Earth and Planetary Science Letters 432 (2015) 166–175

Contents lists available at ScienceDirect

Earth and Planetary Science Letters

www.elsevier.com/locate/epsl

Voluminous silicic eruptions during late Permian Emeishan igneous province and link to climate cooling

Jianghai Yang [a,*], Peter A. Cawood [b,c], Yuansheng Du [a]

[a] State Key Laboratory of Biogeology and Environmental Geology & School of Earth Sciences, China University of Geosciences, Wuhan, 430074, China
[b] Department of Earth and Environmental Sciences, University of St. Andrews, St. Andrews KY16 9AL, UK
[c] Centre for Exploration Targeting, School of Earth and Environment, University of Western Australia, 35 Stirling Hwy, Crawley WA, 6009, Australia

ARTICLE INFO

Article history:
Received 5 August 2015
Received in revised form 25 September 2015
Accepted 29 September 2015
Available online 3 November 2015
Editor: T.A. Mather

Keywords:
silicic volcanism
Emeishan
climate cooling
sulfur gas emission

ABSTRACT

Silicic eruptive units can constitute a substantive component in flood-basalts-dominated large igneous provinces, but usually constitute only a small proportion of the preserved volume due to poor preservation. Thus, their environmental impact can be underestimated or ignored. Establishing the original volume and potential climate-sensitive gas emissions of silicic eruptions is generally lacking for most large igneous provinces. We present a case study for the ∼260 Ma Emeishan province, where silicic volcanic rocks are a very minor component of the preserved rock archive due to extensive erosion during the Late Permian. Modal and geochemical data from Late Permian sandstones derived from the province suggest that silicic volcanic rocks constituted some ∼30% by volume of the total eroded Emeishan volcanic source rocks. This volume corresponds to $> 3 \times 10^4$ km^3 on the basis of two independent estimate methods. Detrital zircon trace element and Hf isotopic data require the silicic source rocks to be formed mainly by fractional crystallization from associated basaltic magmas. Based on experimental and theoretical calculations, these basalt-derived $\sim 10^4$ km^3 silicic eruptions released $\sim 10^{17}$ g sulfur gases into the higher atmosphere and contribute to the contemporaneous climate cooling at the Capitanian–Wuchiapingian transition (∼260 Ma). This study highlights the potentially important impact on climate of silicic eruptions associated with large igneous province volcanism.

© 2015 Elsevier B.V. All rights reserved.

1. Introduction

Basaltic eruptions associated with large igneous provinces (LIPs) have been widely discussed to induce climate warming via CO_2 degassing or cooling by sulfur gas emission (e.g., Jolley and Widdowson, 2005; Mussard et al., 2014; Self et al., 2006, 2014; Zhang et al., 2013). However the climatic impact of LIP silicic volcanism is often overlooked even though it may constitute a substantial component of many LIPs (Bryan et al., 2002) and have a potential linkage with regional or hemispheric climate cooling via delivering sulfur gases and ash into the upper atmosphere (Scaillet and Macdonald, 2006). This is mainly because of the poor preservation of such volcanic activity due to erosion, especially for pre-Mesozoic provinces (Bryan et al., 2002). In the late Permian Emeishan volcanic province in SW China (Chung and Jahn, 1995; Fig. 1A), silicic volcanic rocks are only a very rare component (<1%) of the total exposed igneous rocks (Shellnutt and Jahn, 2010; Xu et al., 2010). Their rarity in the rock archive might result from their dispersal due to the explosive nature of the silicic activity (e.g., Xu et al., 2010) and the stratigraphic restriction to the youngest phases, and stratigraphically highest levels, of the Emeishan LIP (Xu et al., 2010, 2004; Zhong et al., 2014) resulting in their preferential erosion relative to basaltic phases (He et al., 2007). The eroded volcanic products of the Emeishan province were deposited and preserved in the adjacent Late Permian sedimentary systems (He et al., 2007; Yang et al., 2014; Zhou et al., 2000), especially the Youjiang Basin to the southeast (Yang et al., 2014).

