INTROSPECT ANR-FRQSC

A Pilot application of Tomodensitometry in Zooarchaeology: Methodological trial and results of the study of seal teeth from the Norse Eastern Settlement of Greenland

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Projet soutenu par le LIA RESO

INTROSPECT ANR-FRQSC

- The **INTROSPECT** project is a research collaboration between researchers in computer science and archaeology from France and Québec

- **INTROSPECT** aims to develop new tools and applications that facilitate aquisition of new knowledge

- A focus on interactive digital introspection methods that combine Computed Tomography with 3D visualization technologies such as Virtual Reality, tangible interactions and 3D printing

- **Development of methods of non-destructive analysis**

- Integrated analysis of the artefact, the archaeological context, the digital object, and their virtual reconstruction

- **« A virtual trip to the heart of the object and its archaeological context »**

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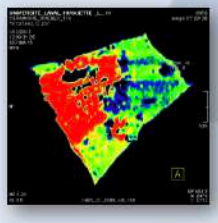
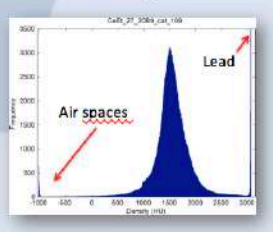
INTROSPECT : Combining the tools and knowledge

Archaeology

- Characterization of materials

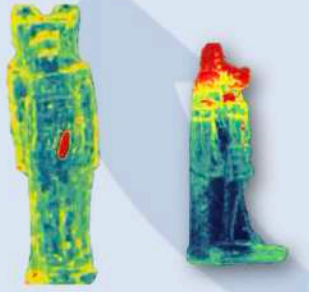
Computed Tomography helps identify the different components and the porosity. **Itrax** will then give the chemical signature.





Ceramic shard with lead glaze

- Manufacturing methods



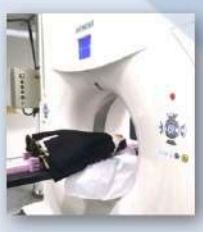
Example : Egyptian *oudja* found at Îlot des Palais, Quebec. Computed Tomography shows the technique used to manufacture these amulets. On the left, we can see in the center a piece of lead to add some weight and on the right, the inequality in the application of the glaze.

Multidisciplinary and international exchange of data

Technology Engineering

- 3D representation

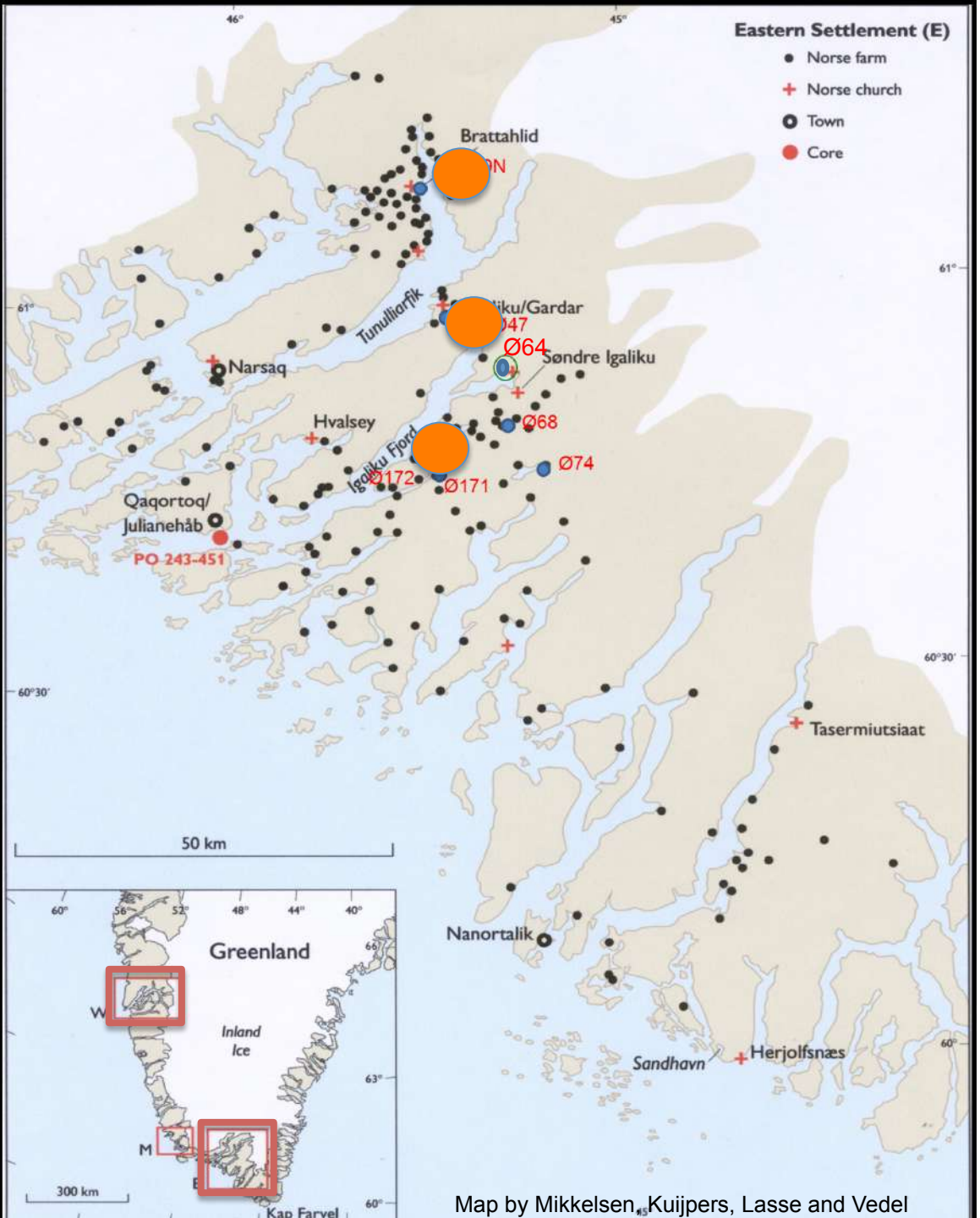
CT-scan provides 3D images and movies. The details of those information can also be used to reproduce artifacts in 3D printing.



