5500 YEARS OF FROZEN VEGETATION AND FIRE DYNAMICS IN THE MONGOLIAN ALTAI

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Introduction

The central position of the Altai Mountains between the vast Siberian Taiga forests and the Gobi desert in Central Asia results in a steep climatic and vegetation gradient with fragmented and diverse habitats including many rare and endemic species [1]. These mountain forest-steppe ecosystems are highly sensitive to global change [2]. In recent years, they experience rapid degradation through anthropogenic pressure (e.g. over-grazing, logging) combined with growing moisture deficiency [3]. We aim at significantly advance the understanding of wildfire and vegetation responses under past climate conditions to derive implications for ecosystem responses under future global change.
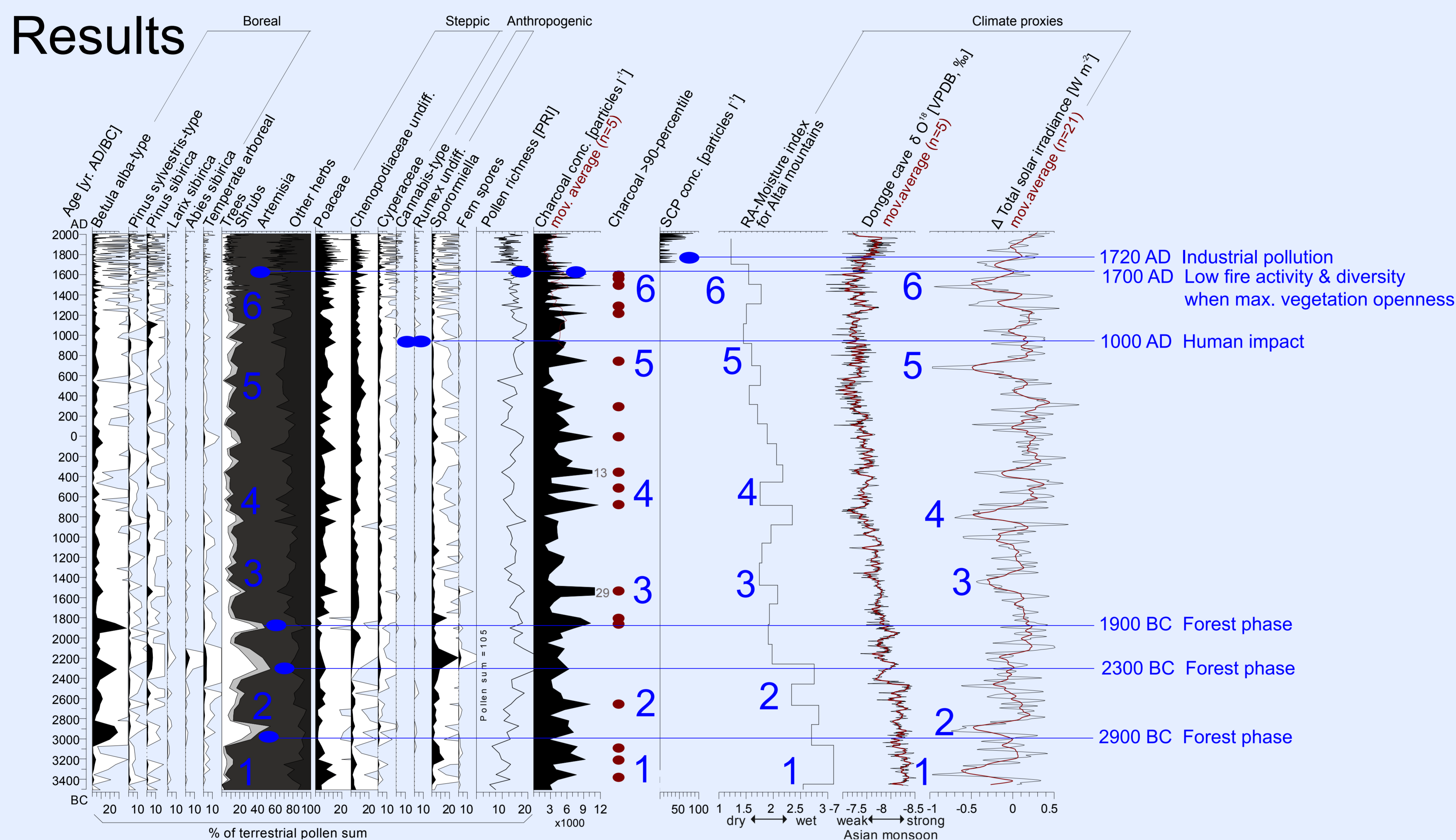
Results

