Preliminary study on the use of δ¹⁸O as a climate proxy for charred oak wood

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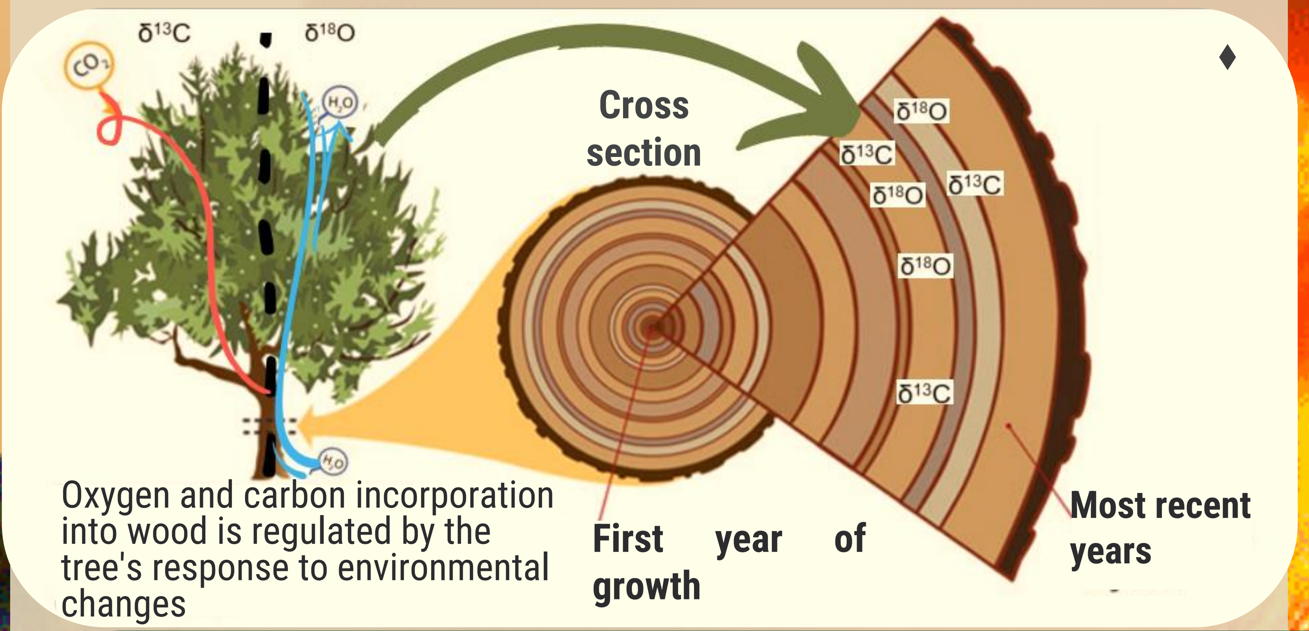
1 Context

The fire of the frame of **Notre-Dame de Paris Cathedral** in 2019 left charred timbers from trees that grew during the **Medieval Climate Anomaly ~ 900-1350 AD.**

There are no **climate reconstructions** for northern France during this period (+ lack of resolution and ill-defined chronological boundaries in Europe)

δ¹³C and **δ¹⁸O** in wood → past climate studies



Aim: Study the impact of carbonization on the δ¹⁸O and the associated physiochemical processes in order to investigate the applicability of isotopic paleoclimatology to charcoal