Emeishan flood volcanism is temporally correlated with the Guadalupian–Lopingian boundary (259.9 ± 0.4 Ma; Gradstein et al., 2012) bio-environmental crisis (Wignall et al., 2009). Climate cooling has been advocated to be associated with the end-Guadalupian event based on positive $\delta^{13}C$ values (Isozaki et al., 2007), an increase in low-latitude conodont $\delta^{18}O$ (Chen et al., 2013) and a climate-related decrease in chemical weathering intensity of paleosols from high-latitude locations in Gondwana at the Capitanian–Wuchiapingian transition (∼260 Ma) (Sheldon et al., 2014). Sulfur gas emissions linked to Emeishan basalt eruptions have been interpreted as a cause for this climate cooling event (Zhang et al., 2013). However, the flood basalts are dominantly effusive (Xu et al., 2004)

* Corresponding author.
E-mail address: yjhcug@126.com (J. Yang).

http://dx.doi.org/10.1016/j.epsl.2015.09.050
0012-821X/© 2015 Elsevier B.V. All rights reserved.

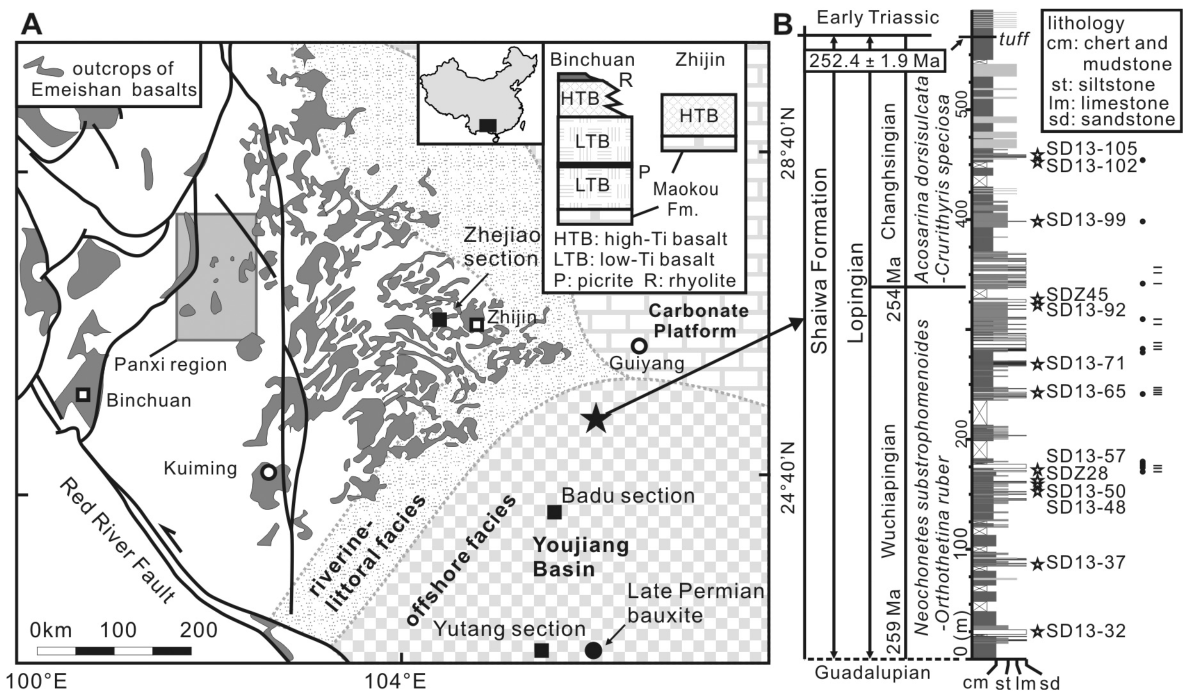

Fig. 1. Location and stratigraphy of sampled section. A, Distribution of Emeishan volcanic province and dispersed riverine-littoral and offshore sedimentary facies in adjacent Youjiang Basin in SW China (revised from Yang et al., 2014; He et al., 2007). Star shows location of the analyzed sedimentary sequence at Sidazhai. Insets show location of region within China and representative stratigraphic columns of Emeishan volcanic sequences at Zhijin and Binchuan (revised from Xu et al., 2004). B, Time scale, based on biostratigraphy and tuff zircon dating (Gao et al., 2001; Yang et al., 2012), and lithologic sequence of the Late Permian Shaiwa Formation with sample positions for zircon separates (blank stars), rock geochemistry (black dots) and thin-sections (dashes). Zircon U–Pb age and trace element data for samples Sdz45 and Sdz28 are reported in Yang et al. (2012) and compiled in this study. Also shown are the locations of Yutang and Badu sections in the Youjiang Basin and Zhejiao section in eastern Emeishan province where sandstone modal and geochemical compositions have been reported (He et al., 2007; Yang et al., 2014) and are compiled for comparison in this study. In addition, the location of the Late Permian bauxites (Deng et al., 2010) in the Youjiang Basin is also marked on the map.

