Parchment Conservation Workshop - March 2016

Micro-CT of Parchment.

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The Apocalypto Project

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.

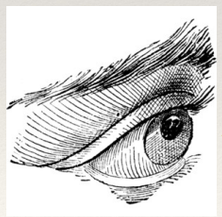
In mid 2009 the Apocalypto Project was born - a collaboration between Conservators, Scientists and Computer Vision experts.

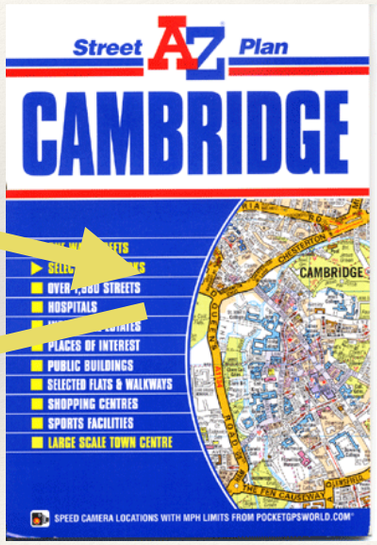
This presentation covers some of what we've worked on and learned along the way

How we got started in this - A dental School and an ophthalmology school doing heritage science

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

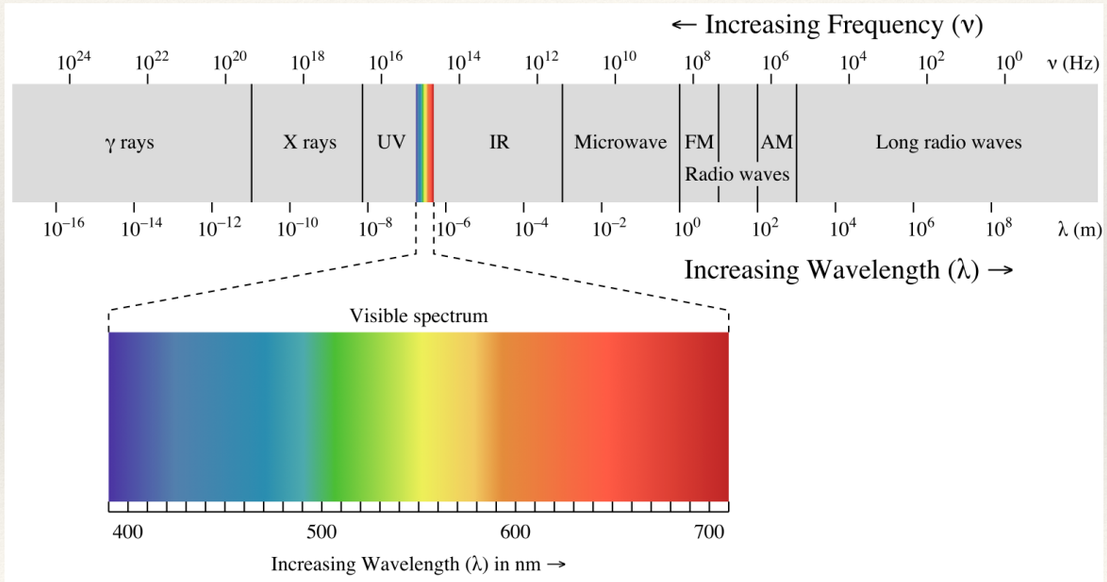
At different wavelengths different things become visible

"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

The same person photographed under UV, Visible and IR light shows different features. Sun damage shows up under UV, Skin is more translucent in IR

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 though the object, not reflected ones.

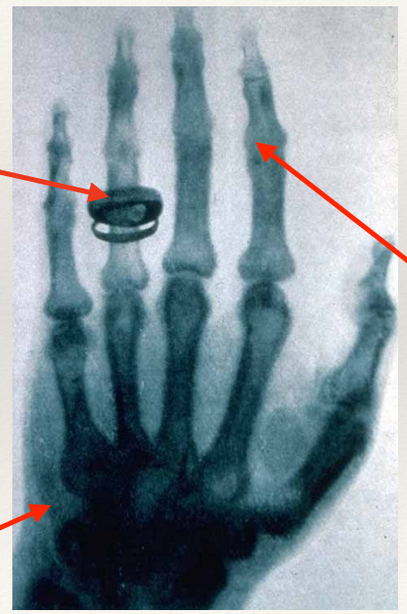
X-Rays are usually detected in transmission mode - you shine them though an object and detect what gets though. First medical X-Ray of Roentgen's Wife

The nature of imaging

What's the contrast mechanism?

Ring:

79
Au
Gold
196.966569



Bone:

20
Ca
Calcium
40.078

15
P
Phosphorus
30.973762

Flesh:

6
C
Carbon
12.0107

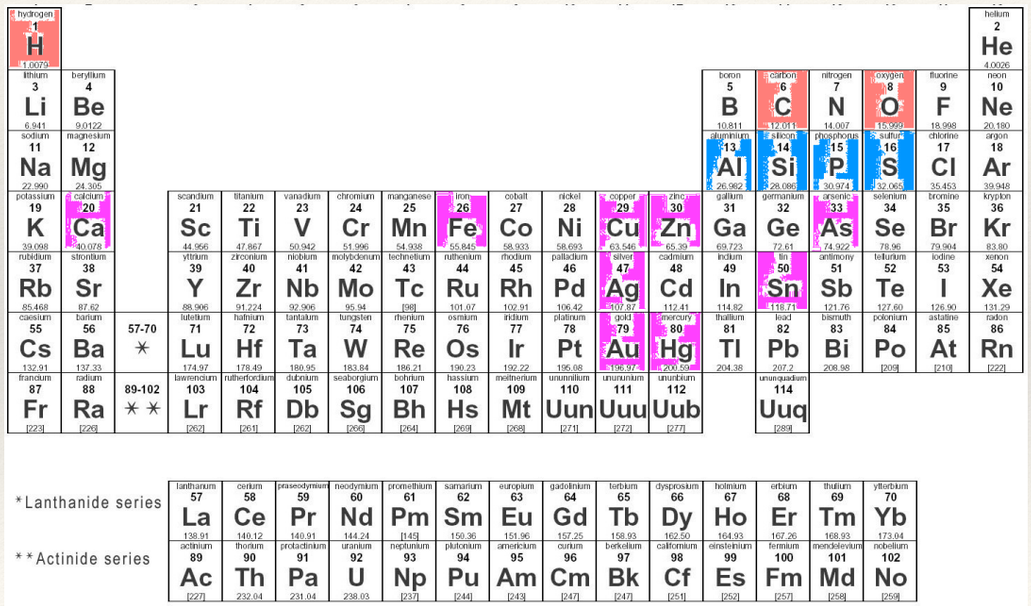
8
O
Oxygen
15.9994

1
H
Hydrogen
1.00794

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



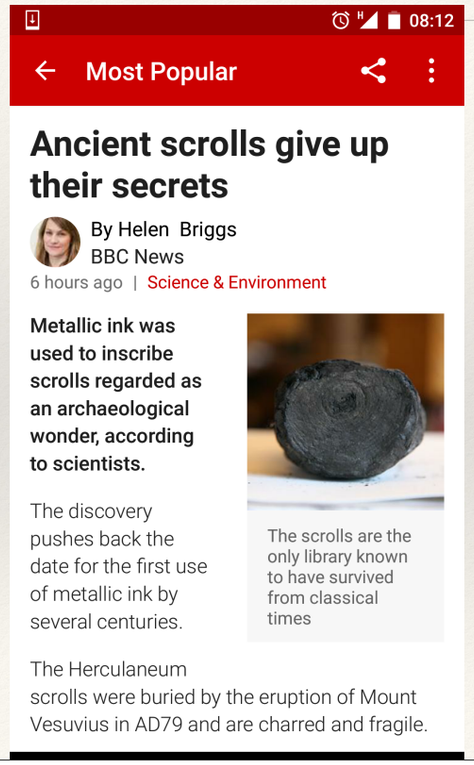
The common elements in materials and inks are shown in the periodic table.

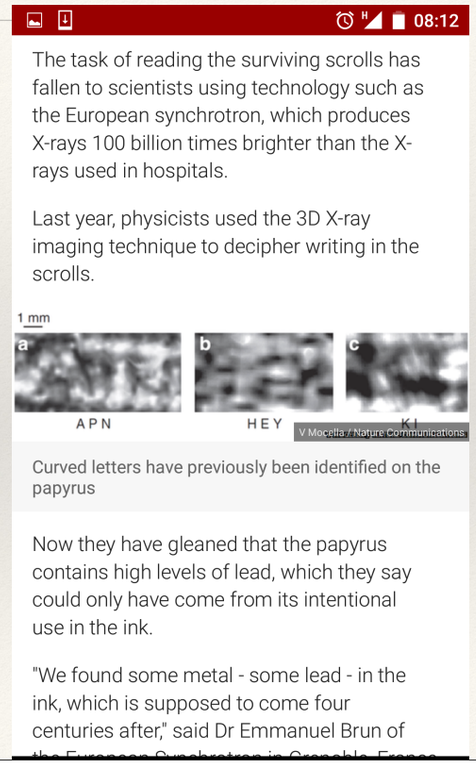
Paper, parchment, organic materials are essentially made of the Orange elements - they don’t image well unless there is a great thickness of them, blue is medium and pink is everything else.

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

Hot Off The Press





Hot off the press this morning

What do you see if you X-Ray parchment?

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.

One X-Ray Isn't Enough

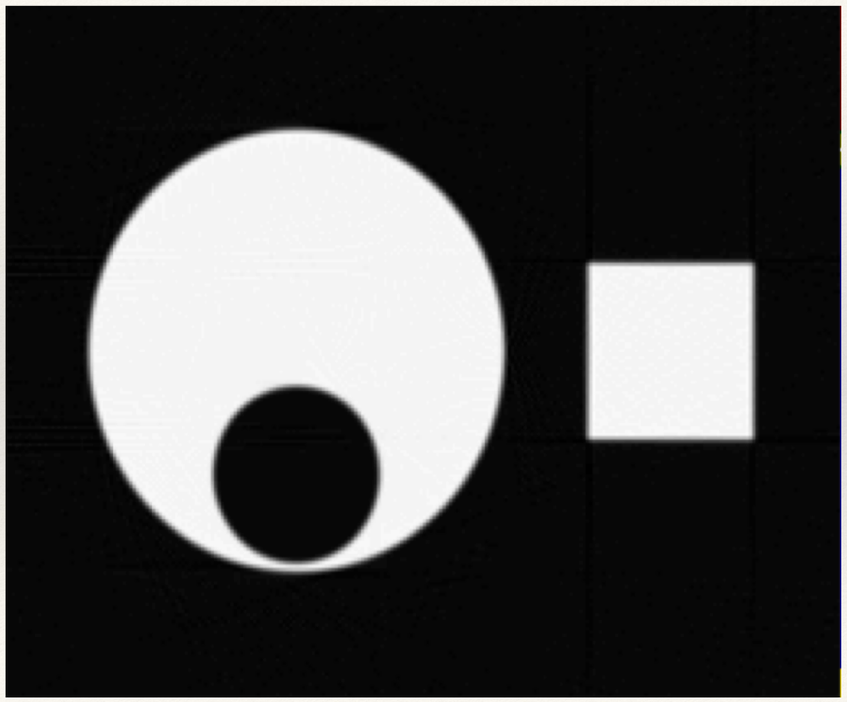
Ei alienum epicurei sit, nec feugait offendit mnesarchum at. No eum leginus intellegat elaboraret, eu vide semper suavitate has. Pri clita