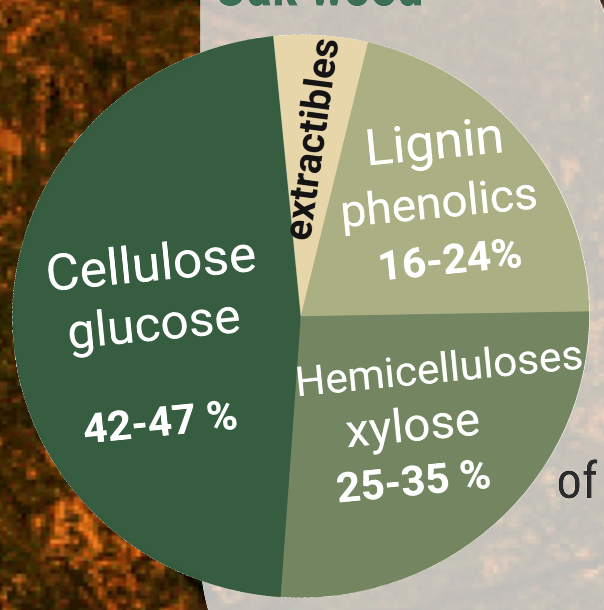
2 Materials & Methods

Experimental carbonization of **oak** (crushed and homogenized) in a **pyrolysis** furnace under N_2

