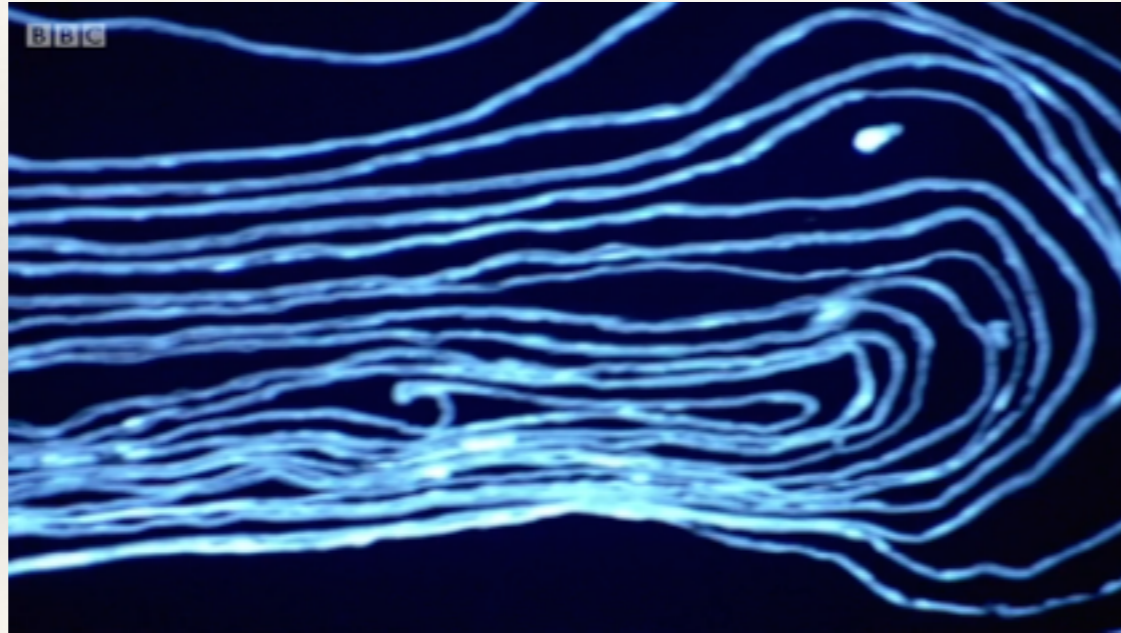
## A virtual slice



A virtual transverse slice through the roll shows how the layers of parchment have stuck together

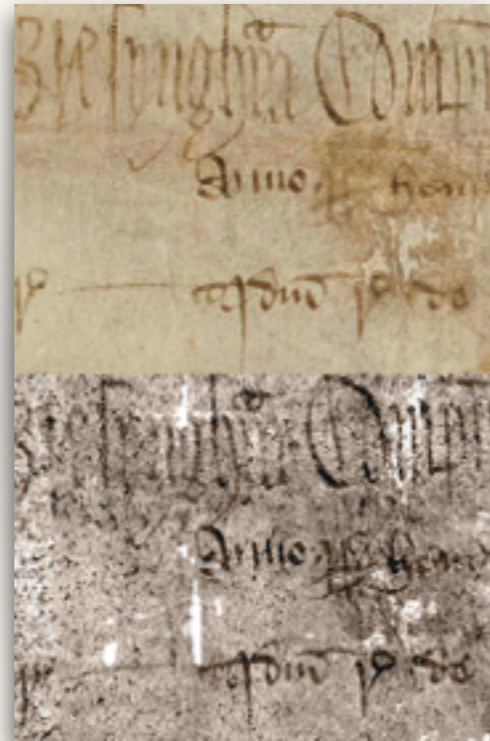
Confirms that the layers could not be safely separated to unroll the document

# The Bressingham Roll



Unrolling

# The Bressingham Roll



Comparing the X-Ray and visible images

Checking the accuracy



# The Bressingham Roll

## Results so far

So far we've revealed the lefthand third of the full length of the roll.