Figure 1 Pollen percentage diagram of Tsambagarav shows selected taxa. White curves = 10 x exaggeration. Diversity estimation (PRI based on a constant pollen sum of 105), charcoal and spheroidal carbonaceous particles (SCPs) concentrations. Comparison with climate records: regionally-averaged moisture index for the Altai Mountains based on pollen records [4], Asian monsoon reconstruction from Dongge cave [5], solar activity fluctuation reconstruction based on [10]Be measurements in polar ice [6]. Blue numbers indicate climatically induced forest minima and fire phases at Tsambagarav.
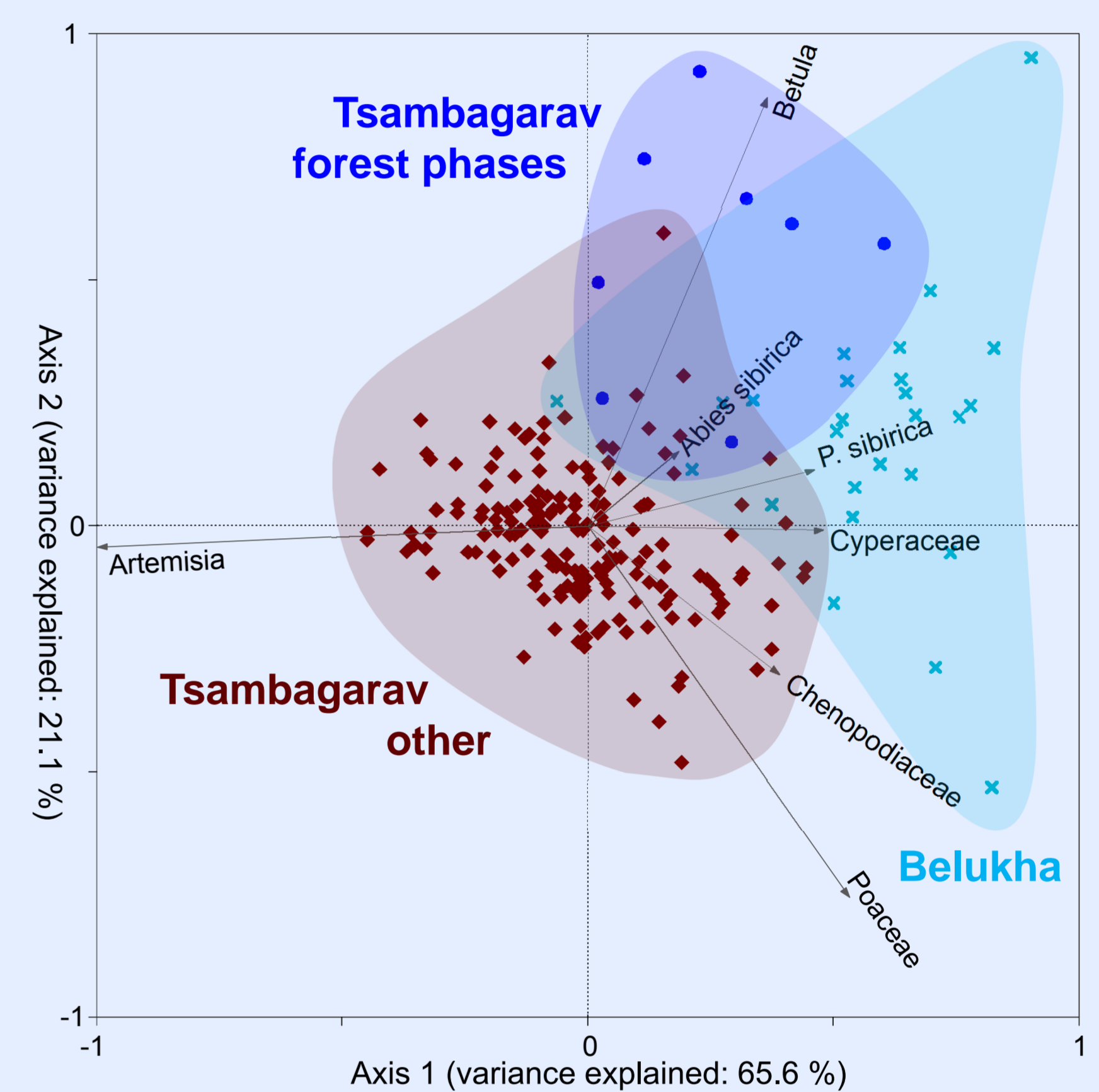

