Reconstructing ancient interglacial environments in Mongolia's permafrost region

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Why?

- Mongolia has warmed by 2.4°C since 1960, making it one of the fastest-warming places in the world[1].
- During this time, Mongolia's permafrost area has shrunk by more than half– and the rest is expected to disappear by the end of this century[2].
- It's unclear what is driving the rapid heating in this region
- **To understand the present, we must look at the past** — but very few long-term reconstructions of Mongolia's climate currently exist[3]
- Reconstructing the environment during previous **interglacials** (the warm periods between ice ages) allows us to understand the driving forces behind environmental change

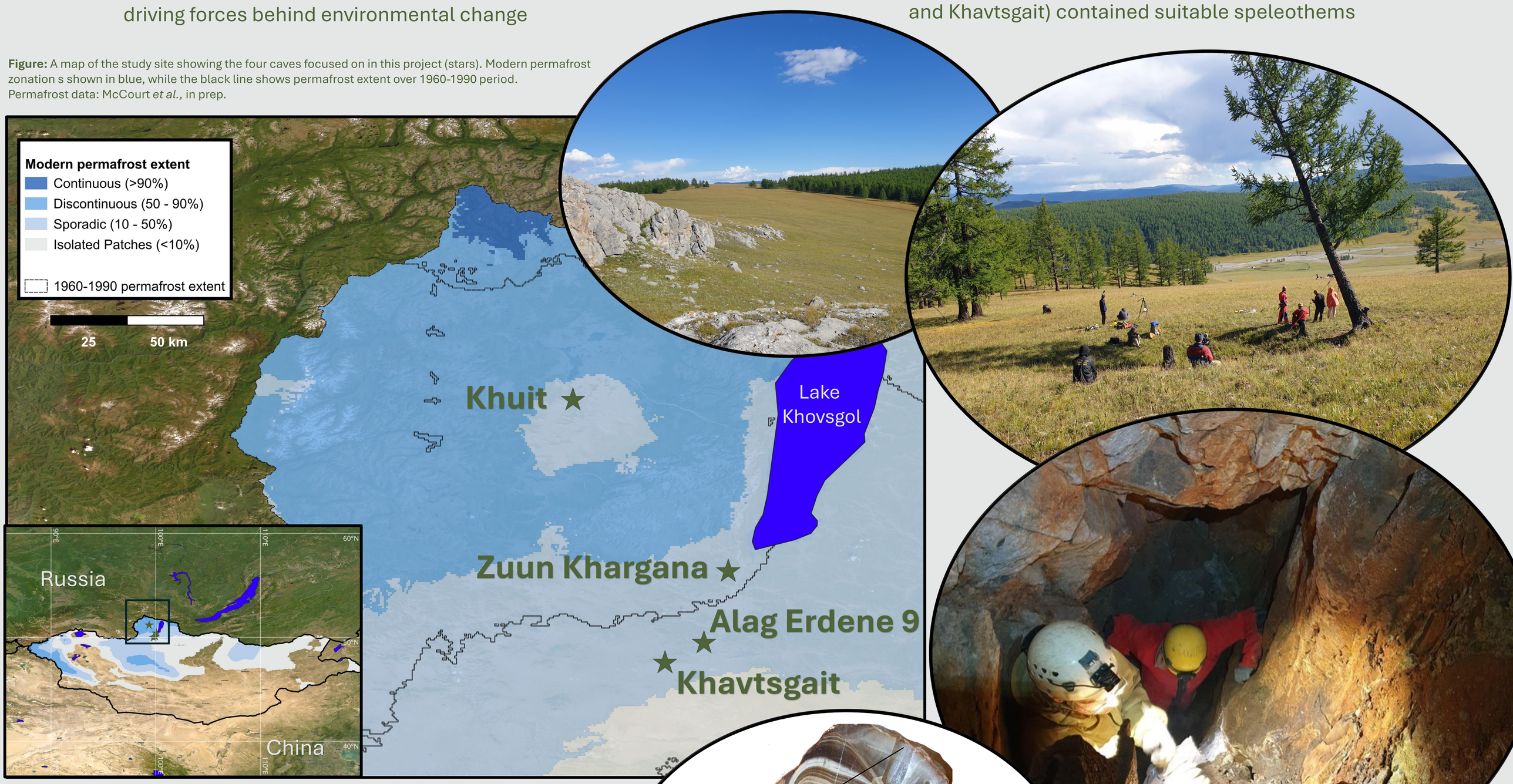
How?

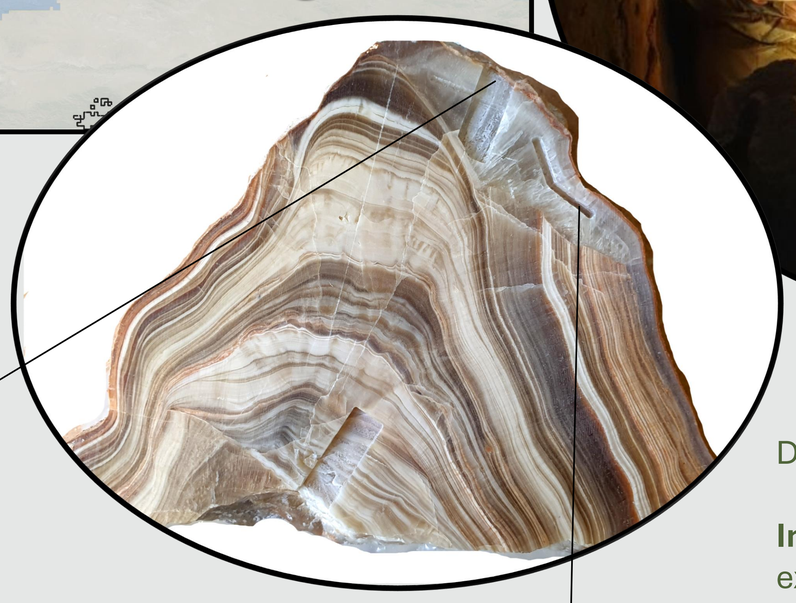
- **Speleothems** (e.g. stalagmites and flowstones) contain information about past climates in the form of **climate proxies**
- Using speleothems, we can reconstruct what the environment looked like when continuous permafrost was absent