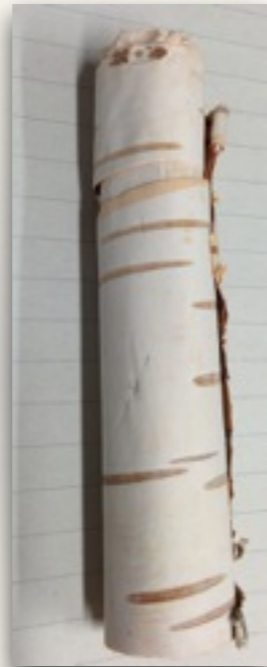
Work in progress to develop new methods to access the other two thirds. All the information exists in the dataset from the scan. No other scanning or access to the roll is needed for this.

<https://www.youtube.com/watch?v=FXkQz9fOafU>

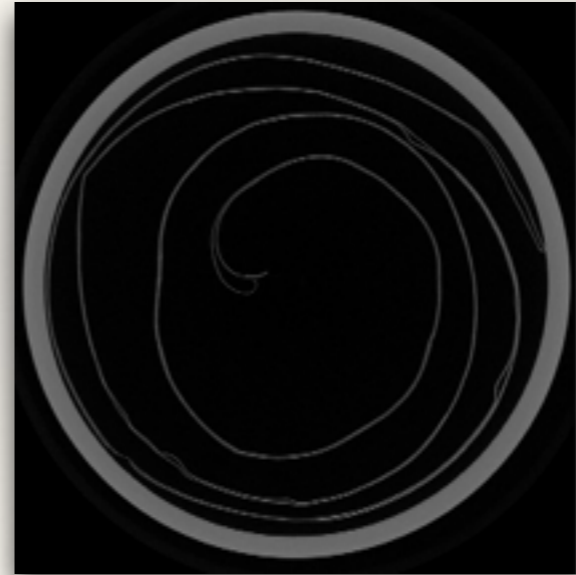
Mills, *et al.* *IADA Journal of Paper Conservation* (October 2014)

Unrolling

# Birch Bark Roll



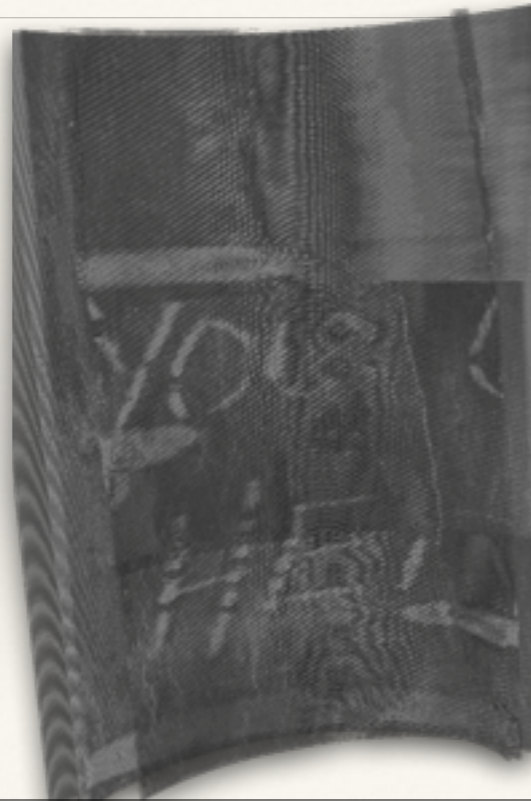
European Silver Birch bark.  
September 2009.  
No ink. Inscribed with blunt stylus



Can we image text when there's no ink / pigment?

Blunt stylus used to make impressions and cause some discolouration of the bark. Nothing added or subtracted from the bark

# Birch Bark Roll



Using a volume render technique we can visualise portions of the writing

Contrast is due to stylus pressure collapsing porous structure of the bark, giving a local increase in density

Yes, we can. The stylus compresses the porous nature of the bark, the X-rays see this as an increase in density, so there's a fraction of a percent more contrast. Our sensitive scanners can see this.