- Virtual reality and augmented reality

The 3D modeling can also be used in a virtual environment and the data of density provided gives a unique opportunity to increase realism.

Norse Farm sites in the Eastern Settlement Greenland

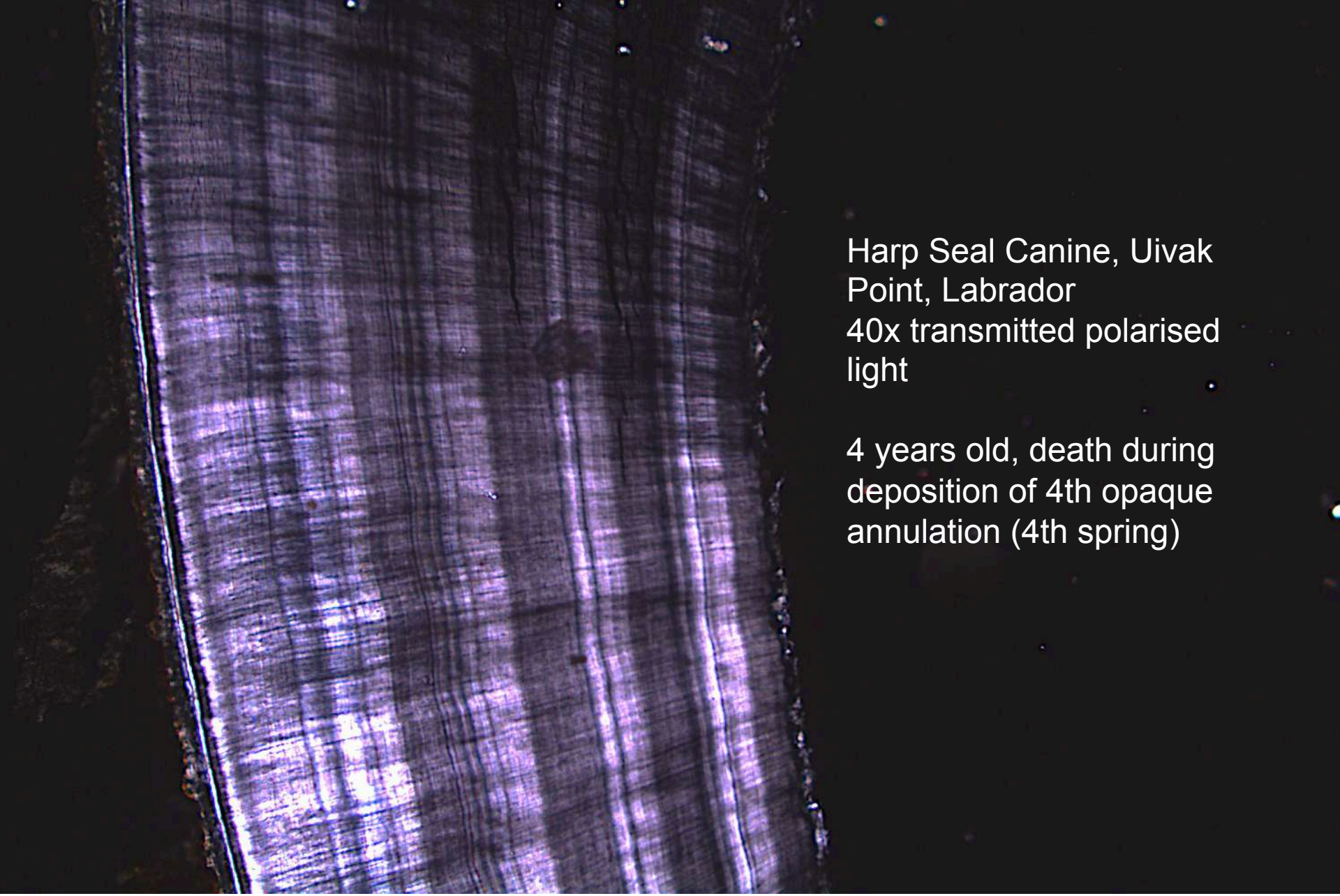


Map by Mikkelsen, Kuijpers, Lasse and Vedel

Norse Farm Sites in Greenland