Where?

- In August 2023, we conducted an expedition to the karst region southwest of **lake Khovsgol, northern Mongolia**
- Our aim: to locate caves with speleothems suitable for paleoenvironmental reconstruction
- Over two weeks, we surveyed a total of eleven caves
- Three of the caves we surveyed (Zuun Khargana, Alag Erdene 9 and Khavtsgait) contained suitable speleothems

Figure: A map of the study site showing the four caves focused on in this project (stars). Modern permafrost zonation s shown in blue, while the black line shows permafrost extent over 1960-1990 period. Permafrost data: McCourt *et al.*, in prep.

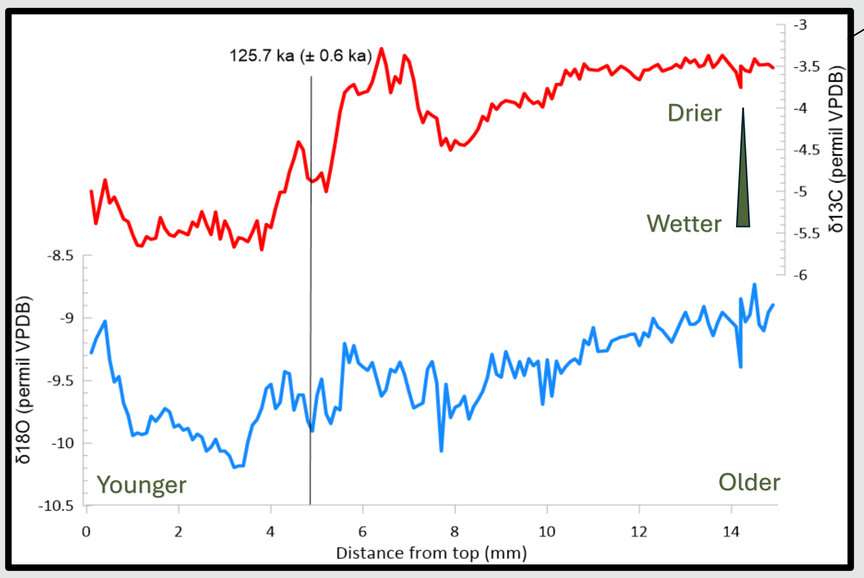




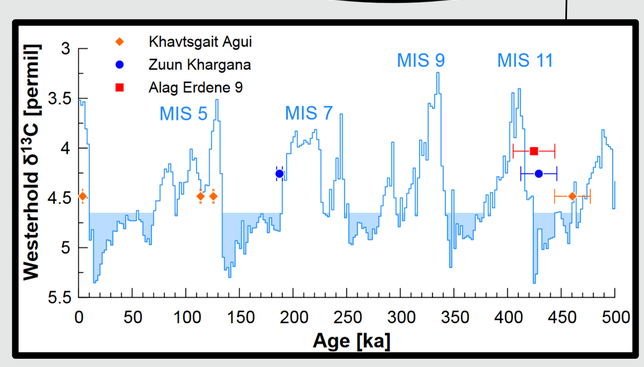
And then what?

We will use the speleothems collected in 2023 to reconstruct **permafrost presence**, **hydrological changes**, **temperature** and **vegetation** during interglacials over the past 500,000 years.

Here are some of our **preliminary results:**



- **Oxygen stable isotopes** can reflect hydrological changes, and carbon stable isotopes can reflect vegetation dynamics
- This graph shows stable isotopes from a stalagmite that grew during **MIS 5e (130,000 – 116,000 years ago)**.
- The $\delta^{13}C$ signature shifted to a more negative steady state at around 125,000 years ago.
- Soils beneath forests produce more negative $\delta^{13}C$ values than grasslands, so this could possibly represent a shift from a predominantly-steppe to a forest environment.



- Speleothems can't form when continuous permafrost is present over the cave, so speleothem growth intervals represent periods when permafrost was degraded or absent[4].
- Using **U-Th dating** to determine when speleothems grew, we can identify times where continuous permafrost was absent.
- Pilot dates reveal that our speleothems grew only during interglacial periods (MIS 1, 5, 7 and 11)– similar to speleothems from southern Siberia.

… And what next?

Data collection for this project is ongoing.

In June 2024, we will embark on a second expedition to northern Mongolia, with the following aims:

- To revisit our study sites to collect previously-installed monitoring equipment and install new equipment (e.g., drip loggers, pollen traps)
- To collect actively-growing speleothem samples
- To survey **Khuit cave** in the remote Darkhad basin region west of lake Khovsgol.
- To search for new caves with potential for paleoenvironmental research in the Darkhad basin

References

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