One X-Ray just gives you all the text on top of each other. Assuming you can see anything anyway. What you need is a 3-D Xray

3-D X-Rays

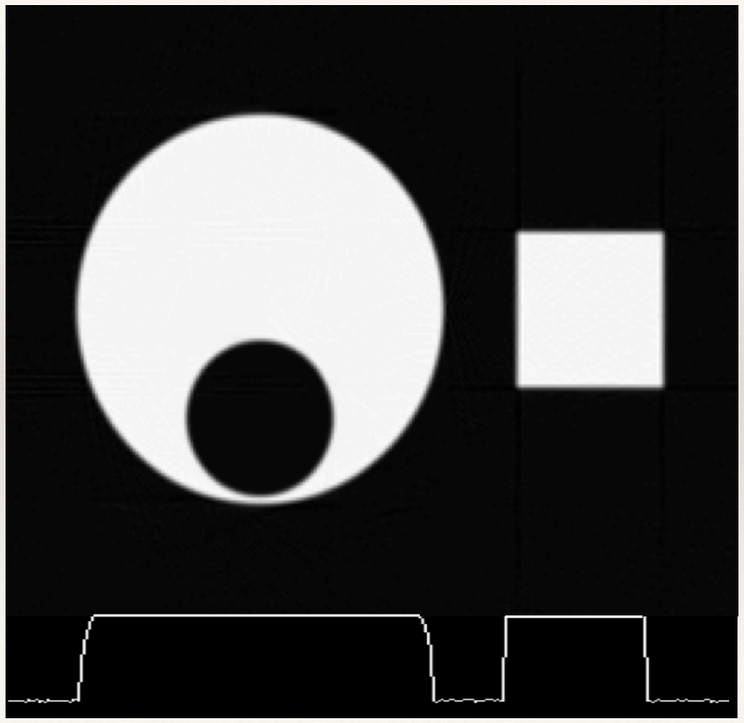
We call these CT Scans

CT Scans Need Lots Of X-Ray Images



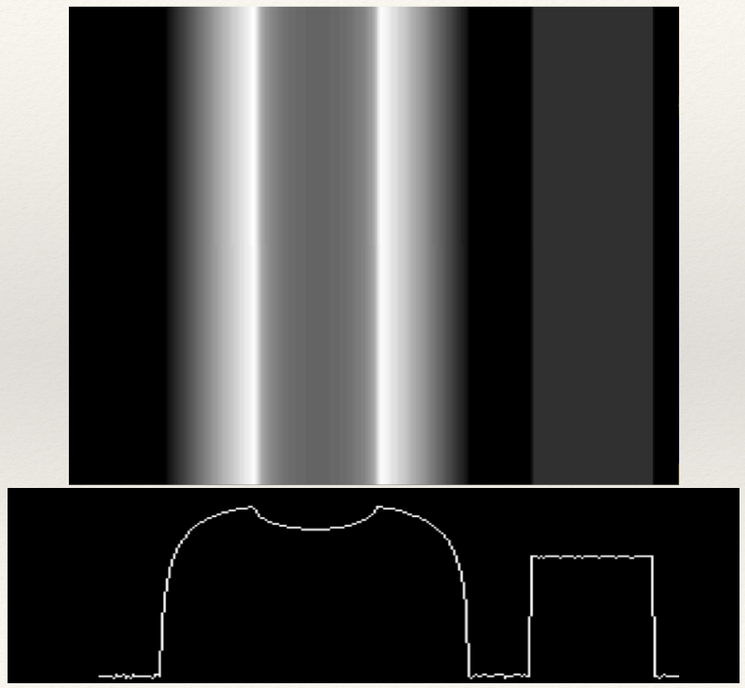
This is an X-Ray Phantom - just an example image, to reproduce it, how many X-rays do we need?

Projection



One X-Ray gives us the line profile shown

Back Projection

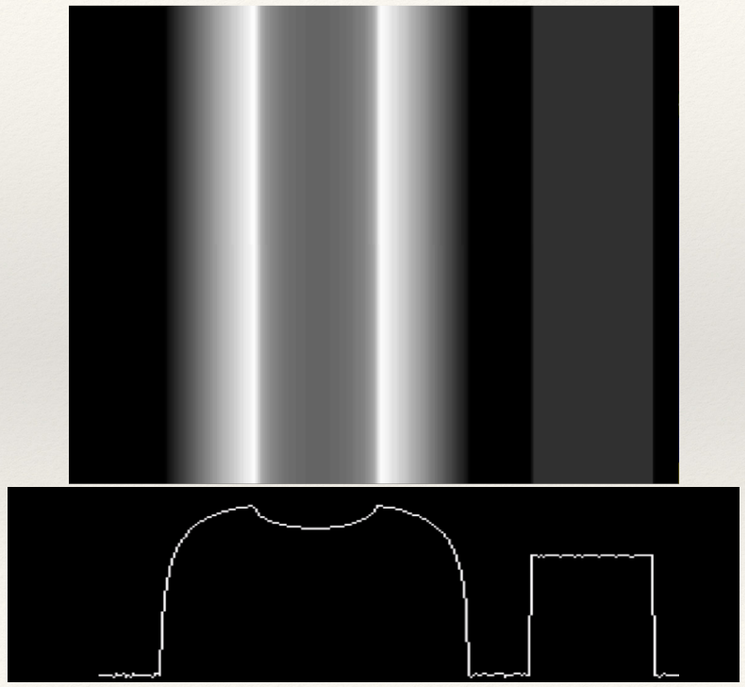


To make our 3-D Xray we need many 2-D X-rays taken at different angles around the object.