-10th to 14th century

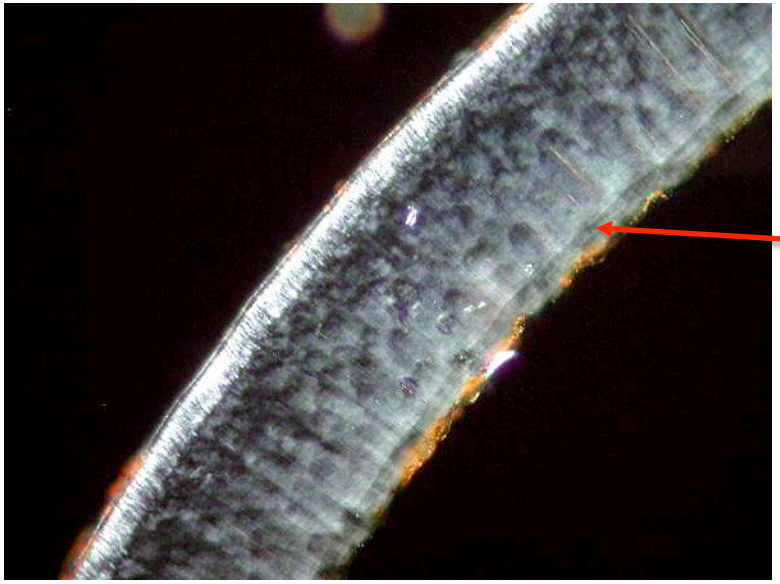
-Primarly engaged in animal husbandry but significant economic contributions from Seal and caribou hunting



Harp Seal Canine, Uivak Point, Labrador
40x transmitted polarised light

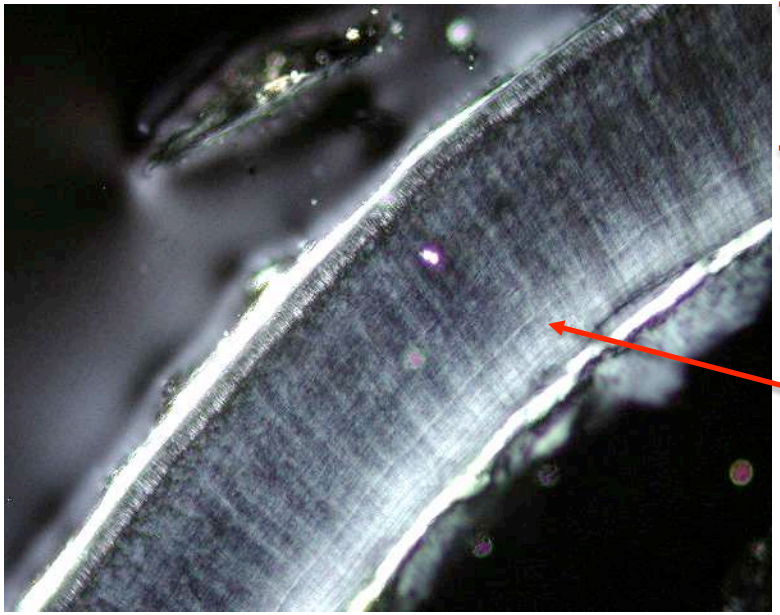
4 years old, death during deposition of 4th opaque annulation (4th spring)

