Effects of volcanic eruptions on peatland development and carbon accumulation on the southern slope of Changbai Mountain, Northeast China

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Introduction

Peatlands play a key role in the global carbon cycle as an important carbon reservoir in terrestrial ecosystems. Many peatlands exist in volcanic terrains, but we still have limited understanding of the effects of volcanic ash deposition on peatland development and carbon dynamics. There are abundant peatlands in Northeast China, especially around the Changbai Mountains—a volcanic mountain range with a crater lake at 2189 m a.s.l.—which experienced multiple eruptions during the Holocene, including a major eruption in 946 CE (Millennium Eruption: ME). Here we used multi-proxy records from 2 long- and 8 short cores at a 1570-m-elevation peatland complex on the southern slope—just 13 km from the crater lake Tianchi—to understand the peatland initiation and carbon accumulation processes under the influence of volcanic eruption.

Objectives

- To develop a peat-core-based paleoecological method to quantify the number and magnitude of volcanic eruptions over the last 4000 years;
- To investigate the effect of volcanic eruptions on peatland initiation and vegetation development;
- To explore the history of carbon accumulation in peatlands and how volcanic eruptions affect carbon accumulation;
- To understand the impacts on peatlands of volcanic eruption events having various magnitudes.

Study site and methods

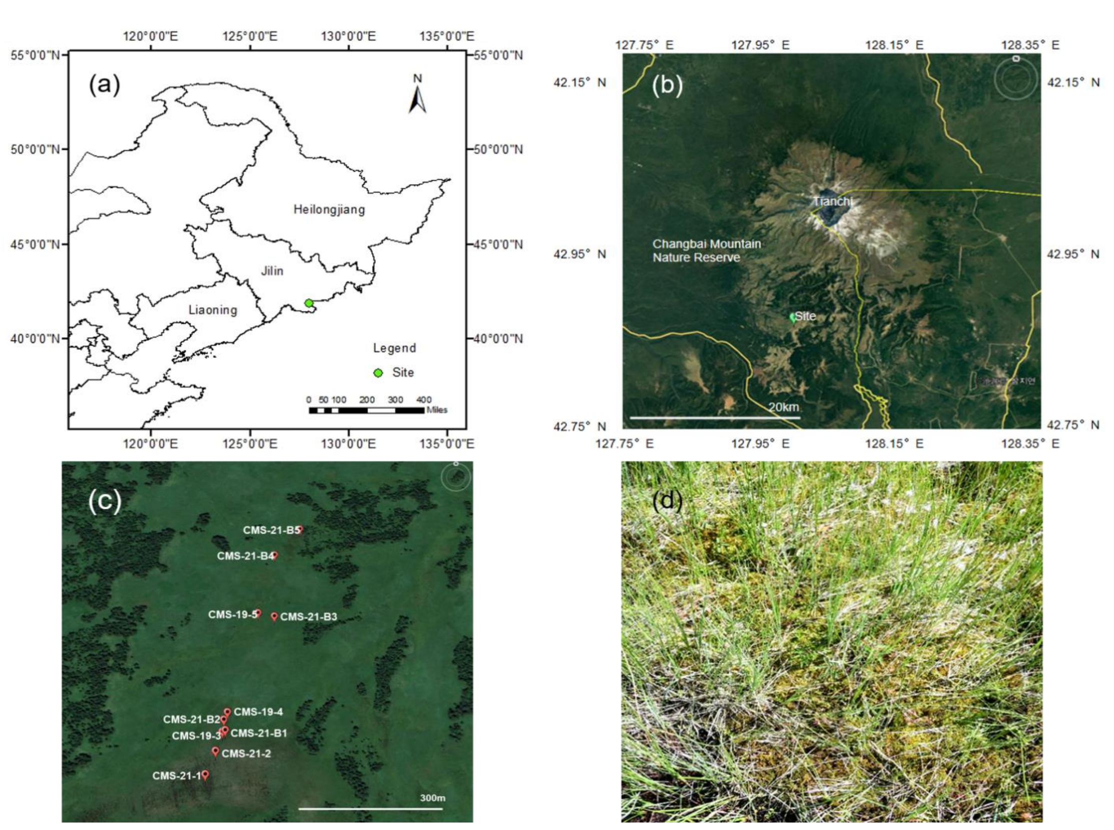
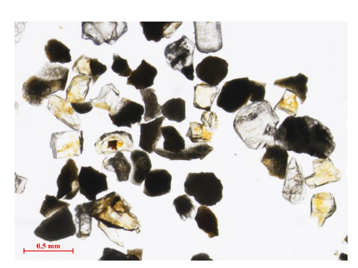