# Burned Title Court Roll

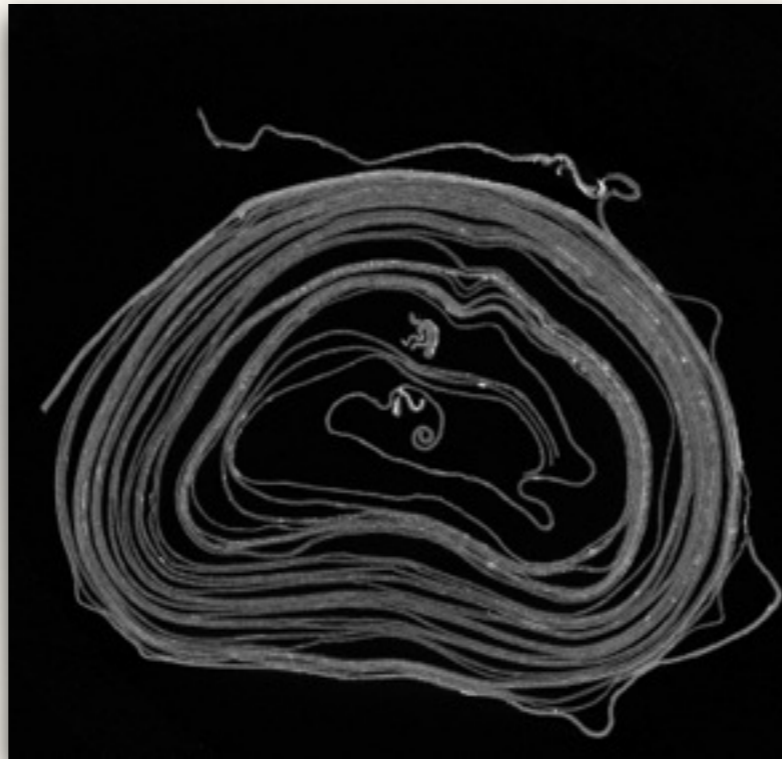


Fire damaged parchment roll c1500  
Details ownership of land and buildings in Diss-Heywood area of Norfolk, UK.  
Burned sometime before 1800s  
Shrunk to ~60% of former size

Another roll from the NRO.

Burned and shrunken. No hope to physically unroll this.

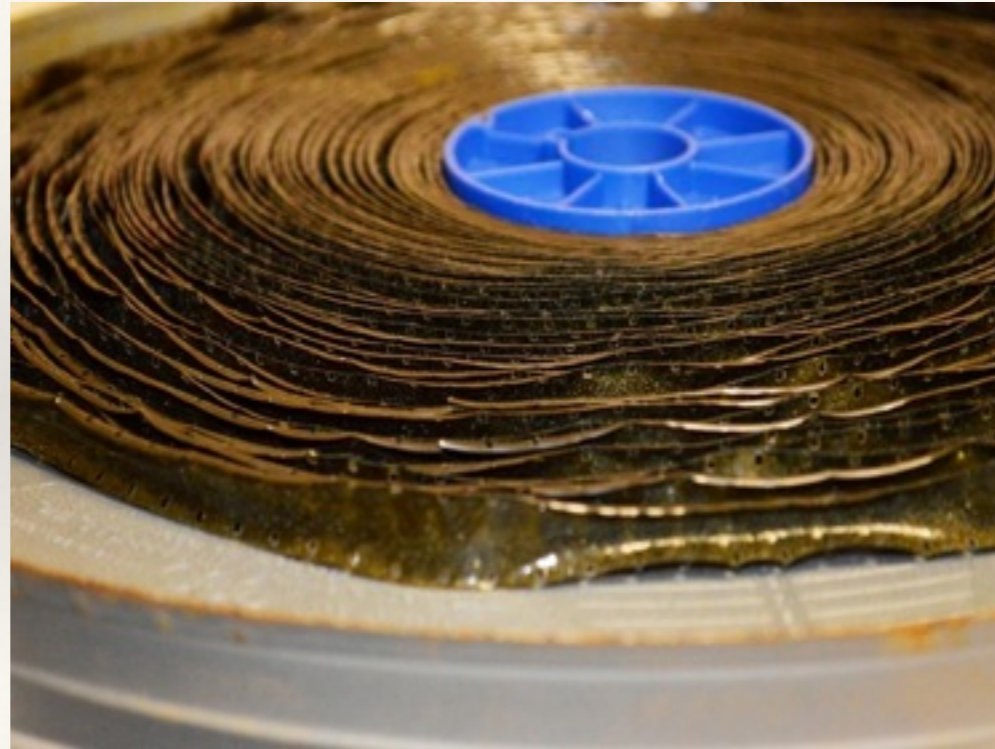
# Burned Title Court Roll



Central slice shows just how bad the roll is.

