

Laser Ablation – Isotope Ratio Mass Spectrometry Imaging: A New Axis in MS-I

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Isotope Ratio Mass Spectrometry (IRMS) is an often-overlooked technique within analytical science. LASER Ablation (LA) coupled with IRMS (LA-IRMS) is a rapidly growing field enabling high spatial resolution sampling across 2D samples. Spatial isotopic data from both natural abundance variation mechanisms (tree rings, bone and geological structures) and artificial abundance variations (targeted tracer studies on live systems) can now be routinely analyzed using the Sercon CryoFlex system coupled with Teledyne's LSX-213G2+ LASER system and the Terra Analytic isoScell. Here, a sample set of LA-IRMS techniques and applications are showcased, including: the analysis of tree rings to reconstruct past climate data, the combination ICP-MS and LA-IRMS imaging to analyze animal keratin and bone from mammals, the ability to analyze isotope ratio differences between pollen, honey and wax enabling better adulteration testing and geolocation, and the analysis of different laminates in plywood to establish provenance.

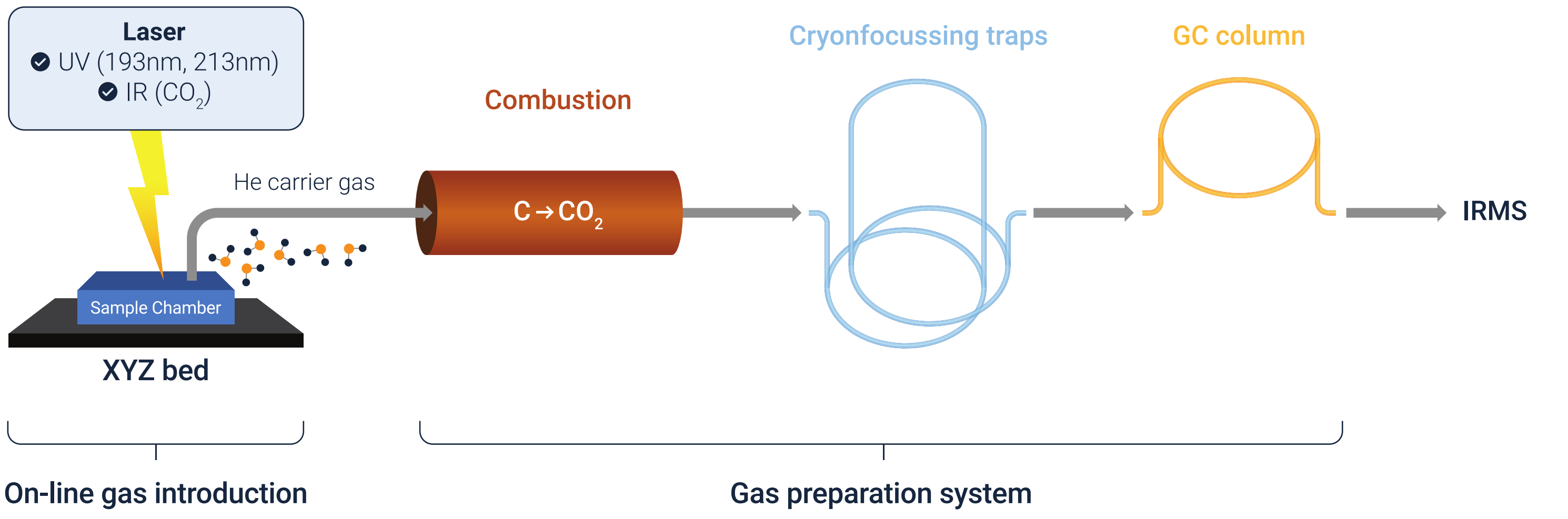
Key Benefits

- Reduced sample preparation (labour, time, consumables)
- No individual preparation necessary for split/subsamples
- Unparalleled spatial resolution
- Repeat analysis
- In situ analysis
- Minimally invasive
- Can handle both solid and liquid samples
- Proven performance in comparison with current techniques