SVB 04-30
P. Vitulina
AU 7



Neonatal line

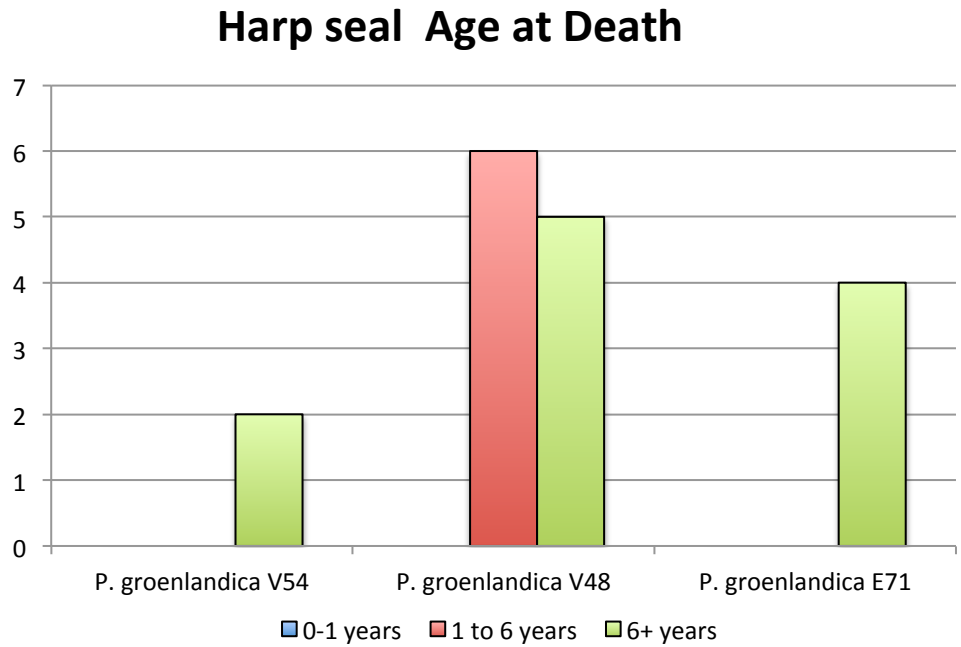
CC-15
Modern *P. vitulina*
1 month old

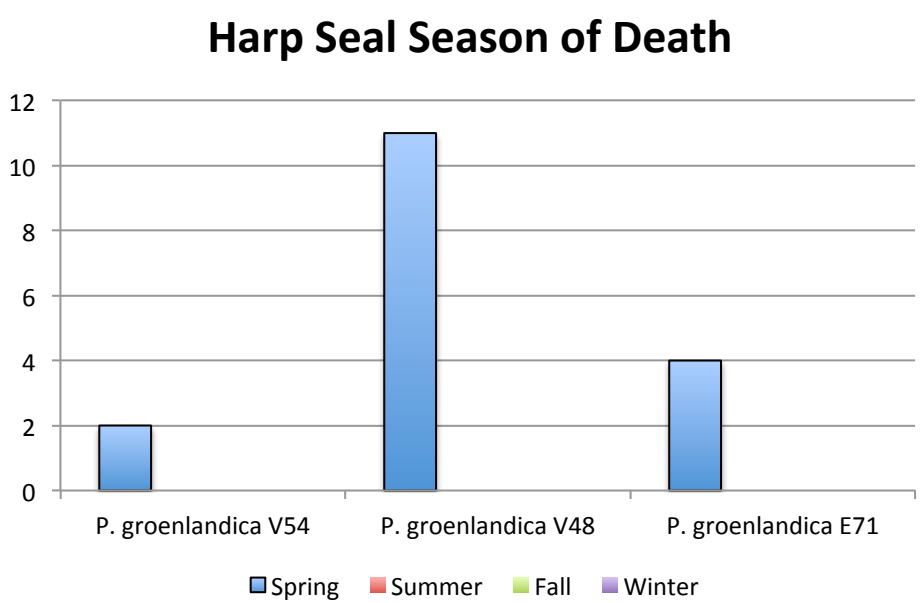


Prenatal Dentine

Postnatal Dentine

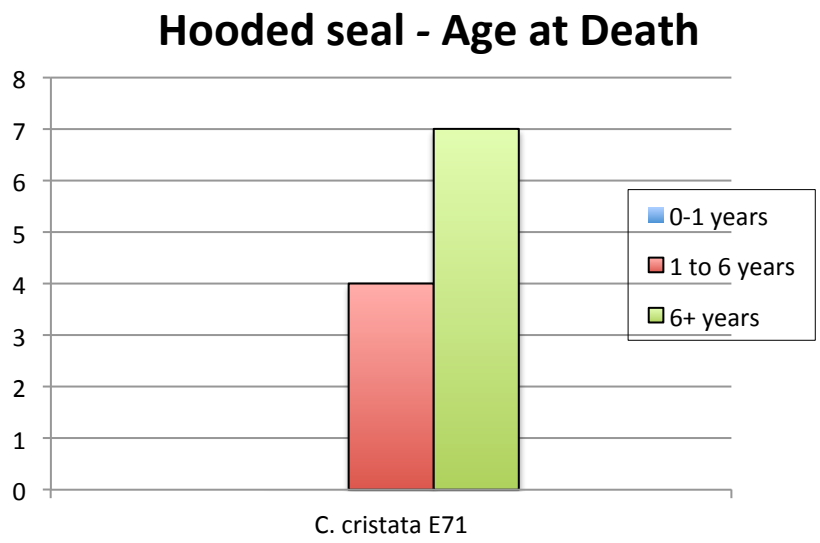
Neonatal line

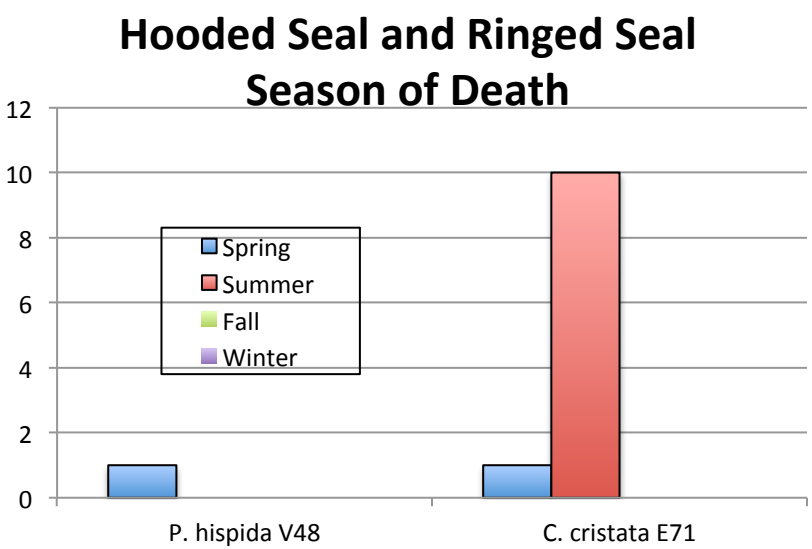




Breeds on ice, migrates in packs, millions of animals annually.

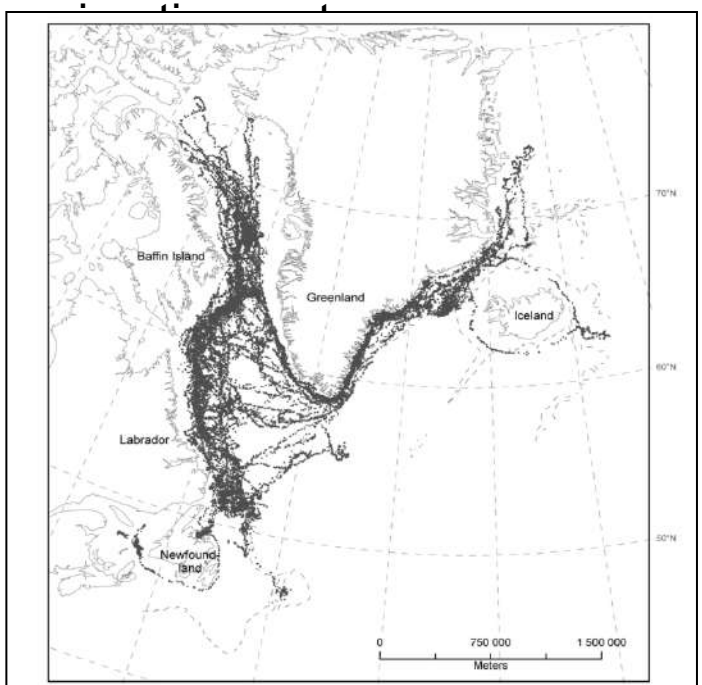
- Mostly adults are hunted on the way north from the breeding colonies off Canada – early migrating young males? Post winter food source?
- These seals are present in GL waters most of the year, but only hunted in the spring, indicating communal effort to harvest this seasonally abundant resource, on a large scale, possibly involving labor and boats from ALL farms
- The same seasonality signature for consumers on coastal and inland sites? How is the catch divided?
- Can we detect harp seal breeding colonies in SW Greenland pre 18-19th Century commercial seal hunt?
- Sea Ice is important, for access and abundance