Smear the line profile backwards and you get a 1-xray image of the phantom

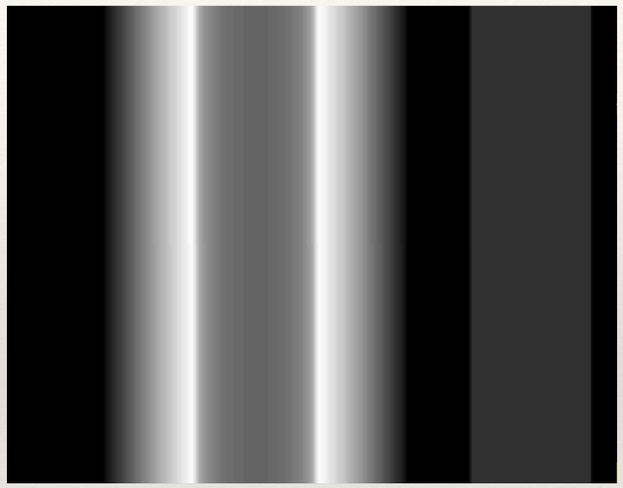
This back projection is known as Reconstruction.

How Many Images? (1)



One X-ray isn’t enough.

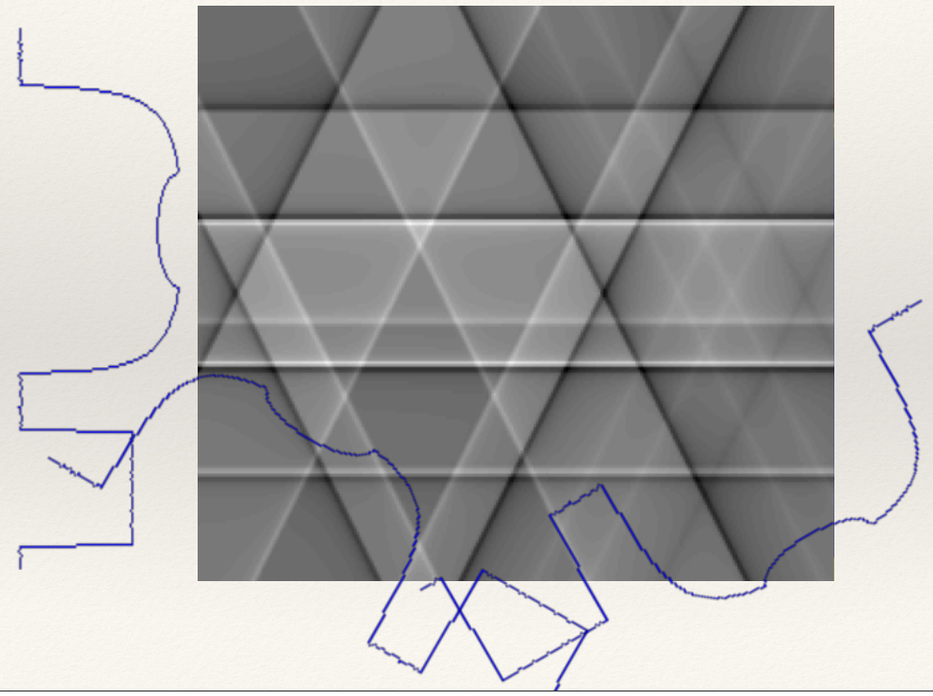
How Many Images? (3)



What if we take three images at 120 degree separation?

Three images aren’t enough

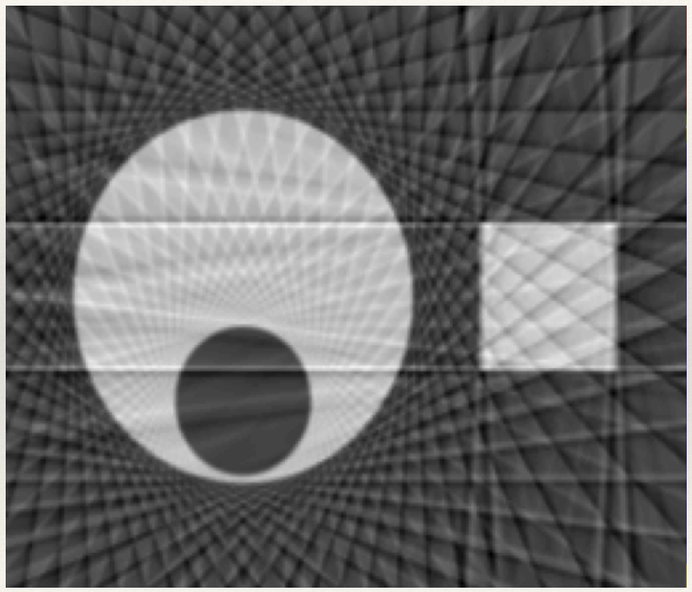
How Many Images? (3)



What if we take three images at 120 degree separation?

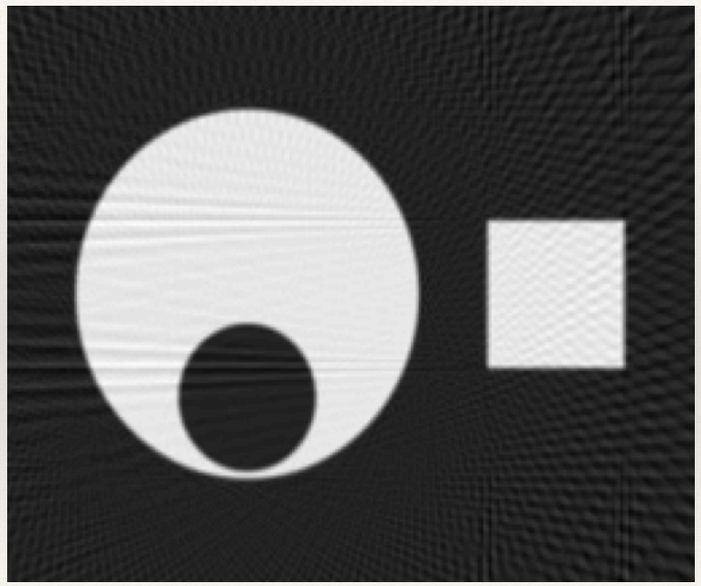
Three images aren’t enough

How Many Images? (27)