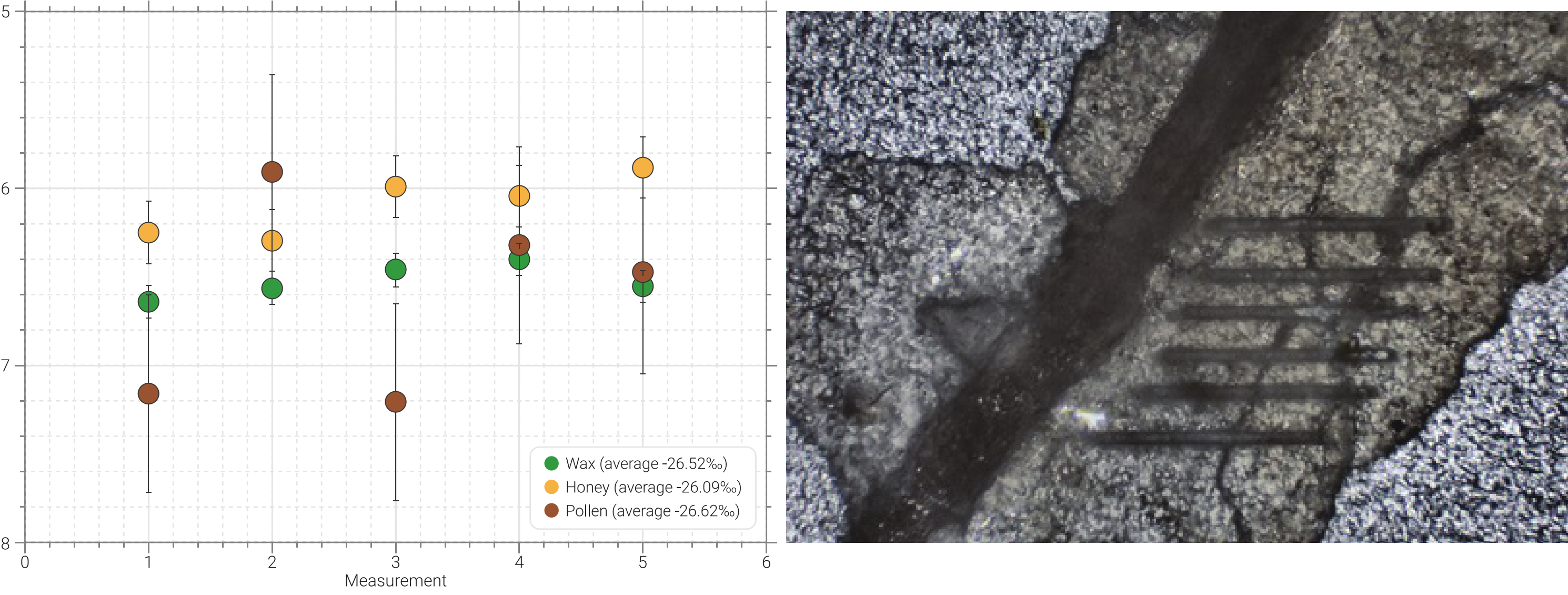
Process

- Laser light typically 193, 213 or 266nm is directed and focused onto sample target area.
- Light is pulsed with energy range μJ to mJ at repetition rates of 1-1kHz. Pulse duration is typically nanosecond (pico/femtosecond are available)
- Sample material absorbs photons leading to rapid localized heating. (UV couples with wide range of materials)
- With sufficient energy density, melting and vaporization begins releasing aerosol particles from the surface.
- Repeated pulsing at a spot creates a crater, typically 1-2 μm depth per pulse.
- Crater profile is dependent on, Laser Energy, Spot Size, Repetition rate Sample Matrix

