

# Setup and first testing of Laser Ablation - ICP-MS measurements for high resolution chemical ice core analyses at University of Cambridge

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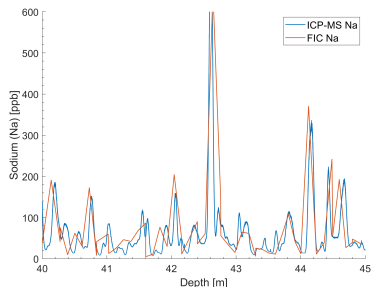
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# Laser-Ablation-ICP-MS in ice cores - why?

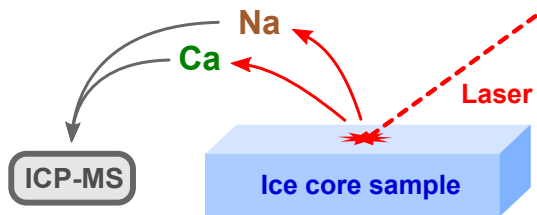
- ▶ Chemical analyses of ice cores are the key to answer many questions about past climate
- ▶ **But:** common methods (e.g. continuous flow analysis, CFA) are **limited in depth resolution to  $\approx 1$  cm**
- ▶ Not sufficient for:
  - ▶ deep, old ice with highly compressed and thinned layers
  - ▶ microstructures, microfolding, location of impurities in the ice matrix



Example sodium datasets of the new Skytrain ice core (see slide 8). Data from CFA ICP-MS and Fast Ion Chromatography (FIC) are shown in comparison. The CFA ICP-MS data are higher resolution than the FIC data, but it is still not possible to resolve the smallest variations with these data, mainly due to mixing in the water lines



# Laser Ablation - Inductively coupled plasma mass spectrometry (ICP-MS)

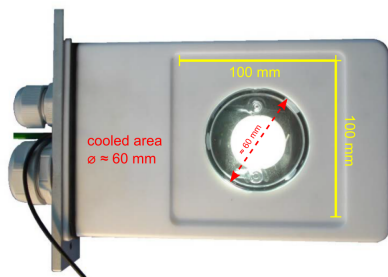


- ▶ Ice surface ablated by high intensity laser, derived material directly purged into an ICP-MS system for analysis
- ▶ Very high **depth resolution down to  $\approx 100 \mu\text{m}$**  or maybe less
- ▶ Virtually non - destructive method, almost all sample material preserved, only very little consumed



# The Cambridge LA-ICP-MS system

- ▶ ICP-MS:  
Perkin Elmer Nexion 350D
- ▶ Laser Ablation System:  
ESI NWR 193UC
- ▶ so far mainly used for  
geological samples
- ▶ equipped with a cryocell,  
designed to hold samples in  
the geometry of a  
microscope slide
- ▶ temperature controlled  
between  $-80^{\circ}\text{C}$  and  $-20^{\circ}\text{C}$  by  
use of liquid Nitrogen



Cold stage of the Cambridge Laser Ablation system (© ESI). It is designed to hold samples of ca. 2 mm thickness at maximum

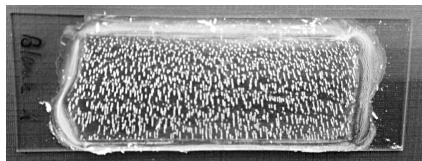
**Main target elements:  
Na, Ca, Mg, Al, Fe**



# First steps towards ice measurements

## Sample preparation:

- ▶ ice strips are cut to ca. 20 x 50 mm with a band saw
- ▶ cut strips are glued to a standard microscope slide
- ▶ glued strips are then shaved down using a microtome to an ice thickness of ca. 1 mm to remove contamination and create a smooth surface
- ▶ samples are finally introduced to the cryocell under a dry  $N_2$  atmosphere to prevent frosting of the surface

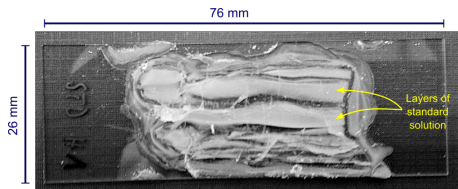


A test sample of ultrapure water, glued to a microscope slide and microtomed to a thickness of 1 mm

# First steps towards ice measurements

## Ice standard preparation:

- ▶ ice samples of known element concentrations are needed to calibrate the Laser Ablation system with a comparable matrix material
- ▶ producing homogenous frozen standards remains a challenge because impurities are being moved by a slow moving freezing front
- ▶ First test: flash freezing of liquid cation standard solution (also used for CFA) in a custom built mould in Liquid Nitrogen



A first test sample of shock-frosted and microtomed layers of standard solution. The concentrations of the different ions are expected to be rather homogenous along the layers.

# The project - WACSWAIN

## WACSWAIN: WArm Climate Stability of the West Antarctic Ice sheet in the last INterglacial

- ▶ The response (including a potential loss) of the West Antarctic ice sheet (WAIS) to a climate slightly warmer than today remains unclear so far
- ▶ The basal section of an ice core from a location where the ice likely survived the last interglacial (LIG) conditions can help to answer these questions



Location of Skytrain ice rise in West Antarctica



## The Skytrain ice core

- ▶ Skytrain ice rise is a small dome close to Ronne ice shelf - a loss of the shelf during LIG will leave a significant imprint in the proxy data stored in the basal ice
- ▶ **Core drilled to bedrock** in field season 2018 / 2019
- ▶ Ice core of **total length 651 m** recovered and shipped to Cambridge



Picture of the drilling camp at Skytrain ice rise in spring 2019  
(© Eric Wolff)

400 m of ice core have been analysed with CFA so far (to be continued)  
the deepest section (LIG ice) will be the main target  
for LA-ICP-MS measurements





# Next steps - open questions

## Methodological

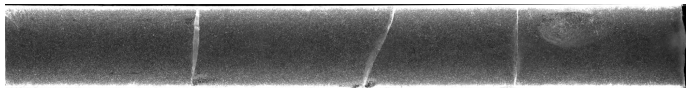
- ▶ Perform first test LA ICP-MS measurements to optimize spot size, scanning speed and laser fluence
- ▶ Is the process of sample preparation and decontamination sufficient? Test by use of artificial blank ice samples
- ▶ Test sensitivity and resolution of the measurement by analysis of:
  - ▶ ice standards of known concentration
  - ▶ shallow sections of Skytrain ice clearly showing annual signals in the CFA data
- ▶ Test process of standard making: is flash freezing of solution the best method or are there others? (e.g. nebulizing)?



# Next steps - open questions

## Scientific

- ▶ Analyse selected deep sections of the Skytrain ice core to:
  - ▶ decipher potential annual layers that can not be resolved by the CFA measurements
  - ▶ investigate sections of rapid changes in climate proxy signals to help answering palaeoclimatic questions
- ▶ Investigate small scale variations in the ice core (e.g. location of impurities, horizontal variability etc.)



Linescan image of the deepest core piece of the Skytrain ice core (© BAS)



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