



Geochemistry and  
Paleoclimate  
Research Group

# Speleothems and inclusion fluids: isotope and trace element variation reflecting climate conditions in Hungary



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## 1 Introduction

In the past decade an increasing number of cave-related paleoclimate studies have been published that used mostly stalagmites as excellent continental climate records. Well studied speleothem occurrences from **Central Europe are scarce and are practically absent in Hungary**. Paleoclimate projects have been started by the **Paleoclimate and Geochemistry Research Group** formed in the Hungarian Academy of Science, in order to study the behaviour of this region to climate change.

The central question was to determine the environment-related geochemical factors which may be preserved in stalagmites. Here we present dated high-resolution multi-proxy records (**stable C and O isotope** as well as **trace element** compositions) and the first measurements of **inclusion water** from Holocene and ancient speleothems from Hungary. Extraction of inclusion fluids using continuous flow IRMS technique was developed to provide information on the isotopic composition of paleoprecipitation.

## 2 Applied analytical technics

C and O isotope compositions: Finnigan MAT Delta S and delta plus XP mass spectrometers (IGCR HAS).

Trace elements: LA-IPC-MS (Univ. Lausanne).

U-Th dates: MC-ICP-MS and alpha counting methods (Univ. Bern and Univ. Bergen).

Inclusion fluids: off-line thermal decrepitation (500 C, 30min) as well as vacuum crushing (SS tubes), followed by reaction with Indiana zinc and on-line tube-cracking using Gasbench II (IGCR HAS).

## 3 Baradla-cave (Aggtelek Karst, Hungary) Termination II.

The study of stalagmites from **Baradla-Cave** spanning the period of **Termination II** provides excellent control on the reflection of major climate change in geochemical records.

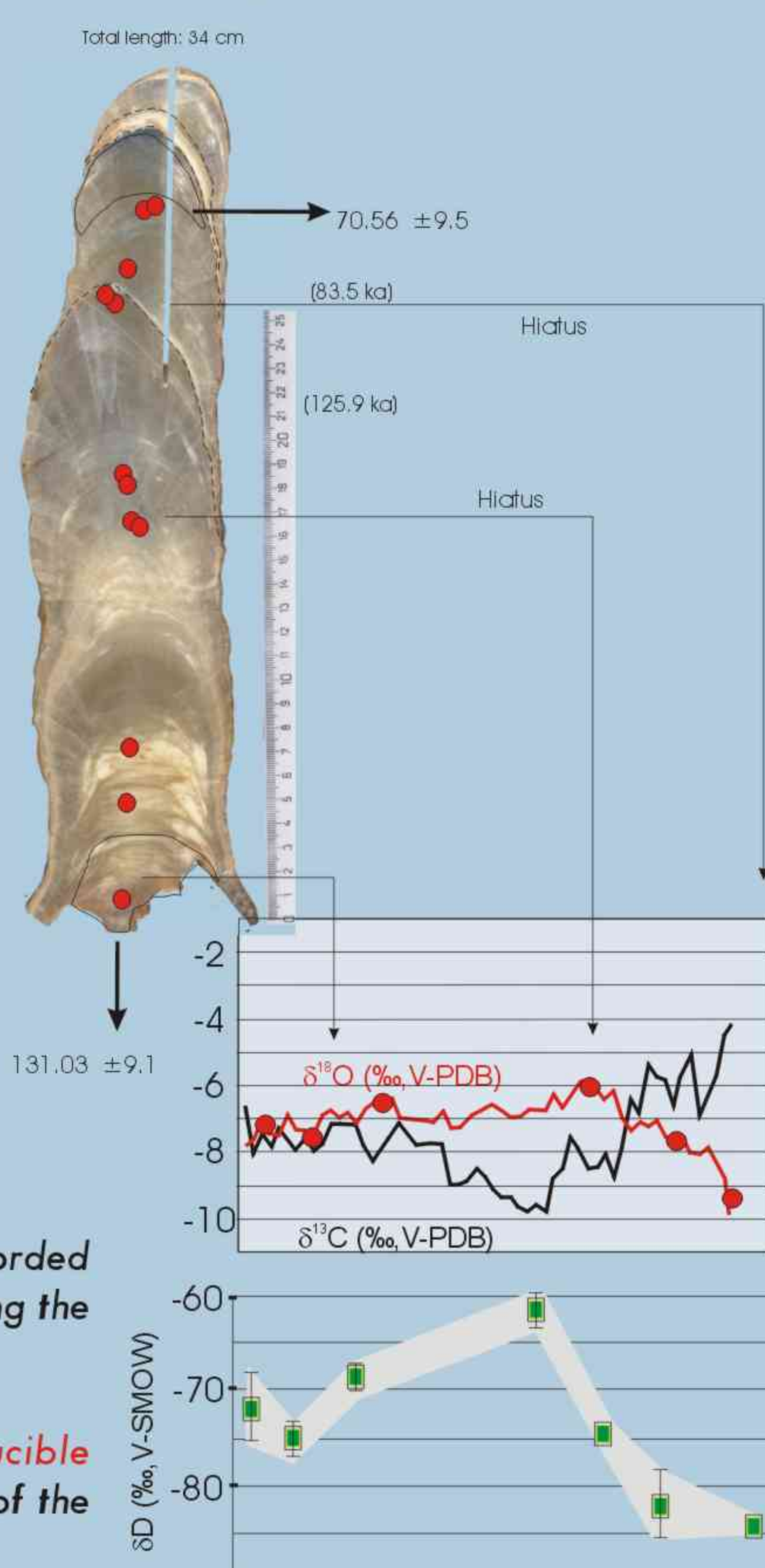
Sample dating revealed Termination II. Oxygen isotope data show the beginning of the **warming period**. This may have also affected the vegetation-soil system as shown by the carbon isotope values: the more negative the  $\delta^{13}\text{C}$  values, the more enhanced the **biogenic effects**.