Matrix	Verified Results	Confirmed Against Traditional EA Analysis on Same Sample	LASER Types Tested
Wood	Yes	Yes	UV 193nm, UV 213nm
Bone Collagen	Yes	Yes	UV 193nm, UV 213nm
Human Tooth	Testing Ongoing		UV 193nm, UV 213nm IR CO2 10.6 μm
Human Bone	Testing Ongoing		UV 193nm, UV 213nm IR CO2 10.6 μm
Sugar	Yes	Yes	UV 193nm, UV 213nm
Vegetable Oil	Yes		UV 193nm, UV 213nm
Human and Animal Hair	Yes		UV 193nm, UV 213nm
Human Fingernail	Yes		UV 193nm, UV 213nm
Animal Horn	Yes		UV 193nm, UV 213nm
Whole Human and Animal Blood	Yes		UV 193nm, UV 213nm
Pollen	Yes	Yes	UV 193nm, UV 213nm
Bees Wax	Yes		UV 193nm, UV 213nm
Honey	Yes		UV 193nm, UV 213nm
Airborne Particulate Matter	Yes	Yes	UV 193nm, UV 213nm

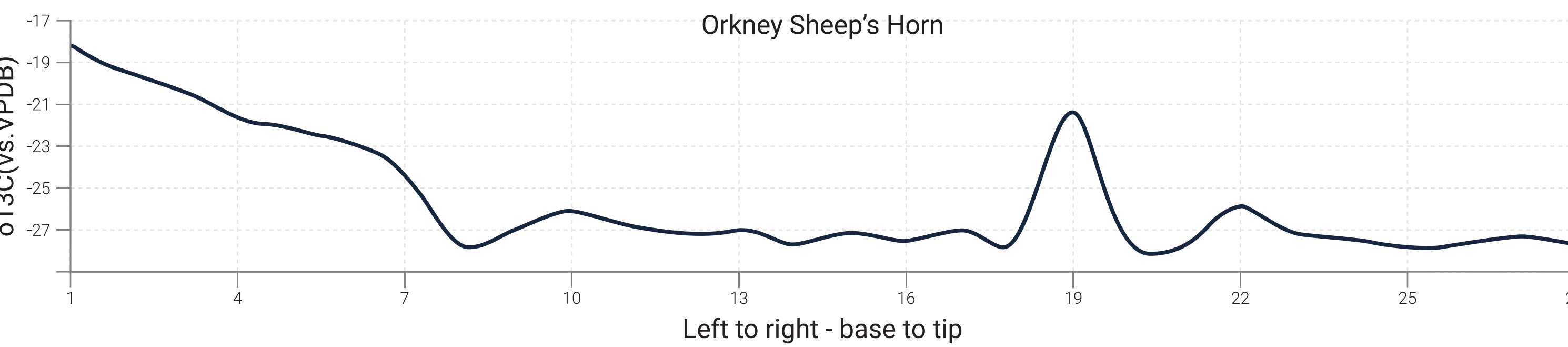
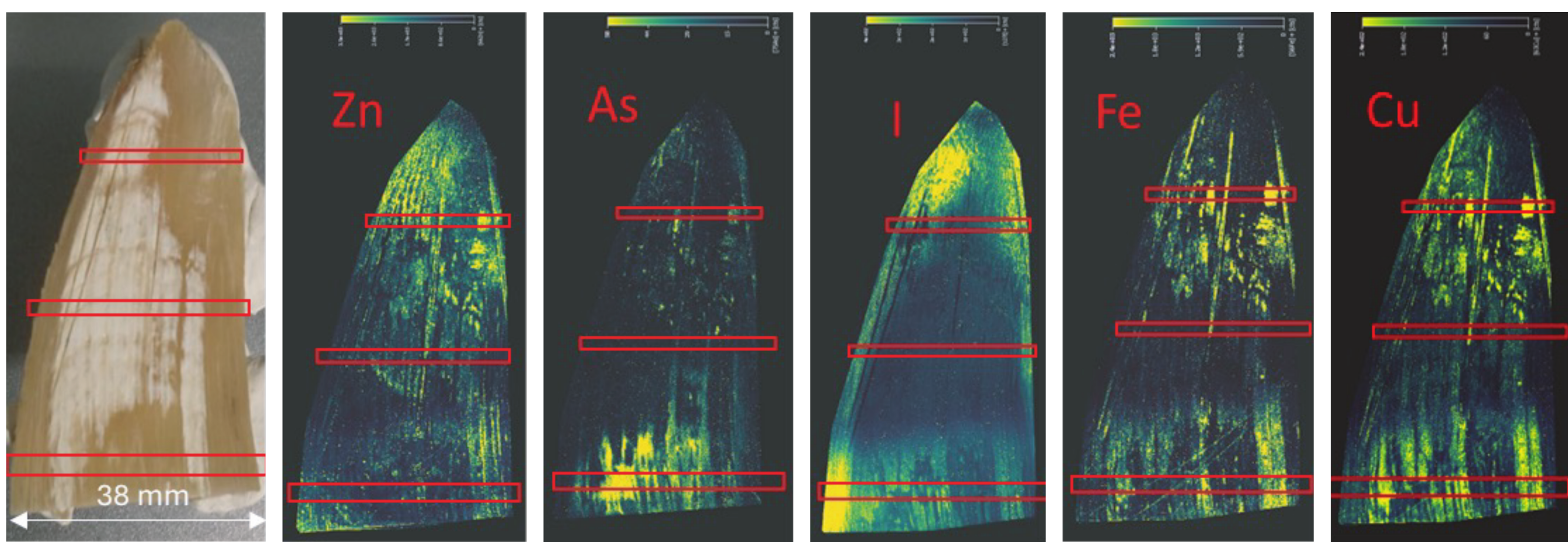