Figure 2 Principle component analysis (PCA) for pollen percentages. Sample scores of Tsambagarav record with symbols for forest phases (dark blue circles, see fig. 1) and others (red diamonds), selected species scores (grey arrows). Sample scores of Belukha record (light blue crosses, [7]) plotted as supplementary data not influencing the ordination.

Study site

We use an ice core from the snow-capped Tsambagarav mountain in the Altai (4130 m a.s.l.) with an excellent chronology, particularly over the last 250 years (Fig.5)
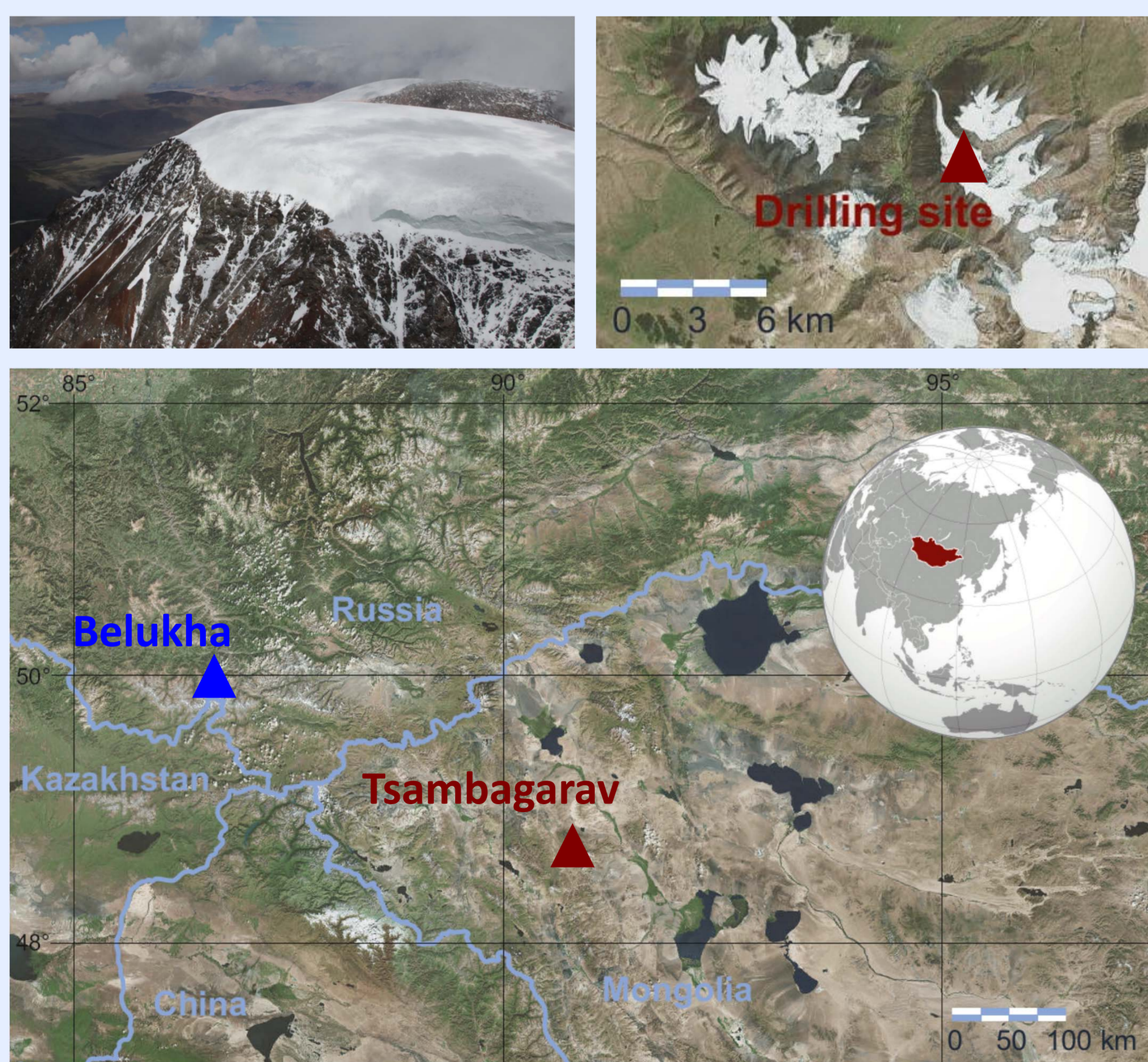

