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Volcanic eruptions in the Longgang volcanic field, northeastern China, during the past 15,000 years

Jiaqi Liu [a,1], Guoqiang Chu [a,*], Jingtai Han [a,2], Patrick Rioual [a,2], Weiyi Jiao [b,3], Kaijun Wang [b,3]

[a] Key Laboratory of Cenozoic Geology and Environment, Institute of Geology and Geophysics, Chinese Academy of Sciences, Huayuan Lu, P.O. Box 9825, Beijing 100029, China
[b] Longwan National Natural Protection Bureau, Huinan County, P.O. Box 9825, Jilin Province 135102, China

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ABSTRACT

The Longgang volcanic field, located in northeastern China, is volcanically active with a number of eruptions during the Quaternary but the chronology of the eruptions is poorly defined. Some tephra layers are well preserved in the annually laminated sediments of maar lakes in the region, and facilitate the construction of a much improved chronological framework for the volcanic history of the area. The results of our investigations reveal that three basaltic explosive eruptions occurred at AD 460, 11460 cal yr BP and 14000 cal yr BP, respectively. The largest explosive basaltic eruption (AD 460) produced a thick black scoria layer in the Longgang volcanic field, including lakes. The tephra distribution and chronological data suggest that this eruption is likely to be from the Jinlongdingzi volcano. Two basaltic flood eruptions occurred at Jinlongdingzi. The earlier basaltic eruption produced a lava flow that spread over a forest and encased standing trees. Two radiocarbon ages obtained from charcoal samples collected from the burned remains of these trees are 1828–1989 cal yr BP and 2164–2359 cal yr BP. In the most recent stage of volcanism, the lava flow extended only ca. 2 km, and flowed into Lake Dalongwan. From the present status of the forest ecosystem, which has not yet reached the fully mature successional stage, we estimate that this lava is very young (ca. a few hundreds years old). Jinlongdingzi is a potentially dangerous volcano. Monitoring and assessment of the potential hazards in the Longgang volcanic field should be carried out in the future.

1. Introduction

The Longgang volcanic field (LVF) is located in Jilin Province, northeastern China (Fig. 1). In recent decades, researchers have paid close attention to the LVF (e.g. Ou and Fu, 1984; Luo, 1984; Liu, 1999; Liu and Zhang, 1997; Fan et al., 2002; Yu and Han, 2005; Guo et al., 2005). Jinlongdingzi volcano in the LVF has been recognized as an active volcano, and as the site of the second largest volcanic eruptions in China during the past 2000 years (Fig. 1) (Ou and Fu, 1984; Liu, 1999; Wei et al., 2003). The eruption history of the LVF is still, however, poorly understood, due in part to the limit of ^{14}C dating of young deposits (e.g. Davies et al., 2004; Colmam et al., 2004; Guilderson et al., 2005; Oswald et al., 2005), as well as the paucity of historical documents relating to this remote area.

Lacustrine sediments are ideal for preserving tephra layers, which can be used to trace the origins of volcanic eruptions and establish the chronological sequences of the volcanic events (Shane and Hoverd, 2002; Lowe et al., 2001; Schmidt et al., 2002; Davies et al., 2004). Annually laminated (varved) lake sediments provide high-precision calendar year ages for tephra horizons (Zolitschka et al., 1995; Brauer et al., 1999; Zillén et al., 2002). In the LVF, varved sediments have been found in several maar lakes (Mingram et al., 2000, 2004; Chu et al., 2005, 2008a,b; Schettler et al., 2006a,b), thus enhancing the potential for reconstructing high resolution paleoclimatic records and establishing the chronological sequences of the volcanic events. This paper presents our recent study of the eruptive history of the LVF with evidence obtained from outcrops and laminated lake sediments.

2. Geological setting

The LVF covers an area of 1700 km^2 with more than 160 Quaternary craters and calderas (Ou and Fu, 1984; Xie et al., 1993; Liu, 1999; Sui et al., 1999). The present regional topography was shaped largely by late Cenozoic volcanisms due to the westward subduction of the West Pacific plate (Liu, 1999).

Eight maar lakes were formed in the west of the LVF. Lake Sihailongwan (SHL) and Lake Xiaolongwan (XIL) were selected in this study because of the sediments from both lakes show

* Corresponding author. Tel.: +86 010 82998394; fax: +86 010 62010846.
E-mail addresses: liujq@mail.igcas.ac.cn (J. Liu), chuguoqiang@mail.igcas.ac.cn (G. Chu), jhan@mail.igcas.ac.cn (J. Han), prioual@mail.igcas.ac.cn (P. Rioual), hntieliwei@mail.jl.cn (W. Jiao), hntieliwei@mail.jl.cn (K. Wang).
[1] Tel.: +86 010 82998203.
[2] Tel.: +86 010 82998385.
[3] Tel.: +86 0448 8218039; fax: +86 0448 8718415.

