Abstract:
Stalagmites forming deep underground in limestone caves have great potential to reveal past climate changes. I collected stalagmite samples from Spring Valley Caverns in southeastern Minnesota for studying climatic changes. The study involved analyzing oxygen isotope composition of the stalagmites and measuring gas record of these isotope variations through time. The oxygen isotope composition is sensitive to the local climate, and hence shows significant changes and hence a time series of oxygen isotope changes essentially shows variation of temperature through time. To obtain precise timing of the Last Glacial Maximum (LGM) and the termination of the LGM, the stalagmites were dated with radioactively dating techniques using the elements uranium and thorium. The stalagmite material record extends back about 80,000 years (Fig. 4) and shows variation of temperature in southern Minnesota over time. Our study demonstrates that model predictions of climatic changes for the upcoming decades are in line with the global climate system. This last aspect is particularly important for studies that model future climate changes.

Cave Deposits in Minnesota Reveal Climate Changes over Last 8000 Years
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SECTION 1: BACKGROUND ON ISOTOPES, FORMATION OF STALAGMITE AND INCORPORATION OF CLIMATE SIGNAL INTO IT

We made use of Hydrogen (H) and Oxygen (O) stable
Oxygen can exist in water as 18O and 16O. The number refer to their masses) called isotopes of oxygen. Of these, 16O is heavier and 18O is lighter.

When rain forms from cloud the temperature of the cloud is higher than the temperature of the earth. The isotope 18O tends to be lighter and hence the rain formed at high temperature.

When rain water cools down the isotope 18O remains while 16O is lost. High degree of humidity causes the rain to be enriched in 18O.

How does a stalagmite form?
Rain water mixes with carbon dioxide in the soil to form carbonic acid and dissolves the limestone, which percolates through it. Rain water then carries the dissolved limestone to the cave below. In the cave the water carries the dissolved limestone, which solidifies on the roof of the cave (Fig. 3).

The temperature of the cave typically corresponds to the average annual temperature of the ground above the cave. During deposition of the stalagmite, the ambient temperature of the cave determines the amount of 18O and 16O that will go into the stalagmite.

We study the ratio of the two oxygen isotopes i.e., δ18O and δ16O and see how this ratio varies through time. If the mean annual temperature above the cave changes due to climatic change, the cave temperature will also change and hence the δ18O/δ16O ratio will also change.

In the next section we show how we study the isotopes in the stalagmites and obtain past climate information.

SECTION 2: LOCATION, SAMPLE PREPARATION AND ANALYTICAL METHODS

LOCATION:
Spring Valley caverns (41°44'24" N, 92°24'36" W) are located in Fillmore County in southeastern Minnesota.

The samples were collected from a narrow passage inside the cave (Fig. 6). The passage is located more than sixty feet below the ground.

The tall stalagmite is about 60 cm in length.

In our record we observe that Minnesota was in general warmer than today from about 8000 to 2500 years

Conclusions:
Stalagmites are capable of producing very high-resolution records of past climate changes as they can be dated very precisely.

The Spring Valley record is interpreted as a warming/cooling record and it shows how the climate evolved over the past 8000 years in southern Minnesota.

Comparison of Spring Valley record with North Atlantic Ocean record shows opposing climate pattern in the two regions.

This type of high-resolution climate record provides information about the earth’s climate at a time when data sets were not available. As this situation is similar to present day, these past high-resolution records can provide valuable insights for modeling future climate.