Work in progress to produce an unrolled version. We've been able to see individual letters, but no full words or lines of text yet.

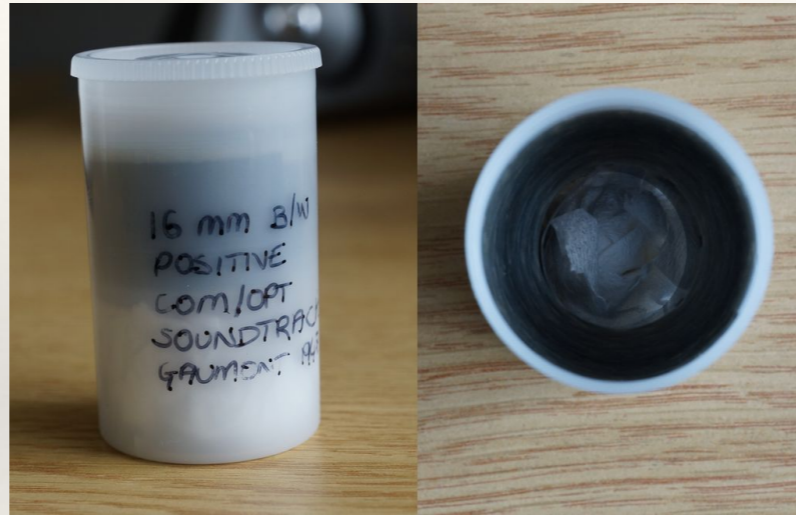
# Something Different



After the BBC made the short film about the Bressingham roll, we were contacted by Charles Norton (freelance writer for BBC archives) to ask if we could unroll film.

It's rolled up and there's silver in it, so would we see anything in X-Rays

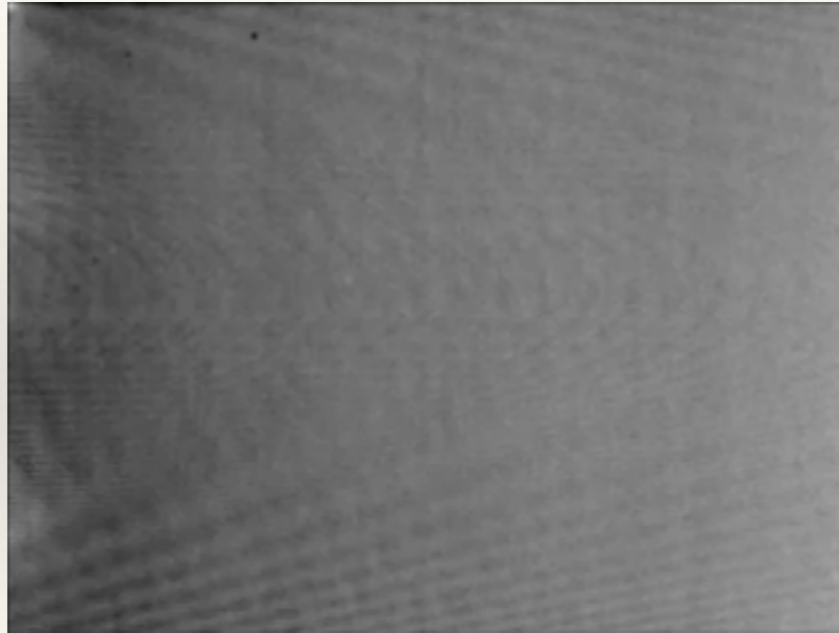
# Proof Of Concept



16mm acetate stock positive film "Gaumont British News"

As a proof of concept test we acquired some 16mm acetate stock and scanned it rolled up in a 35mm film can.