As the C and O isotope compositions seemed to reflect climate change processes perfectly, a stalagmite was selected for  $\delta\text{D}$  measurements on inclusion water.

The applied method allowed us to follow the oxygen isotope shift representing the gradual warming and subsequent cooling period. The **remarkable cooling period** appears at the section caused approx. **4‰ shift in the oxygen and 30‰ shift in the hydrogen isotope values** of the speleothem.

According to these results

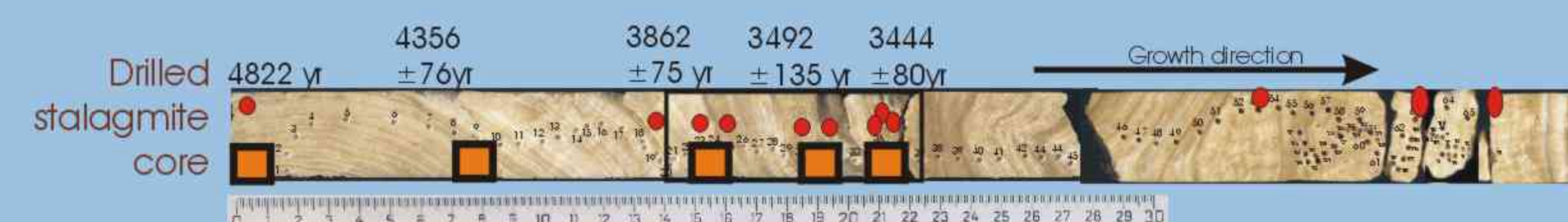
- 1.) The site selected for the study has recorded **significant oxygen and carbon isotope shift** during the Termination II.
- 2.) The developed method with **reproducible extractions** is appropriate for the investigation of the paleoclimate changes.



## 4 Trió-cave (Mecsek-Mts., Hungary) Middle Bronze Age record

We present a high resolution stable isotope and trace element record of a stalagmite from Trió Cave, Hungary.