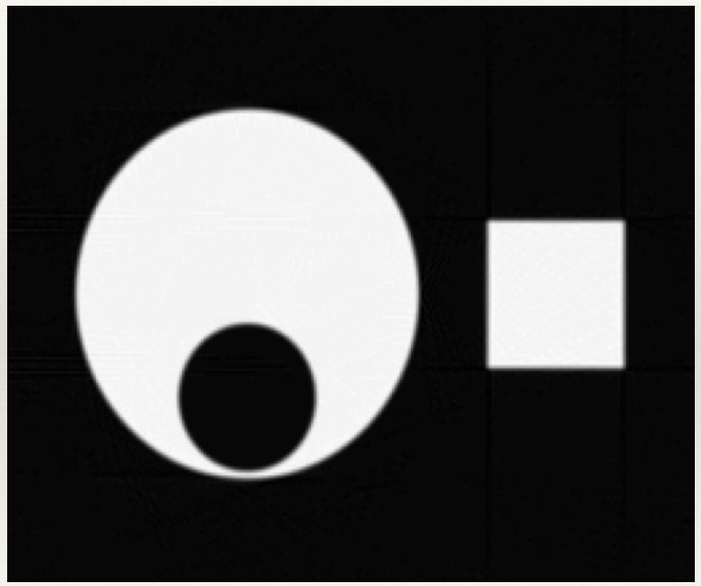
Getting better, but contrast is still low

How Many Images? (80)



A noisy image

How Many Images? (300)



300 X-Rays gives a pretty good image in this case where there is 100% contrast between the two elements (black and white). What about when we have much less contrast - such as ink against paper?

For Real Items - Thousands

Video showing reconstruction of birch bark scroll from 2101 images.

Damage?

Dental X-Ray - Dentist wears lead apron

CT Scan - Technician is in a separate lead lined room

We know X-rays damage living things - what about non living things?

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

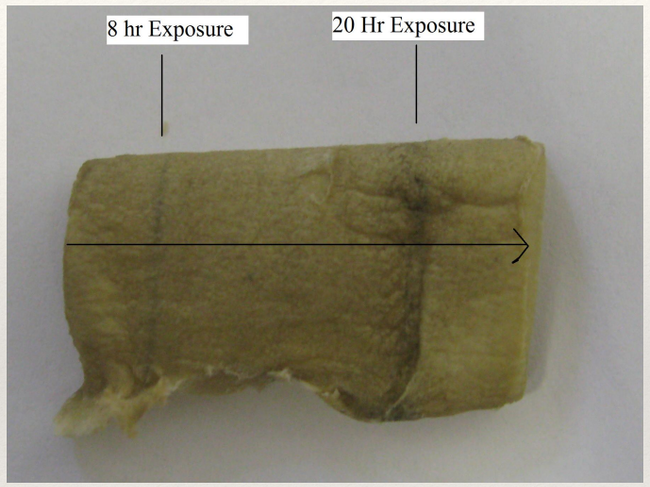
Conclusions

"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."

We know X-rays damage living things - what about non living things?

The technique is really only applicable to damaged material anyway.

Damage?



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

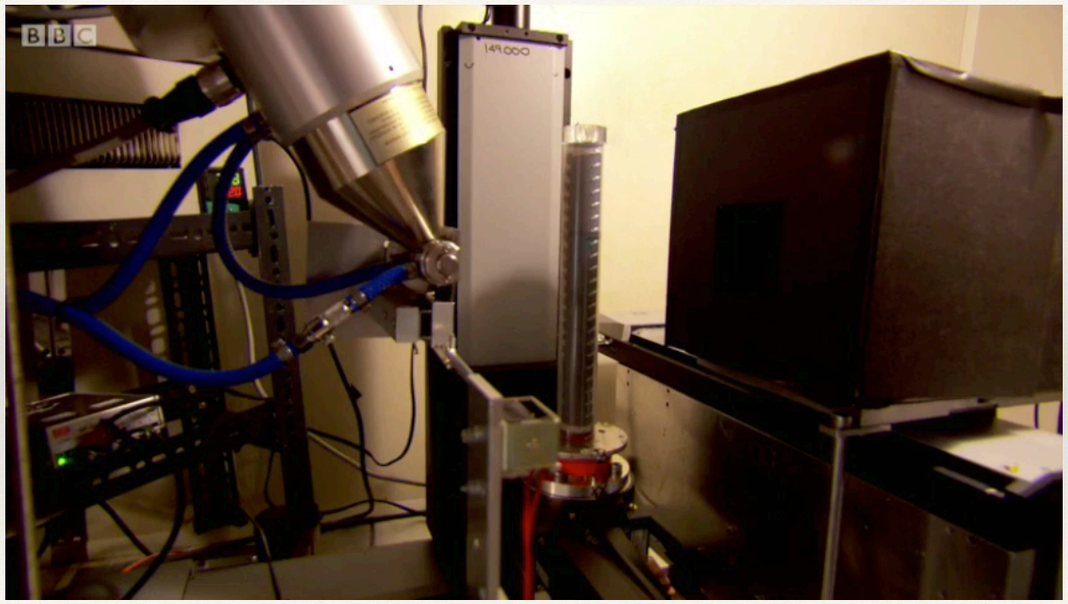
Soaking wet, rotting parchment was the only case where we saw visible damage after a scan. This isn't material we'd scan.

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.

The silver tube to the left is the X-Ray source - the black box on the right is our camera and the vertical tube in the middle is the scroll being scanned.