# Proof Of Concept



A lot of processing later...

Remember this was pristine film, no detectable damage to deal with at this point.

# Something Exciting



Pleased with this result and a couple of other tests with different films. We got to try this.

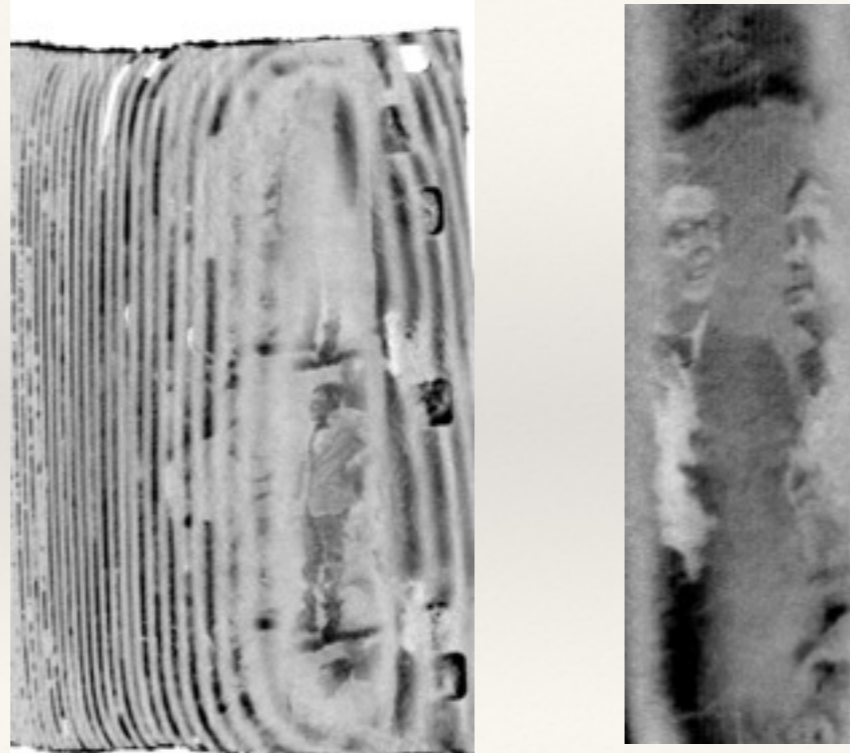
The only known copy of the first episode of a TV show

Acetate stock is degrading to acetic acid - it stinks of vinegar

You can see the acid pooling

Found in South Africa in poor conditions. Shelf life even cooled was estimated as <18 months

# Something Exciting



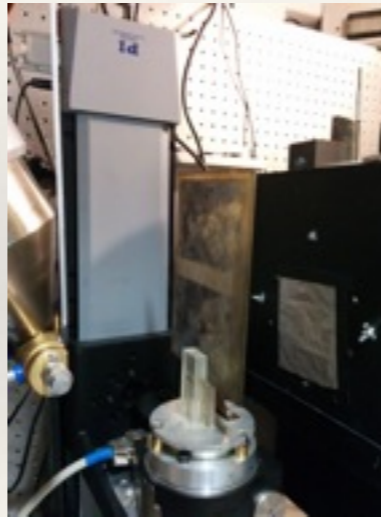
Initial results.

The damage is so severe we're never going to be able to get video from this. We're recovering around 50% of the frames, more in some areas, few to no frames in other areas.

# Some other projects...



Mamluk Cap with writing on internal paper



Glass plate photographs



Bundle of letters

Cap is held by textile archive at Leeds

Glass plates from London Metropolitan archive

Letters from Leiden - technology demonstrator at the moment.

# How can we help you?

What do you have in your collection that's inaccessible?

website : <http://apocalypto.org.uk>

email : [d.mills@qmul.ac.uk](mailto:d.mills@qmul.ac.uk)

Cap is held by textile archive at Leeds

Glass plates from London Metropolitan archive

Letters from Leiden - technology demonstrator at the moment.

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# Acknowledgements

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Charles Norton & the BBC