Fig. 1. Study region and site. (a) The location of the study site in Northeast China. (b) The study site is located on the southern slope of Changbai Mountain (CMS Peatland), only 13 kilometers from the Tianchi crater. (c) Locations of 10 peat cores studied (red symbols). (d) Photo of the coring site CMS-21-1.



Volcanic glass shards

LOI analysis

Plant macrofossils

Fig. 2. Methods

Methods used:

- AMS ^{14}C dating ● Volcanic glass counting ● LOI analysis ● Plant macrofossil analysis

Volcanic glass shards analysis:

- Two methods to count volcanic glass shards: for coarse fraction (100 µm-2 mm) under a stereo binocular microscope at 20x magnification, and fine fraction (<10 µm) using smear slides under a compound microscope at 400x magnification;
- Estimates of volcanic ash deposition magnitude were based on (1) the presence or absence of volcanic glass shards; (2) the size of galss shards; (3) the abundance of volcanic glass shards.

Results

Fig. 3. Photo of master core CMS-21-1.

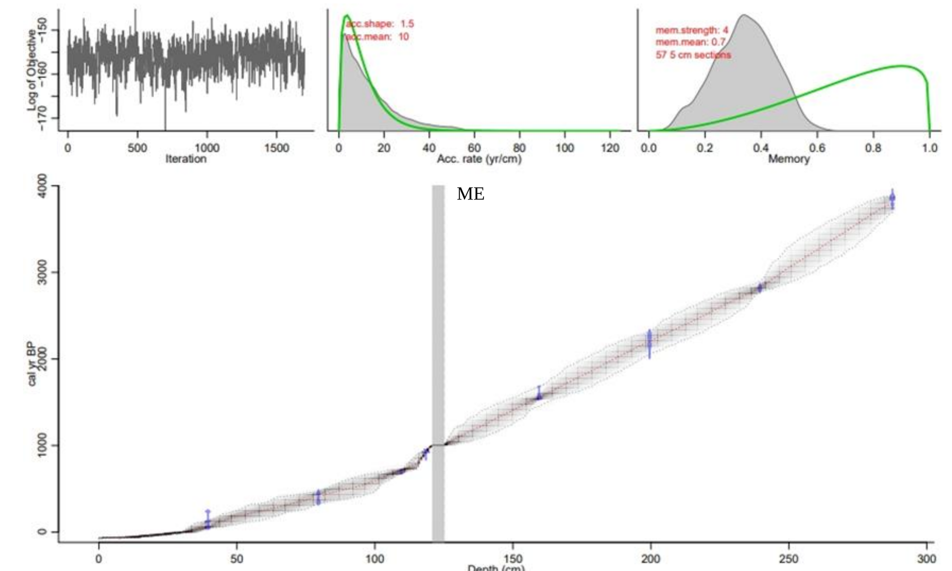


Fig. 4. Bacon age-depth model of core CMS-21-1.