and, in contrast to explosive silicic rocks, unlikely to be able to result in major stratospheric S loading (but see the buoyant plume model of Glaze et al., in press). The potential climate impact of Emeishan silicic eruptions have not been considered, as their original volume is poorly constrained and there are no melt inclusions in phenocrysts that could have been used for a direct determination of S contents due to syn- and post-eruptional alteration (e.g., chemical weathering and mechanical fragmentation) and general aphyric texture. In this paper we develop methods to estimate the volume of eroded Emeishan silicic volcanic rocks based on modal and geochemical data from Late Permian sandstones derived from the province. We also evaluate the petrogenesis of the silicic rocks using detrital zircon trace element and Hf isotopic data from these Late Permian sediments. On the basis of the derived volume estimate and petrogenetic model for Emeishan silicic eruptions, we further explore their potential climate effect by estimating the associated sulfur gas emissions according to the experimental and theoretical calculations proposed by Scaillet and Macdonald (2006).

2. Emeishan LIP and its derived Late Permian sediments

The Emeishan LIP lies on the western margin of South China Craton with an exposed area of $\sim 2.5 \times 10^5$ km^2 and a thickness ranging from several hundred meters up to 5 km (Chung and Jahn, 1995; Xu et al., 2001; Fig. 1A). This province consists of massive flood basalts and subordinate amounts of picrite, pyroclastic rock and rhyolitic tuff (Chung and Jahn, 1995; Xiao et al., 2004; Xu et al., 2001). Voluminous mafic–ultramafic intrusions and peralkaline, peraluminous and metaluminous A-type granitic rocks are associated with the province in Panxi Region (Shellnutt and Jahn, 2010; Shellnutt et al., 2009; Xu et al., 2008; Zhong et al., 2011). Two general basaltic groups, high-Ti and low-Ti basalts, are distinguished on the basis of geochemical parameters with the former stratigraphically above the latter in the west but directly overlying the Middle Permian carbonates in the east of the province (Fig. 1A inset; Xu et al., 2004). Silicic volcanic rocks including rhyolite and trachyte have only been reported from the uppermost part of preserved volcanic stratigraphy, and only at a very few locations (e.g., Binchuan, Fig. 1A inset; Xu et al., 2004). Studies of biostratigraphy of intercalated marine beds, magnetostratigraphy, and zircon U–Pb dating on the volcanic sequences constrain the LIP volcanism to a short pulse around 262–259 Ma (He et al., 2007; Wignall et al., 2009; Zheng et al., 2010; Zhong et al., 2014). Geologic, geophysical and geochemical data established that the Emeishan LIP is related to mantle plume activity (Chung and Jahn, 1995; He et al., 2003; Xu et al., 2004, 2001). The Emeishan flood basalts overlie Middle Permian carbonates, and are, in turn, overlain by latest Permian terrestrial or marine clastic rocks in the east and Triassic sedimentary rocks elsewhere (e.g., He et al., 2007). This stratigraphy and related provenance data suggest that the Emeishan volcanic province experienced extensive exposure and erosion during the Late Permian–earliest Triassic (He et al., 2007; Yang et al., 2014; Zhou et al., 2000). The eroded volcanic materials from this province were partly dispersed southeastward and preserved as sediments in the terrestrial–littoral (e.g., the Late Permian Xuanwei and Longtan formations, He et al., 2007) and offshore facies of the Youjiang Basin (e.g., the Late Permian Shaiwa and Linghao formations, Yang et al., 2014) (Fig. 1A). These sediments thus allow for quantitative volume reconstruction of the eroded part of the Emeishan province.

3. Sampling sequence and analytical methods

In this region, the Late Permian successions are generally dominated by fine-grained sedimentary rocks, such as mudstones and siltstones, and mostly are devoid of coarser deposits like sandstone.

Download English Version:

https://daneshyari.com/en/article/6427829

Download Persian Version:

https://daneshyari.com/article/6427829

Daneshyari.com