Figure 3 Top left: Tsambagarav ice cap (Photo: H. Machguth). Top right: Tsambagarav mountain with ice cap and drilling site (red triangle). Bottom: Map of the Altai region with palynological records from glaciers (triangles), maps modified from U.S. Geological Survey.

Conclusions

Tsambagarav demonstrates for the first time the ecological potential of ice palynology and provides novel insights into past fire and vegetation dynamics in the Mongolian Altai
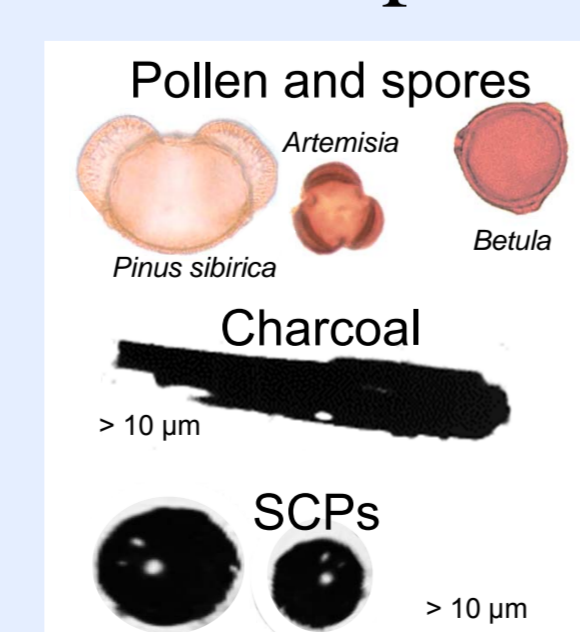
- Monsoon-related precipitation regime changes were the main driver for late-Holocene forest collapses
- Forest collapses may have increased dead biomass as fuel and thereby enhanced fire activity
- Limited timber availability correlates with early industrial pollution after 1720 AD
- Lacking resilience of forest communities to moisture emphasizes future vulnerability of forests in other dry areas in Central Asia (e.g. Russian Altai) if global warming is associated to moisture declines [8]

Present forest belt in Russian Altai

Future moisture decline

Modern forest relicts in Mongolian Altai

Figure 4 Future vegetation scenario.