An initial result

A scrap of parchment with Iron Gall Ink

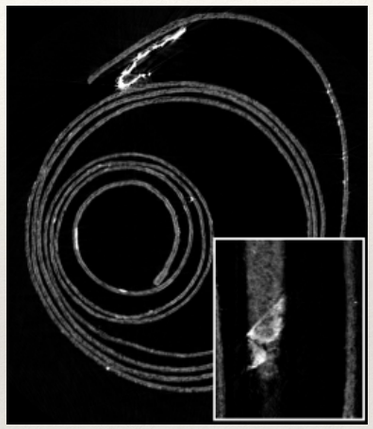
Small parchment roll and cross section view (video)

An initial result

Virtual unrolling

Virtually unrolled

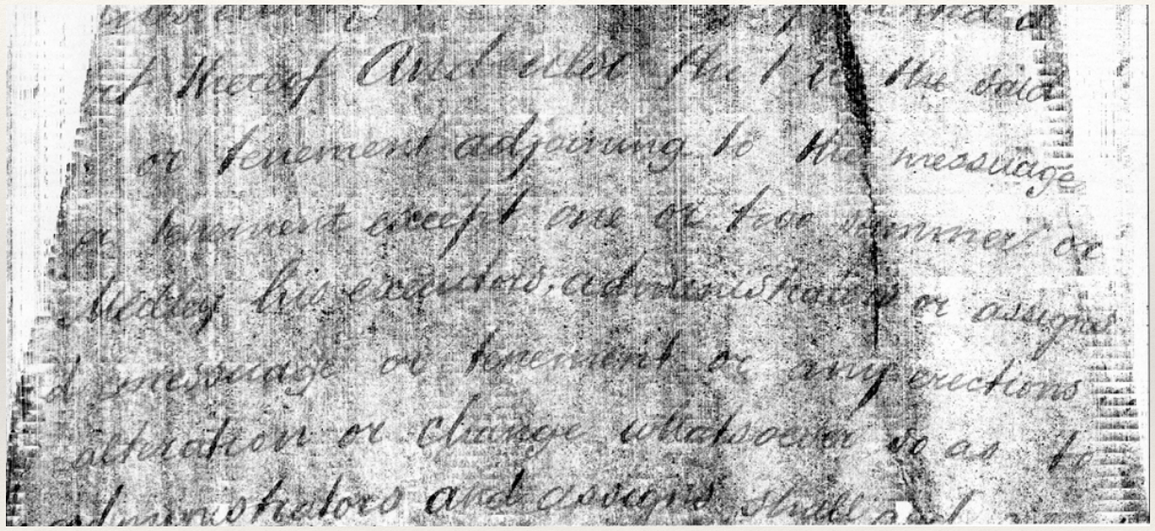
Unknown Text Experiment



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

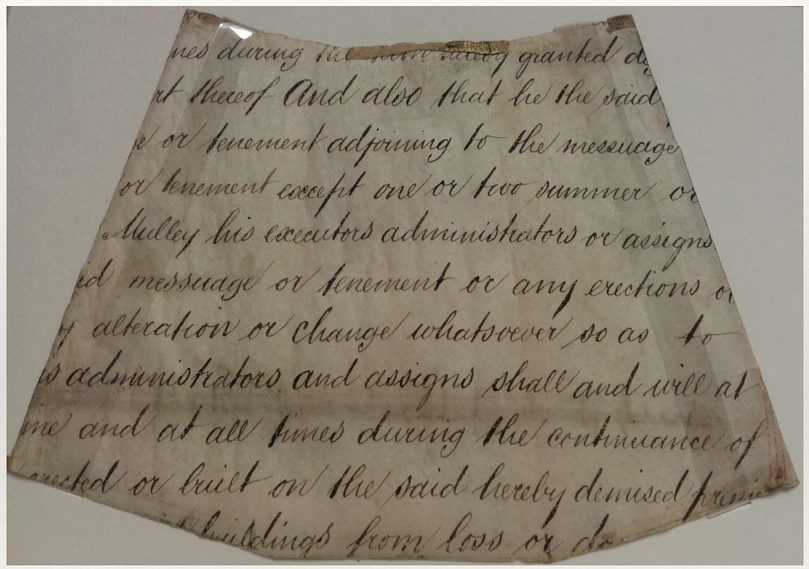
Virtual Unrolling



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

Virtually unrolled

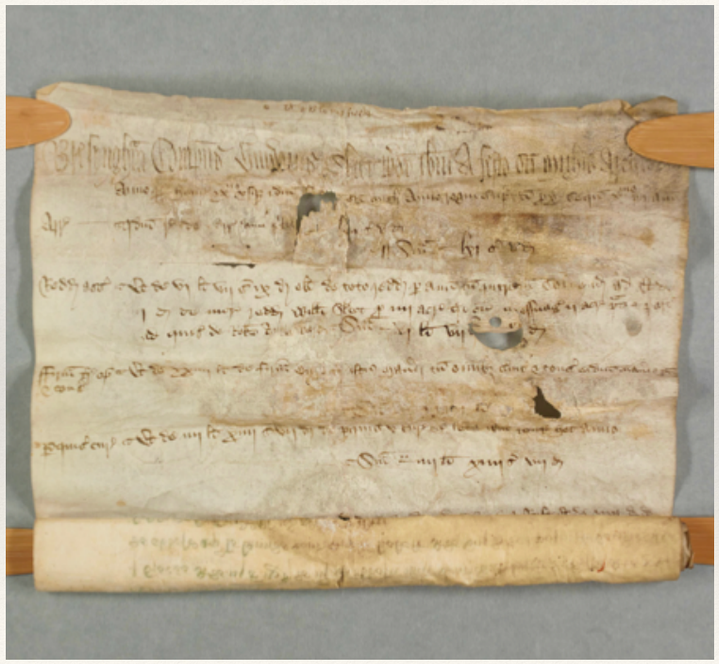
Comparison



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 Bresshingham in Norfolk UK.