Migratory, large and aggressive seals

- Only adults are hunted while molting on ice drifting from East Greenland?
- Pups are not present in Greenland, breeding occurs on ice off Canada (Gulf of St. Lawrence)
- Hooded seals are archaeologically almost exclusively present in the Eastern Settlement corresponding to their



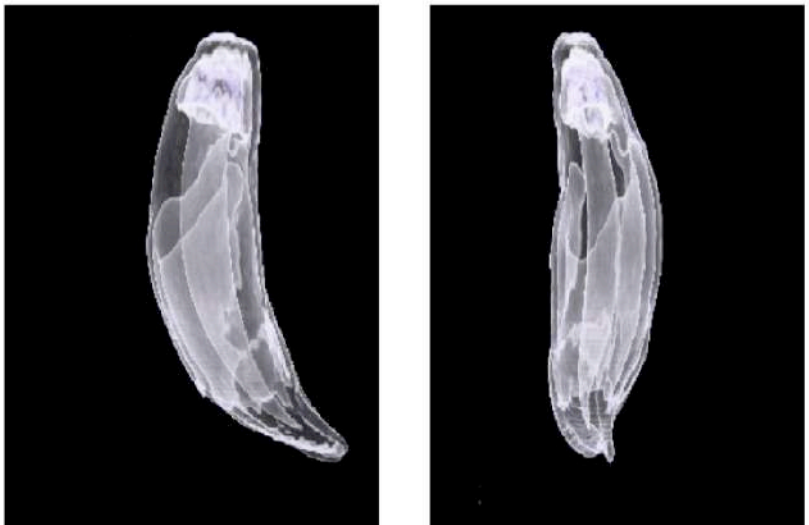
Andersen, J. M., Y. F. Wiersma, and G. Stenson. 2009.

The case of seal teeth

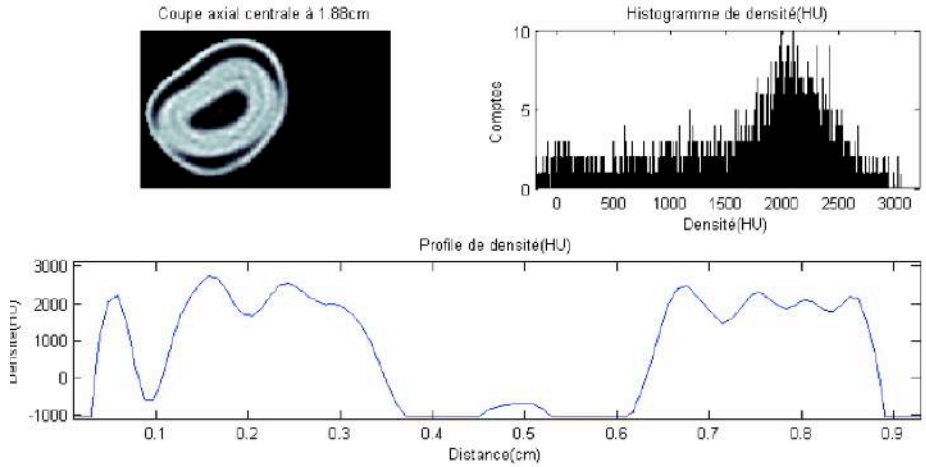
Characterisation of the morphological and structural characteristics of tooth and bone

- Development of a non-destructive method of observing and analysing incremental growth structures
- Obtain results in the form of images and digital data
- Digital data permits statistical and morphometrical approaches
- Keep a 3D imaging inventory of each tooth
- Curation and re-use of data

Observation of specimen structure in multiples axes, 3D



Detailed morphometric analysis of structure (density) synchronus with structural observation