Material & methods

Glaciers are natural archives that store vegetation, fire, and pollution history over millennia [7]. We use:

Proxies for vegetation composition and land use

Proxy for fire activity
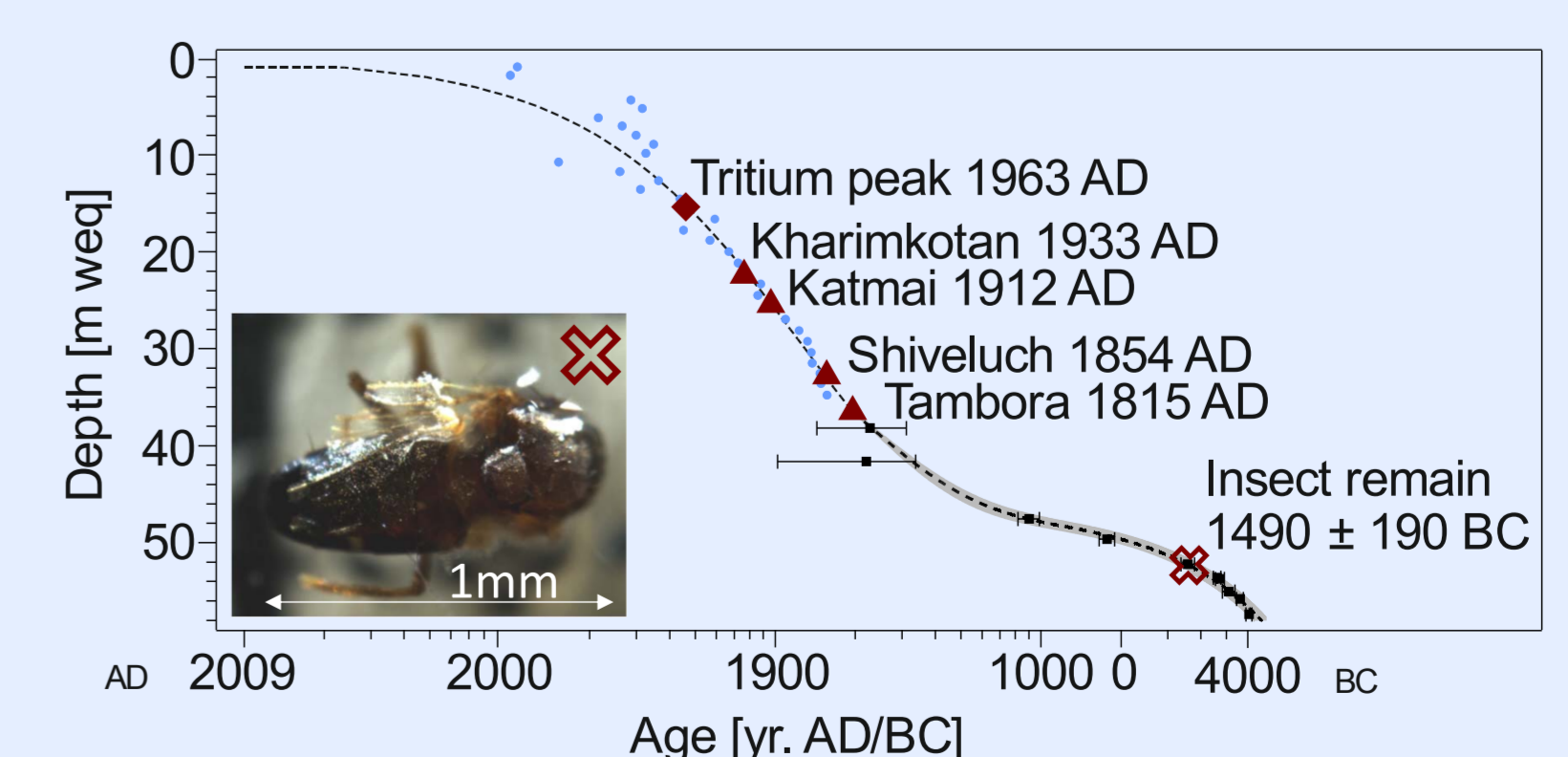
Proxy for fossil fuel combustion

Figure 5 Tsambagarav chronology based on layer counting, max. tritium peak (diamond), volcanic layers (triangles), ^{210}Pb activity (blue circles), and [14]C- dating (black squares). Insert: ^{14}C-date of an insect (red cross) and photo [9].

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