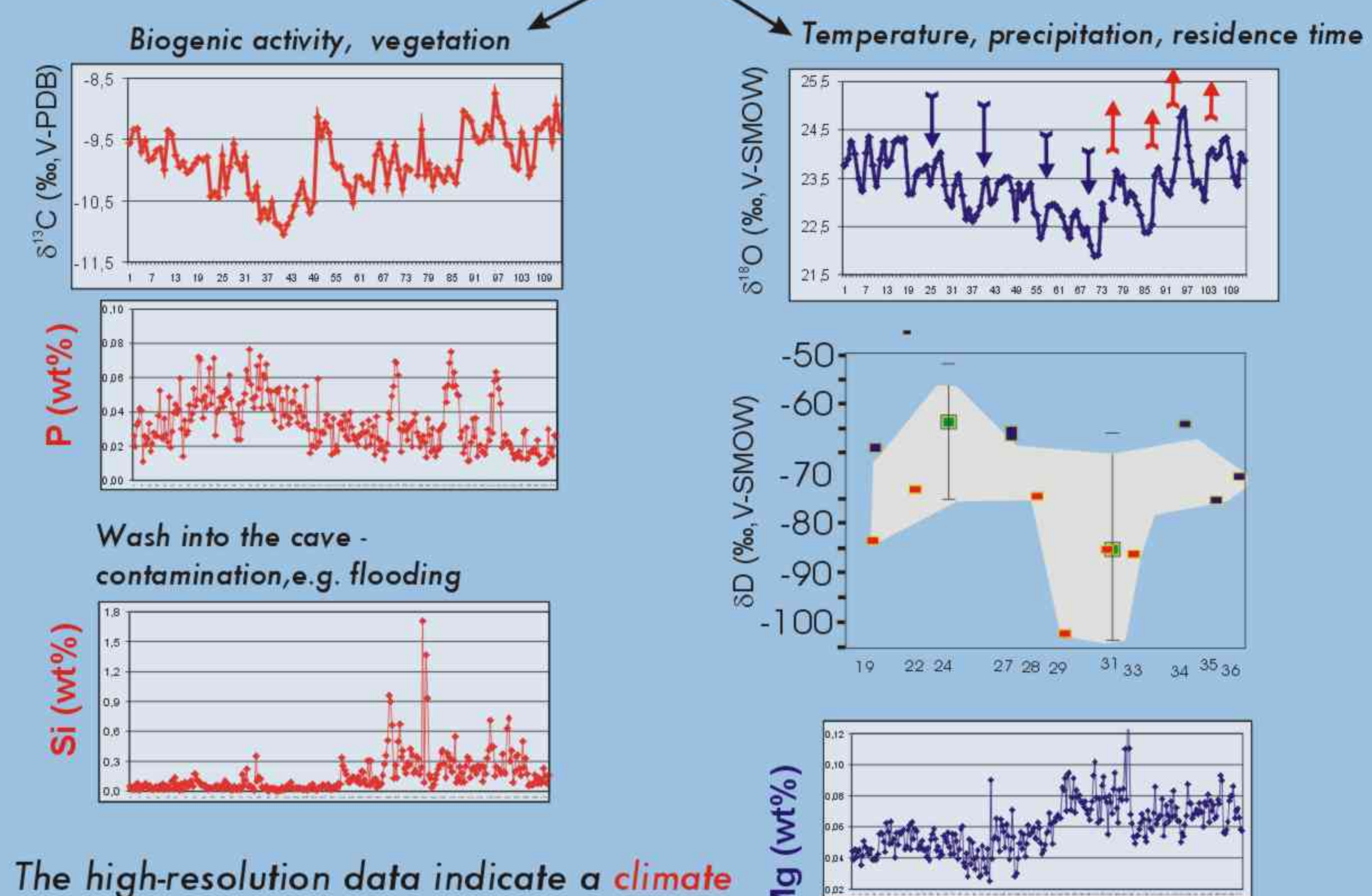
U-Th dates from the Trió Cave provide precise chronological constrains on climate and environmental changes in the Southern part of Hungary during the late Holocene. The section - still active - grew from 4800yr to present.