→ **200 to 1000°C → 1h**

→ 3 replicates = **36 samples**

Oak wood

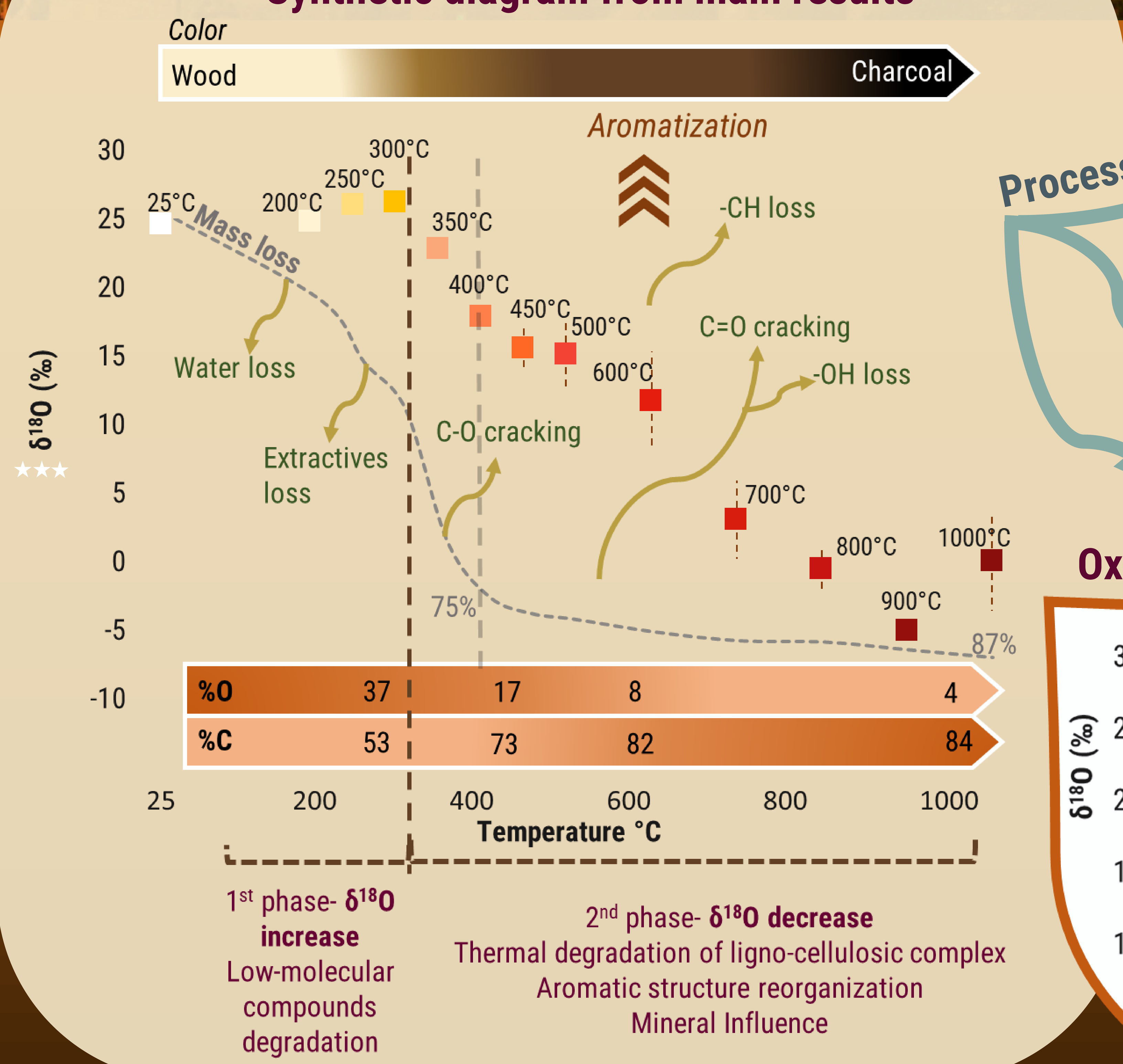


Methods

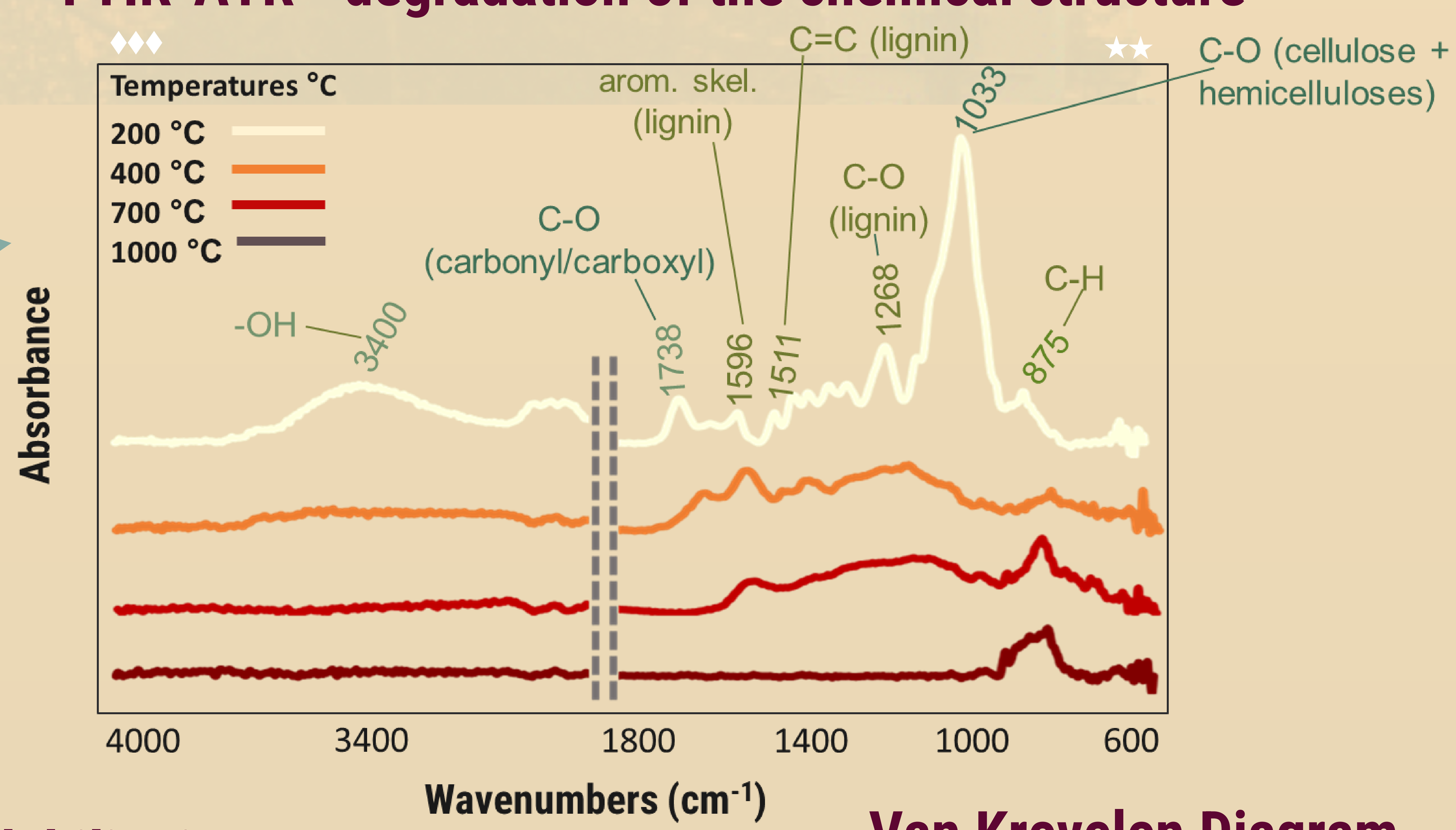
- Measurement **δ¹⁸O → TC/EA-IRMS**
- **%C,O,H → OEA**
- Physico-chemical structure of charcoals → Spectroscopy **Raman**, Infrarouge (**FTIR-ATR**)★
- **% low-molecular hydrocarbons → Rock-Eval®** thermal analysis