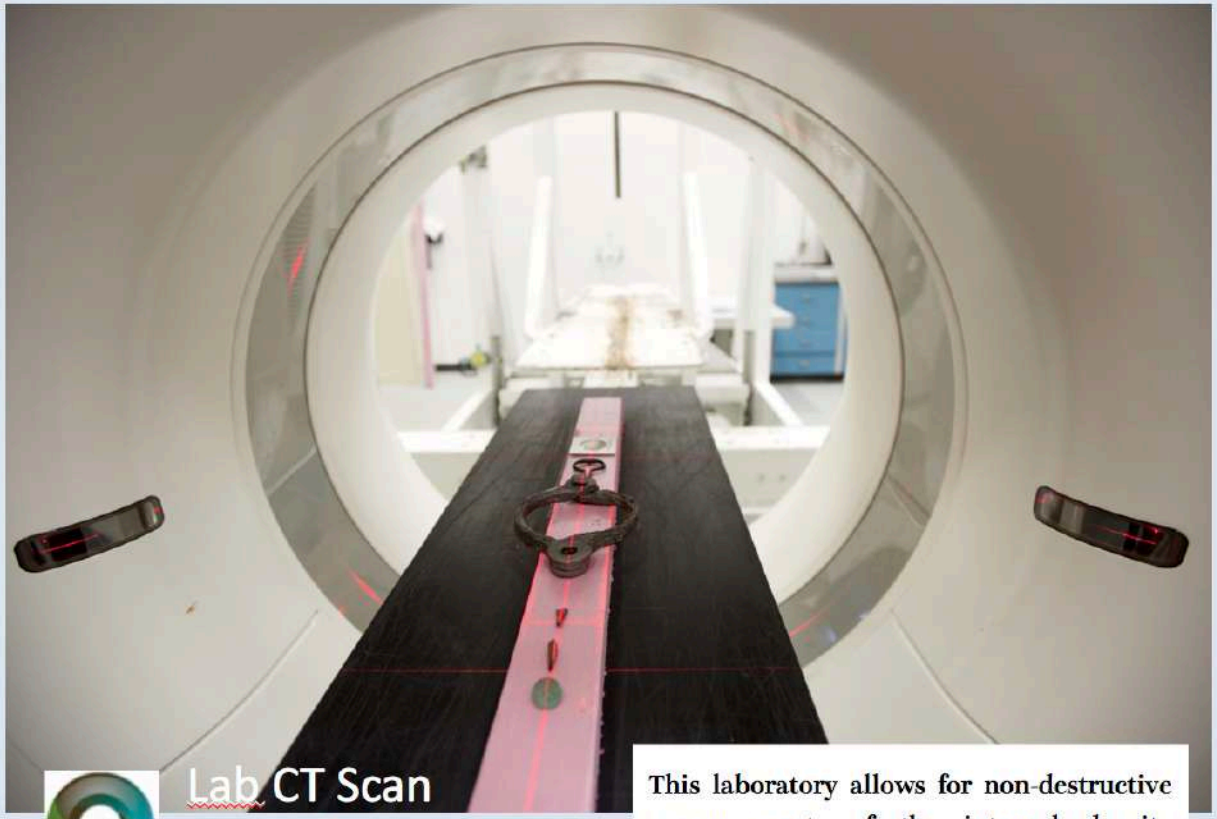
Development of a trial method

- A Siemens Somatom Definition As+ tomographic scanner has been used for tooth scanning: permits spiral, continuous data collection, seamless observation without relignment of the sensor)
- The examination table stand is stationary while the CT-scanner performs spiral scanning (custom built for this sensor)
- The CT-scanner is mounted on a sliding gantry : allows reconstruction of the whole specimen or slice by slice
- Scan acquisition parameters : 120 kV, 300 A/s : suitable for very dense specimens
- Pitch of 0.3s (0.3s per slice)
- Reconstructions iterations have been performed using SIEMENS SAFIRE algorithm
- Image slice pixel resolution of 0.1x 0.1x 0.4 mm^3
- A total of four hours were needed to scan 126 samples

Skeletonization Algorithm used in Virtual Colonoscopy Adapted to the Analysis of Seal Teeth

- Skeletonization algorithm is a process used to extract morphological information from biological tissue
- MATLAB software was used for image processing and implementation of the skeletonization algorithm
- The first phase is to compute a 3D Euclidian distance transform of the object
- To calculate the volume of the cavity, a vitual sphere is inserted and the the process is repeated until the cavity is filled
- Finally, interpolation between points is performed and an extrapolation is used to merge the center line to cavity to the outer edges of the object
- A medical software package
- Why use a colonscopy tool? The colon is a tube that is not uniform in dimension or form, similar to the tooth.