### Stable isotope record by conventional IRMS

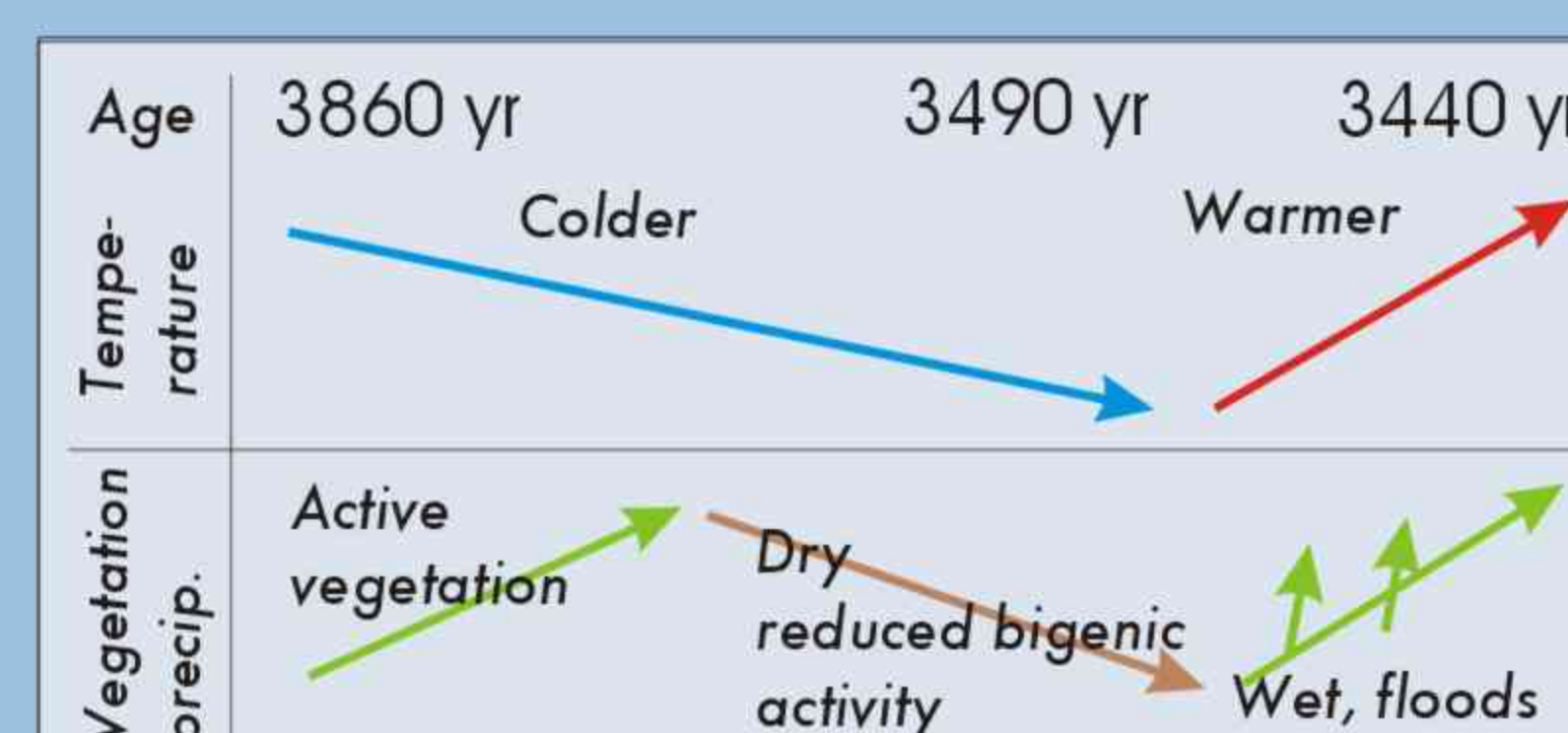


Selected section for the detailed study

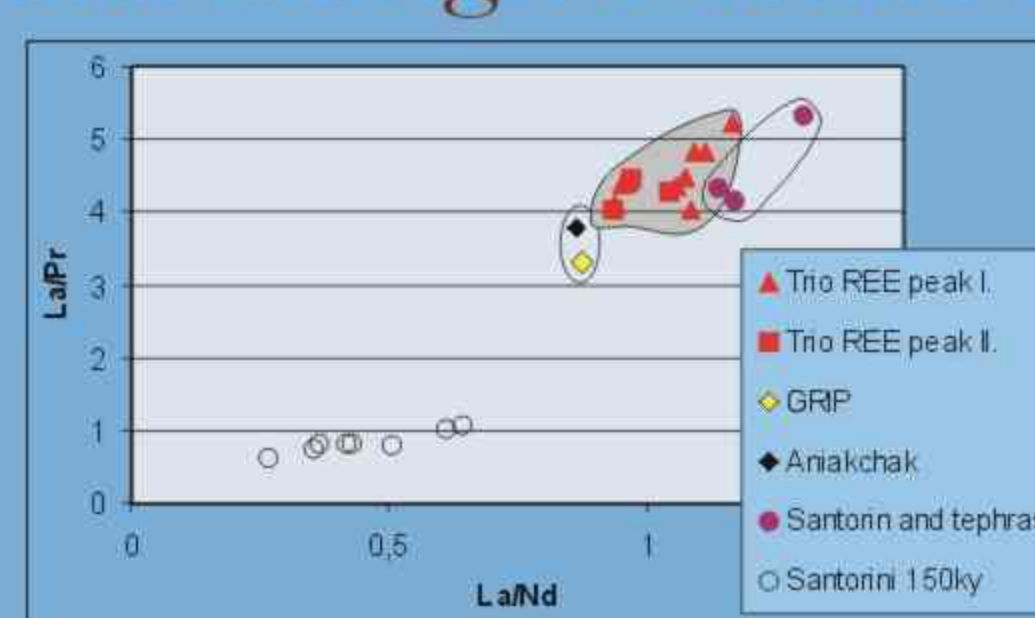
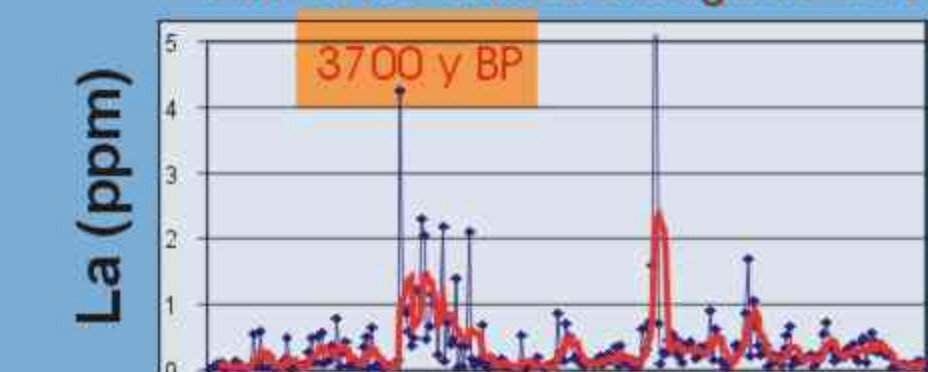
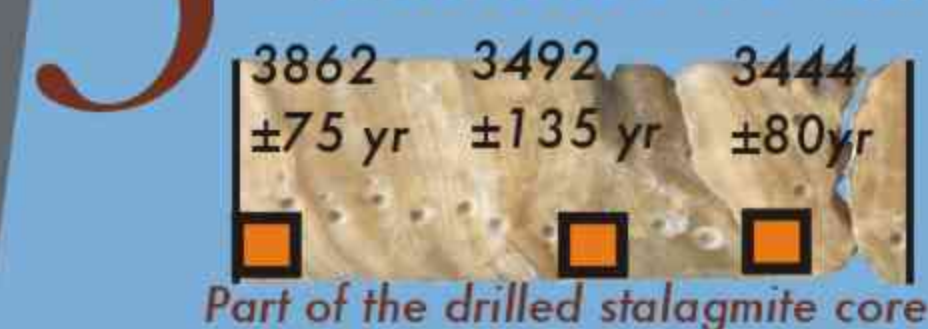


The high-resolution data indicate a **climate change event between 3800 to 3400 year**. The stable isotope record together with trace element variations provided a powerful proxy for changes in climate conditions and suggest a **major cooling and subsequent warming event at around 3500 yr** coupled with a drop in precipitation amount followed by wetter conditions.

An approx. -20‰ negative  $\delta\text{D}$  shift was observed at the  $\delta^{18}\text{O}$  minimum, supporting cooling-related isotopic change in the meteoric water ~3800-3500 years ago.