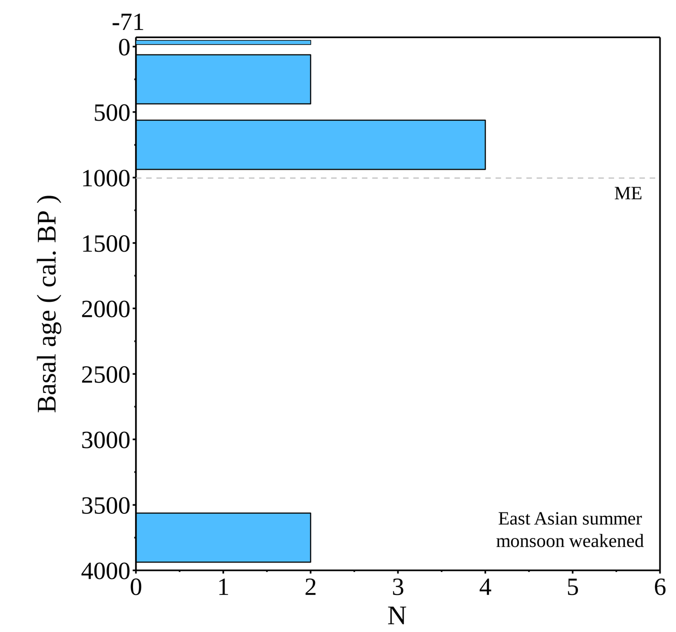


Fig. 5. Frequency of basal ages of all 10 peat cores, suggesting the roles of climate and volcanic eruptions in peat initiation.

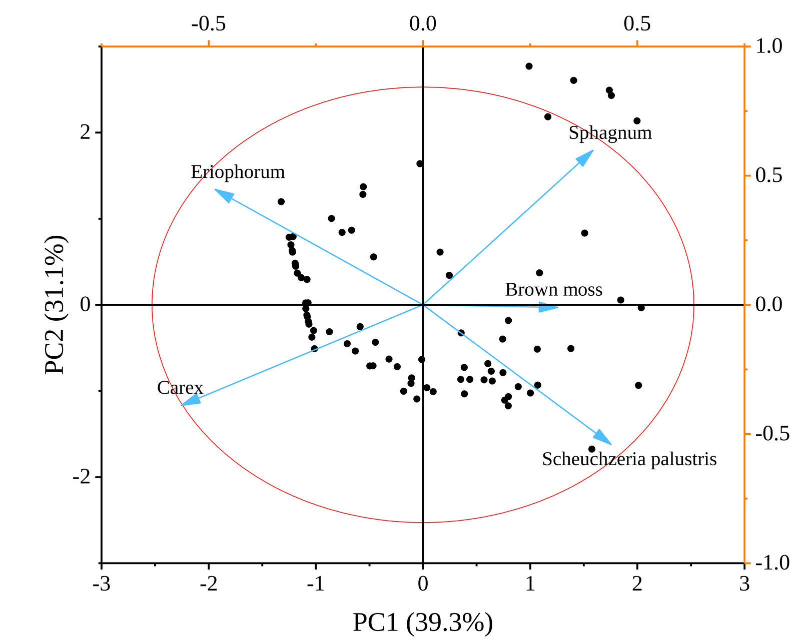


Fig. 6. Biplot of PCA ordination scores of 79 macrofossil samples and key macrofossil types from core CMS-21-1.