The Labscan and materials



Lab CT Scan

Laboratoire multidisciplinaire de tomodensitométrie
Pour les ressources naturelles et le génie civil

This laboratory allows for non-destructive measurements of the internal density variations on static body (internal structure, porosity, etc.) or dynamic phenomena, mainly hydrodynamic (experiment in 4D).

It is the only facility of its kind in a Canadian university.

Results

- Density, curvatures and Ferret diameter profiles have been extracted
- Density profile gives indication about the presence or absence of diseases
- The pulp cavity can be described in terms of volume but also in terms of length and diameter using profiles along the tooth
- Curvature profile shows how complex the tooth shape is; peaks and plateaus indicate transitions from one curve radius another.
- Statistics on the curvature shows promising avenue to assist in telling the story of each sample
- The skeletonization algorithm was well suited for the teeth samples and performed rapidly

Results

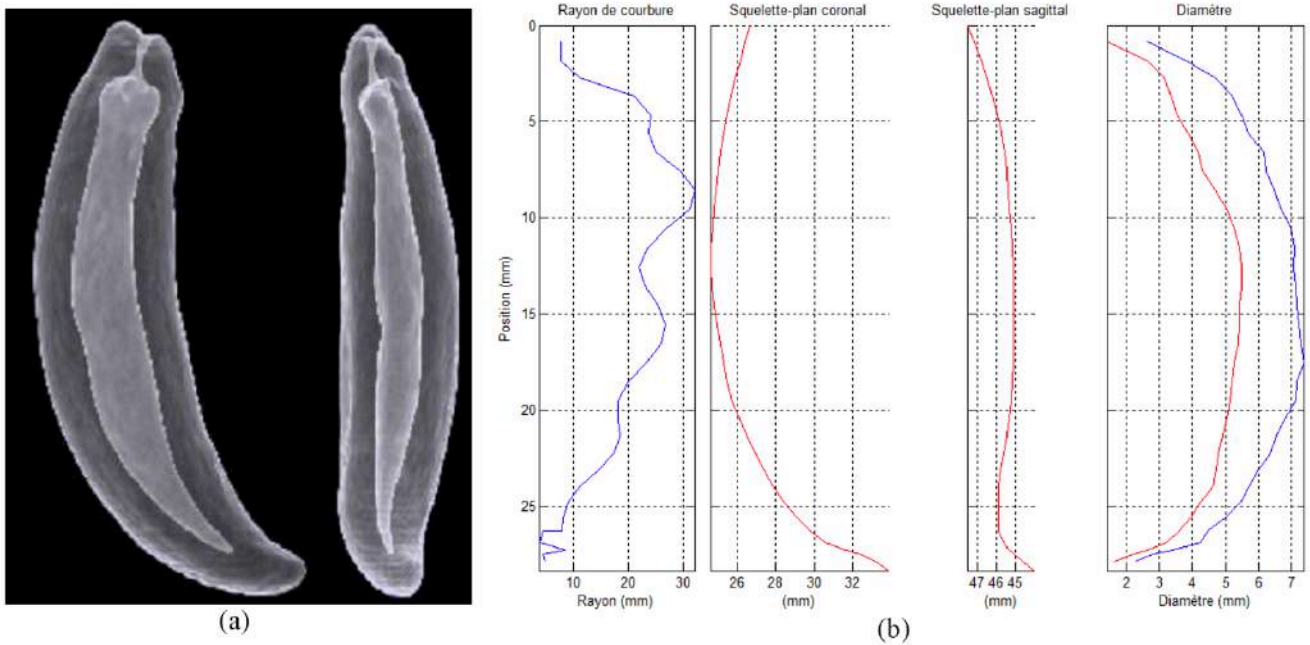


Figure 1: (a) Coronal and sagittal MPR rendering of the tooth #25. The cavity is clearly visible. (b) Curvature profile, skeleton coronal and sagittal views and Ferret diameter (minimum and maximum) profile are shown.

The ability to automatically and quickly analyse a large number of similar archaeological samples (different materials) is a great advantage. It provides researchers a tool for performing robust statistics about their archaeological specimens and new type of information that was not accessible before.

Thank you for your attention.

Questions?

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