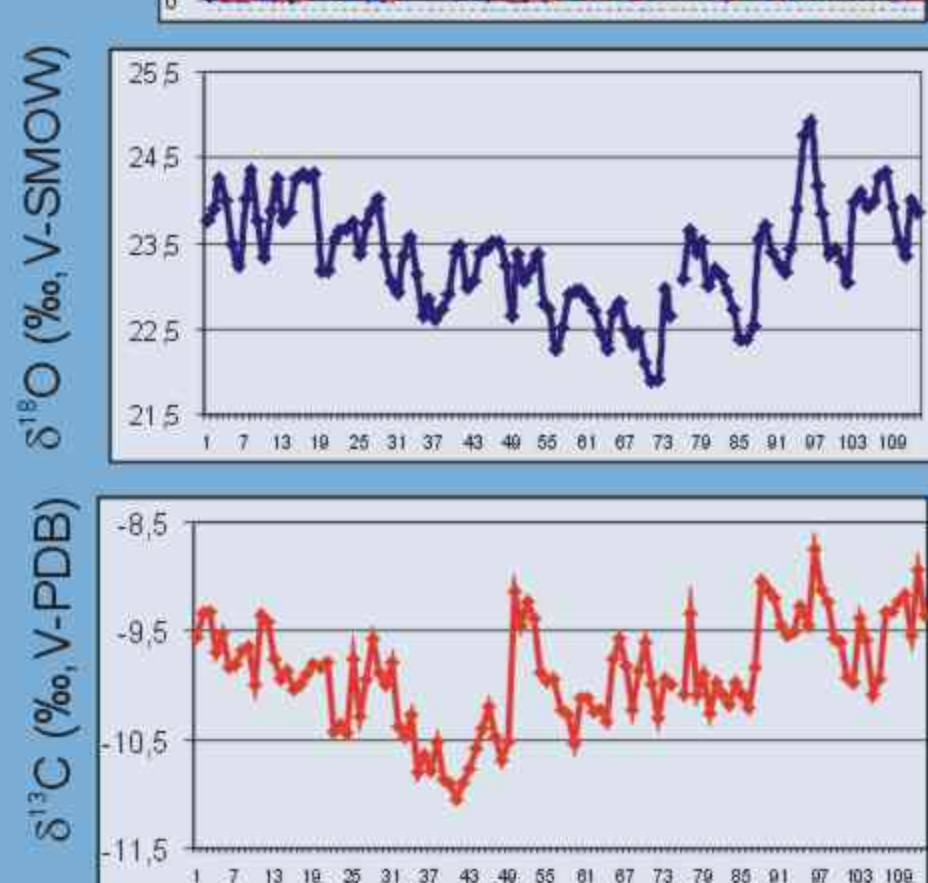


## 5 Middle bronze age climate change: volcanic activity



The rare earth element composition imply **volcanic derived impurities directly preceding the cooling event**. The figure presented here show the La/Pr vs. La/Nd ratios of a tephra layer from the GRIP ice core (~3650 yrs ago) and volcanic rocks of **Santorin and Aniakchak of the same age**. A 150ky eruption at Santorin can be clearly distinguished from the young event indicating the usefulness of the REE record.

The volcanic activity seems to be represented in the Trió stalagmite section and may have been **responsible for the short period cooling event**.



## 6 Conclusion

Coupled stable isotope and trace element studies have been conducted on **Pleistocene and late Holocene** (Middle Bronze Age) speleothems as a part of a complex investigation on the climate change effects in the Carpathian Basin.

The effects of changes in temperature, precipitation amount and vegetation activity are **demonstrated by co-variations of C and O isotope ratios** in the case of the ancient stalagmite (Termination II.). Measured **H isotope** data from extracted water inclusion followed the trend defined by the oxygen isotope shift, allowed us to use  $\delta\text{D}$  values as a tool for assuming the isotopic composition of **paleoprecipitations**.

These relationships were used to interpret a cooling-warming cycle with associated changes in precipitation amount of a Middle Bronze Age stalagmite. **Rare earth element compositions lead us to assume a volcanic derived dust** deposited and washed into the cave ~3700 years ago followed by a cooling trend.

"The farther backward  
you can look,  
the farther forward  
you are likely to see."

(Winston Churchill)

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