Analysis of Wax, Honey and Pollen Individually In The Same Honey Sample

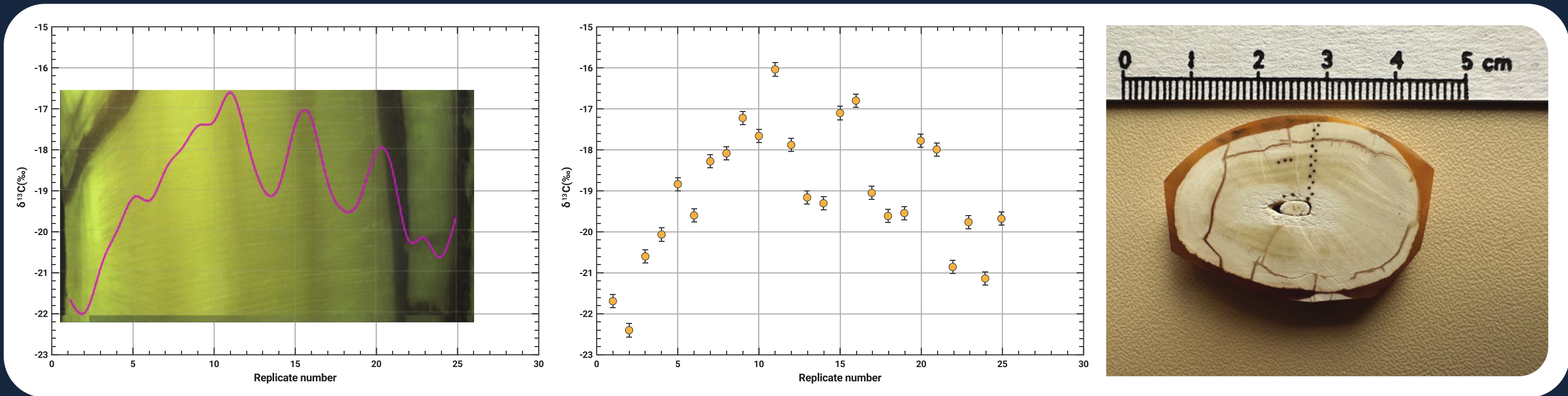


Measurement	Wax	Honey	Pollen	Pollen EA
1	-26.64	-26.25	-27.16	-26.487
2	-26.56	-26.29	-25.91	-25.667
3	-26.46	-25.99	-27.21	-27.558
4	-26.4	-26.04	-26.32	-26.570
5	-26.55	-25.88	-26.49	-27.075
STDEV	0.09	0.17	0.56	0.496

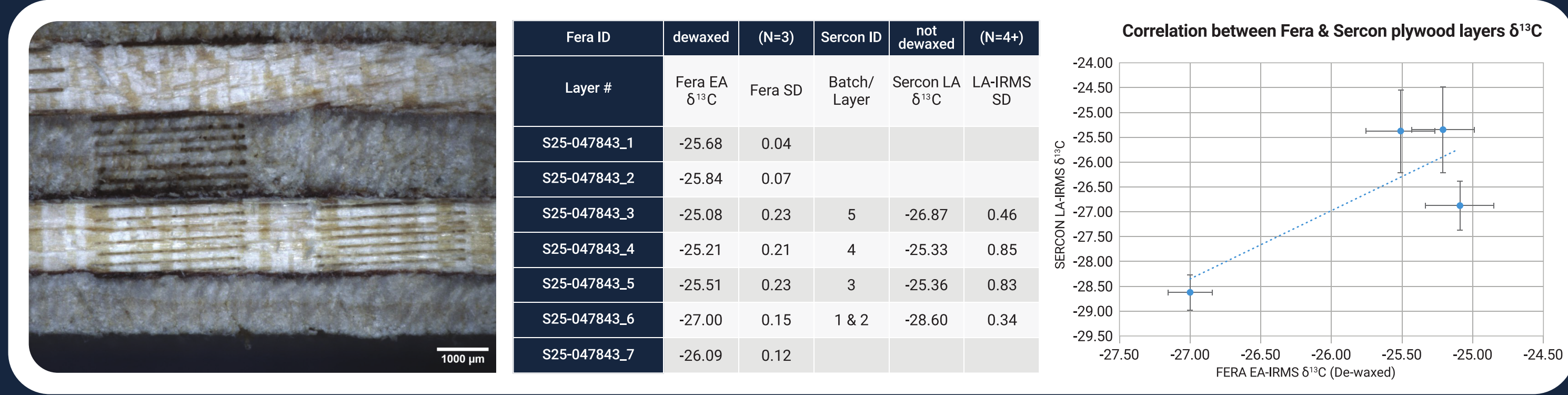
Coupling with ICP-MS: Analysis of Growth Structures in Orkney Sheep Horn



Dentine in Cave Bear Teeth



Determination of Adulterated Conflict Timber Without Manual Extraction and De-Waxing



Where Next:

- Work Already Completed to Add $\delta^{18}\text{O}$ to The LA IRMS Method (see Published Data).
- Works Underway to Add $\delta^{15}\text{N}$ to The LA IRMS Method.
- Stable Sulphur Isotope Species
- Carbonate Analysis
- Food Forensics
- Ecology
- Multi Isotope Measurements
- Stable Isotope Tracer Studies

Published Data:

- Preservation of $\delta^{13}\text{C}$ signatures in oak charred wood: Application to the “forest” of Notre-Dame de Paris – Journal of Archaeological Science: Reports, Feb 2025
- Drivers of intra-seasonal $\delta^{13}\text{C}$ signal in tree-rings of pinus sylvestris as indicated by compound-specific and laser ablation isotope analysis – Plant, Cell & Environment, June 2023
- Analysis of 180/160 Isotope Ratios in Organic Matter by Laser Ablation IRMS – Analytical Chemistry, March 2025