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

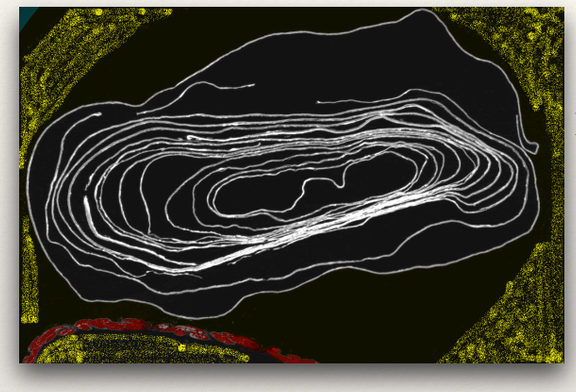
The Bressingham Roll

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

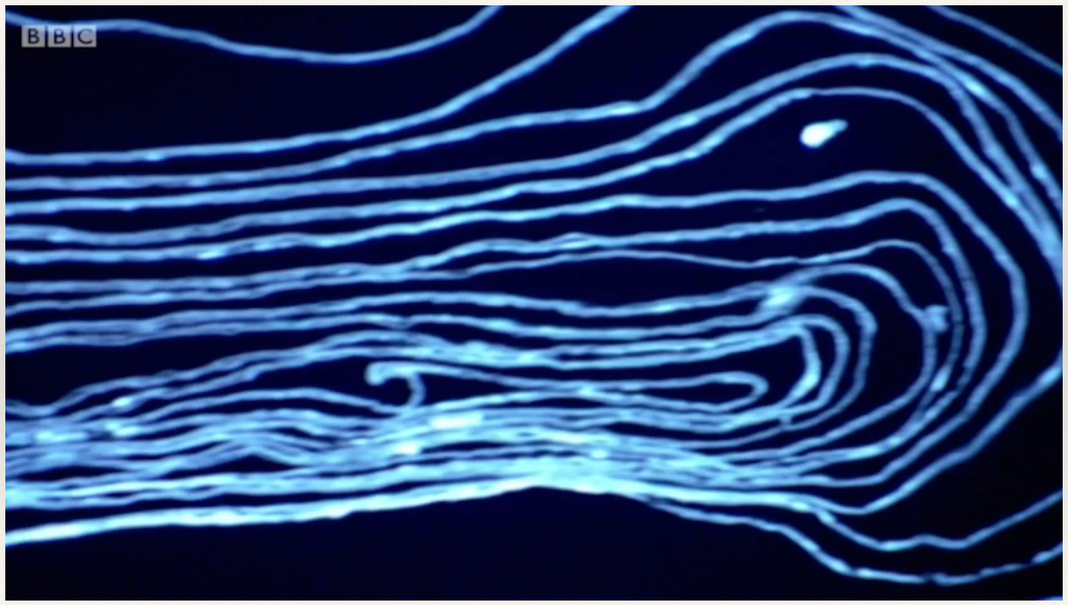
A virtual slice



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

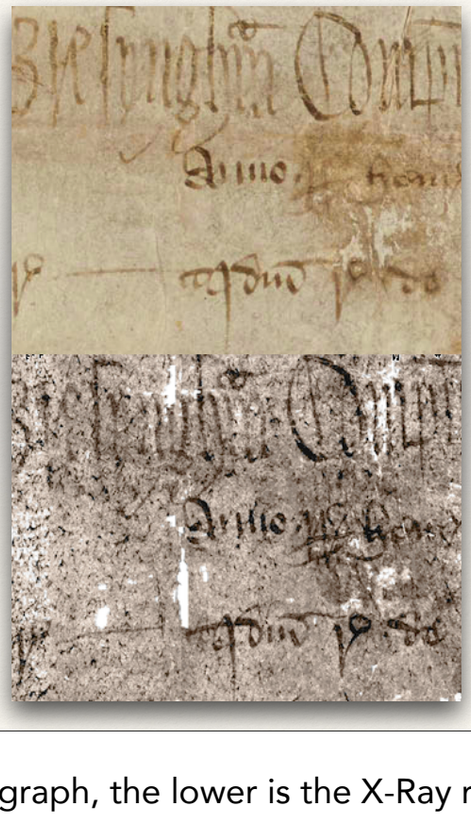
The white material in the image is the parchment. You can see that in places it is totally merged together, rendering physical unrolling impossible. Just seeing this was useful to the conservators, proving physical intervention would be damaging at best.

The Bressingham Roll



Unrolling (video)

The Bressingham Roll



Comparing the X-Ray and visible images

Checking the accuracy the top image is a photograph, the lower is the X-Ray result. You can see that in places where the ink seems faded in the photograph, there is still good contrast in the X-Ray image.

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

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.

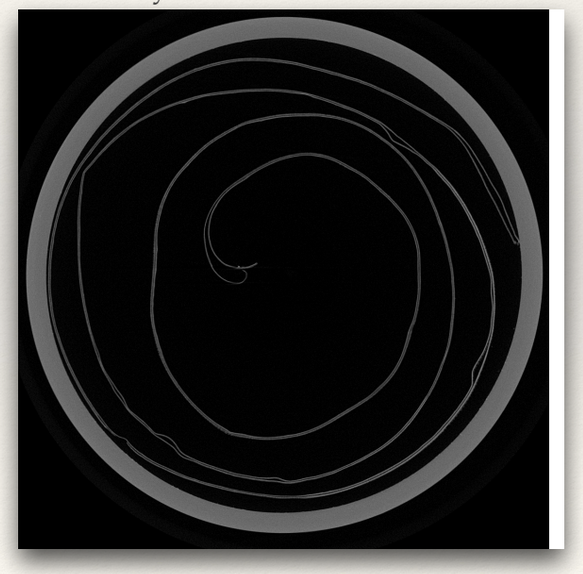
Burned Title Court Roll

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.