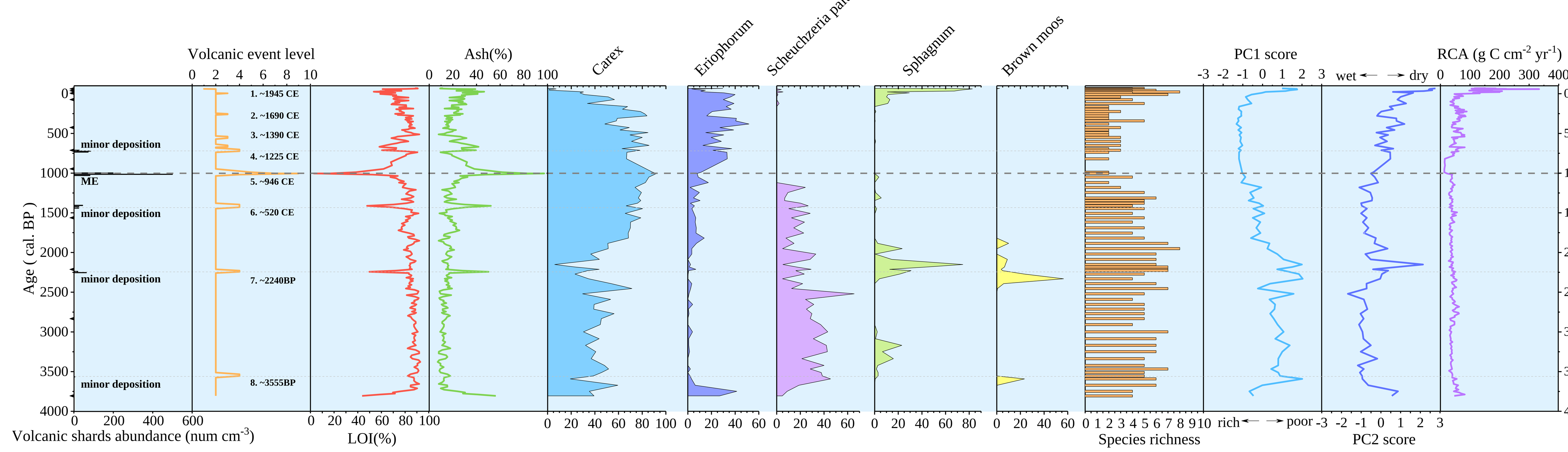


Fig. 7. Summary diagram of results from core CMS-21-1, including volcanic glass shards abundance (>100-µm size); relative volcanic abundance level by also considering 5-100-µm size shards estimated using smear slides under a compound microscope (from level 0 absence to level 10 most abundance) and eruption events with estimated eruption ages; organic matter content (LOI); ash content (ash=100% - LOI); major macrofossil types, species richness and PCA axis 1 and 2 scores and rates of carbon accumulation (RCA).

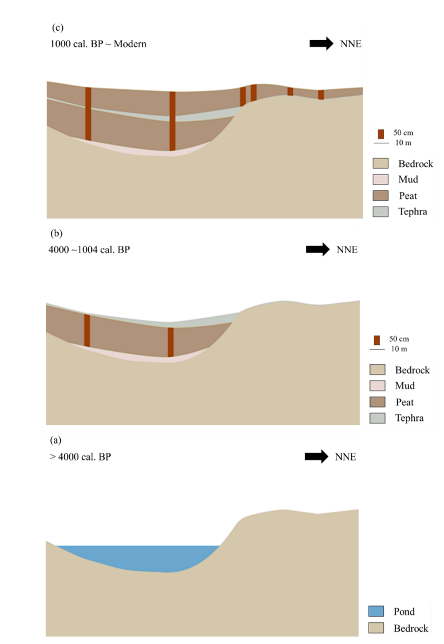
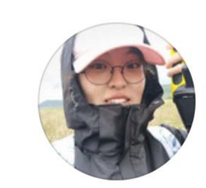


Fig. 8. Schematic diagram showing peatland developmental history (from bottom to top).

Conclusions

- The study peatland on the south slope of the Changbai Mountains was initiated through terrestrialization (lake-infilling) process at 3800 cal yr BP, likely in response to a dry climate associated with the weakening of the East Asian summer monsoon in the late Holocene.
- The Millennium Eruption promoted the formation of new peatlands and facilitated lateral expansion, as the compact fine-grained tephra layer served as an impermeable layer, causing waterlogging conditions.
- Different magnitude of volcanic ash depositions had diverse effects on peatland vegetation and carbon accumulation. The deposition of the ME caused a dramatic change in the peatland plant community, reducing its diversity, and also resulted in a significant reduction in the rate of carbon accumulation, which lasted for almost 200 years. Only three out of seven minor volcanic ash deposition events induced a brief increase in *Sphagnum* but had little impact on species richness and carbon accumulation.
- The ME promoted the formation of new peatlands but slowed down the development of existing peatlands. The balance between the formation of new peatlands and the carbon accumulation in existing peatlands would determine the carbon sink capacity of peatlands in the study area.



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