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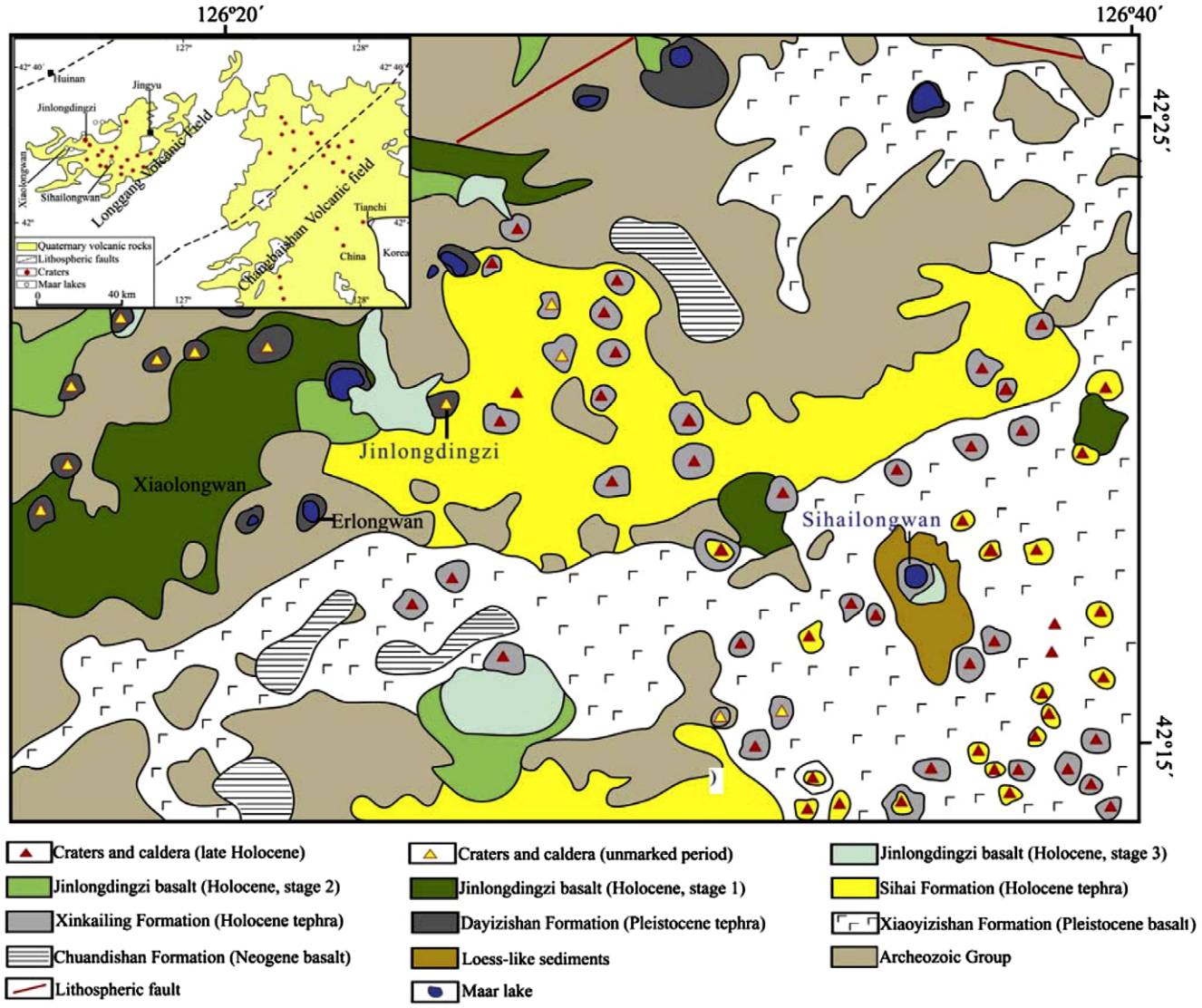

Fig. 1. Regional geological map. Modified from Bureau of Geology and Mineral Resources of Jilin Province (1979, 1988). A geological sketch showing the location of the Longgang volcanic field and the Changbai volcanic field.

well-developed annual laminae (Mingram et al., 2004; Chu et al., 2008a). Maar lake Sihailongwan (42°17'N, 126°36'E, altitude: 791 m asl) is situated about 20 km southeast of the Jinglongdingzi volcano. The lake has a surface area of 0.39 km^2 and a maximum depth of 50 m with 0.7 km^2 of catchment area. Lake Xiaolongwan (42°18'N, 126°21'E, altitude: 655 m asl) is located at the southwest of the Jinglongdingzi volcano with a surface area of 0.079 km^2, a maximum depth of 15 m, and a catchment area of 0.16 km^2. The vegetation at both lakes is dense mixed broadleaf – conifer forest with little human disturbance. The Jinlongdingzi volcano (42°19'N, 126°25'E, altitude: 999 asl) is a horseshoe-shaped crater and is mainly composed of basaltic scoria and bombs (Fig. 1). Lava can be observed at the foot of its southwestern side.

3. Methods

3.1. Field studies

Field investigations of the volcanic rocks have been made in the areas of Jinglongdingzi volcano and lakes SHL and XIL. The Jinglongdingzi tephra (JLT) was sampled mainly along an NW transect of the tephra sheet (Fig. 2). A series of sediment cores (frozen, gravity and piston cores) have been recovered from both maar lakes since 1998 (Mingram et al., 2004; Chu et al., 2005, 2008a).

3.2. Varve and dating

The sediment cores were sampled into slabs of 6.5 cm in length with a 1.5 cm overlap, then shock-frozen, vacuum-dried and impregnated with epoxy resin in advance of preparation for thin sections. Varves were identified and counted from thin sections at different magnifications (4×, 6.5×, 20×) using a Leitz optical microscope. Independent chronological control using radionuclides analyses such as ^{137}Cs, ^{210}Pb and ^{14}C (Mingram et al., 2004; Chu et al., 2005, 2008a; Schettler et al., 2006a,b) supports the results obtained by varve counting, demonstrating that the sediments of the two lakes are annually laminated. In this study, new radiocarbon data were obtained from outcrops and lake sediment cores (Table 1).

3.3. Tephra geochemistry

Tephra samples were taken both from outcrops and sediment cores from both lakes. In preparation for geochemical analysis,