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

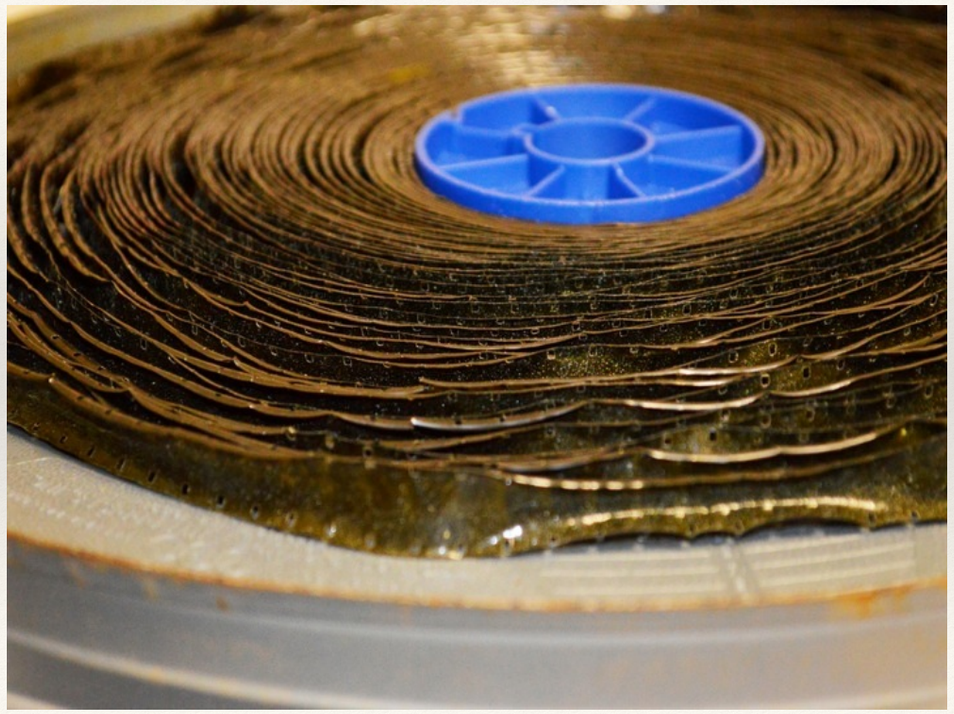
Birch Bark Roll

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.

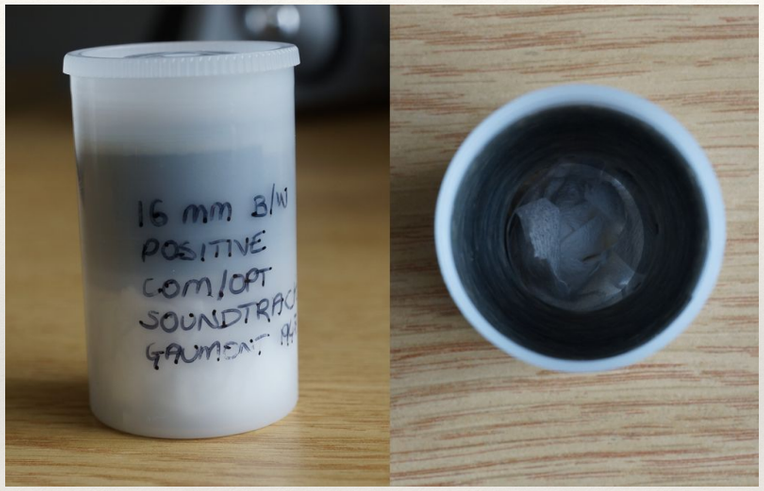
Something Different



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

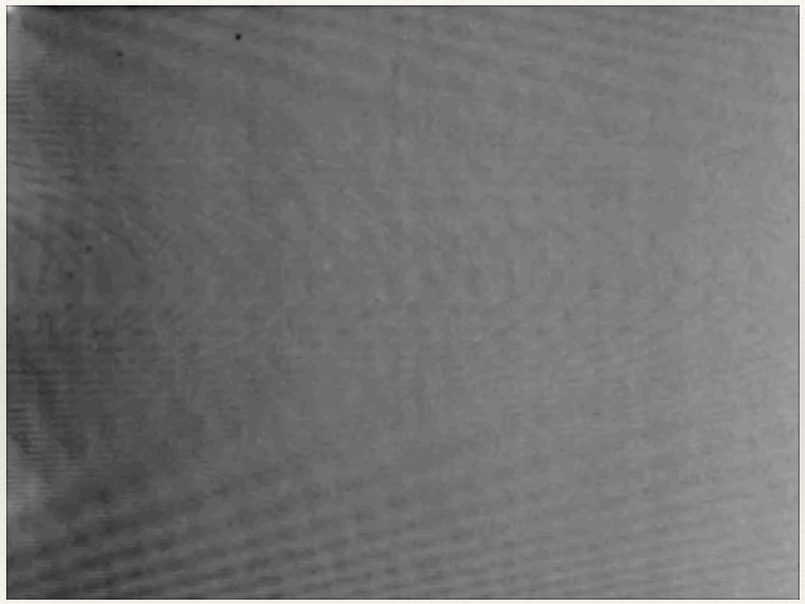
Proof Of Concept



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



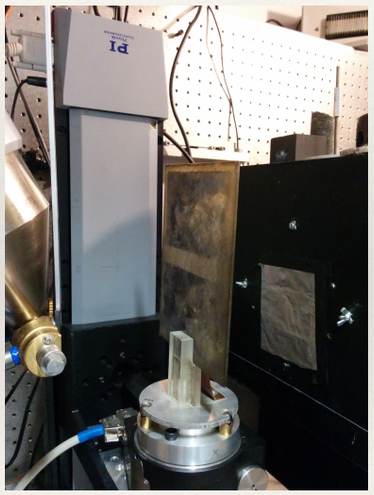
(Video)

A lot of processing later…

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

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

Acknowledgements

Graham Davis, Paul Rosin and Yukun Lai

Antoinette Curtis, Jana Dambrogio , Jacqui Hyman, Meagen Smith, Caroline De Stefani,

Charles Norton & the BBC