3 Main Results

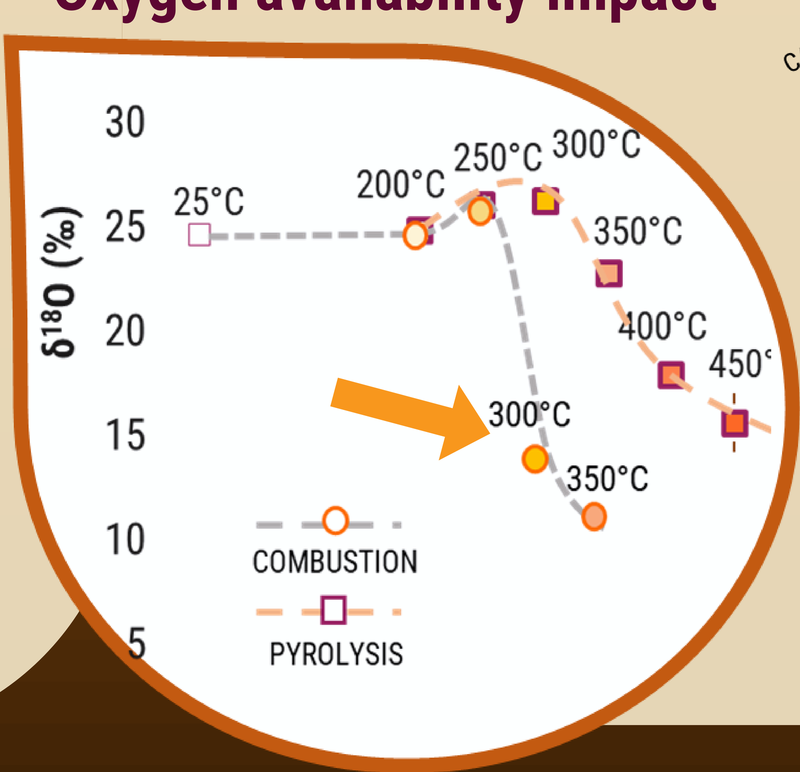
Synthetic diagram from main results



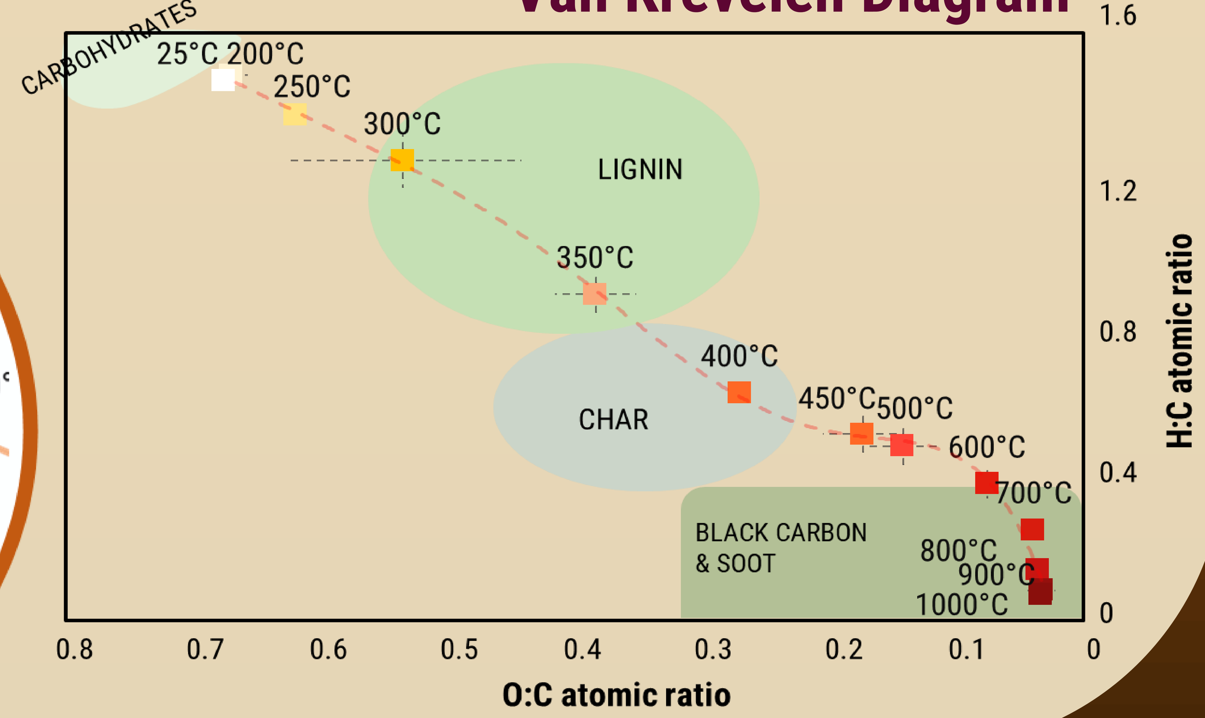
★ FTIR-ATR - degradation of the chemical structure



Oxygen availability impact



Van Krevelen Diagram



4 Conclusion & Outlook

- **2 notable phases** in oxygen isotopic composition under T°C influence (T°C≤300°C [δ18O ≤1.5 ‰]; T°C≤1000°C [δ18O ≤30 ‰]) due mainly **to conversion of functional groups, thermo-degradation of organic matter and concomitant with aromatization of compounds**

  ¹⁸O depletion in oak wood as a function of temperature (What does it imply for the interpretation of δ¹⁸O in geologic OM ?)

- Need to investigate possible **kinetic fractionation processes** (gas emissions), isotopic exchange (CO_2, H_2O) and the contributions of the different components during carbonization (mineral part such as carbonates; the ash part)

  Large variations of δ¹⁸O observed in charred wood. **Is it possible to correct them and use δ¹⁸O as a climate proxy?**

Abstract

ANR CASIMODO (2021-2024)
Optimum ClimAtique médiéval et développements SocIo-éconoMiques : étude de la charpente de NOtre-Dame de Paris et implications pour les fOrêts

Bibliography / sources
♦ Modified from a diagram by C. Corona
♦♦ Modified from a photo by E. Rocha
♦♦♦ Band assignment from Ishimaru et al. Journal of Materials Science 42, 122-129 (2007)

Notes
★ Fourier transform infrared spectroscopy in attenuated total reflectance mode
★★ Subtracted baseline and maximum peak normalized spectra
★★★ $\delta^{18}O=[(^{18}O/^{16}O_{samp.})/(^{18}O/^{16}O_{standard})-1]*1000$

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