Earth and Planetary Science Letters 479 (2017) 206–218

Contents lists available at ScienceDirect

Earth and Planetary Science Letters

www.elsevier.com/locate/epsl

Intracontinental mantle plume and its implications for the Cretaceous tectonic history of East Asia

In-Chang Ryu [a], Changyeol Lee [b,*]

[a] Department of Geology, Kyungpook National University, Daegu, 41566, Republic of Korea
[b] Faculty of Earth Systems and Environmental Sciences, Chonnam National University, Gwangju, 61186, Republic of Korea

ARTICLE INFO

Article history:
Received 10 November 2016
Received in revised form 10 September 2017
Accepted 13 September 2017
Available online xxxx
Editor: F. Moynier

Keywords:
intracontinental mantle plume
plume-slab interaction
numerical model
Cretaceous
East Asia
adakite

ABSTRACT

A-type granitoids, high-Mg basalts (e.g., picrites), adakitic rocks, basin-and-range-type fault basins, thinning of the North China Craton (NCC), and southwest-to-northeast migration of the adakites and I-type granitoids in southern Korea and southwestern Japan during the Cretaceous are attributed to the passive upwelling of deep asthenospheric mantle or ridge subduction. However, the genesis of these features remains controversial. Furthermore, the lack of ridge subduction during the Cretaceous in recently suggested plate reconstruction models poses a problem because the Cretaceous adakites in southern Korea and southwestern Japan could not have been generated by the subduction of the old Izanagi oceanic plate. Here, we speculate that plume-continent (intracontinental plume-China continent) and subsequent plume-slab (intracontinental plume-subducted Izanagi oceanic plate) interactions generated the various intracontinental magmatic and tectonic activities in eastern China, Korea, and southwestern Japan. We support our proposal using three-dimensional numerical models: 1) An intracontinental mantle plume is dragged into the mantle wedge by corner flow of the mantle wedge, and 2) the resultant channel-like flow of the mantle plume in the mantle wedge apparently migrated from southwest to northeast because of the northeast-to-southwest migration of the East Asian continental blocks with respect to the Izanagi oceanic plate. Our model calculations show that adakites and I-type granitoids can be generated by increased slab-surface temperatures because of the channel-like flow of the mantle plume in the mantle wedge. We also show that the southwest-to-northeast migration of the adakites and I-type granitoids in southern Korea and southwestern Japan can be attributable to the opposite migration of the East Asian continental blocks with respect to the Izanagi oceanic plate. This correlation implies that an intracontinental mantle plume existed in eastern China during the Cretaceous and that the mantle plume was entrained into the mantle wedge as a channel-like flow. An intracontinental mantle plume can explain the adakitic rocks, A-type granitoids, high-Mg basalts, and basin-and-range-type fault basins distributed in eastern China. Thus, the mantle plume and its interaction with the overlying continent and subducting slab through time plausibly explain the Cretaceous tectonic history of East Asia.

1. Introduction

The tectonic history of eastern China during the Cretaceous features complex magmatism, including A-type granitoids (Kim et al., 2016; Wang et al., 2006b; Wu et al., 2002, 2005), high-Mg basalts such as picrites (Gao et al., 2008), and adakitic rocks (Castillo, 2012; Wang et al., 2006b; Xu et al., 2002), as well as a unique tectonic history that includes lithospheric thinning of the North China Craton (NCC) (Menzies et al., 2007; Wang et al., 2006b; Wu et al., 2005; Xu et al., 2002) and NE-trending basin-and-range-type fault basins, such as the Bohaiwan and Songliao Basins (Okada, 1999; Ren et al., 2002) (Fig. 1a). In addition to the intracontinental magmatism and tectonic history, adakites and A- and I-type granitoids are present in central and southern Korea (Kim et al., 2016; Wee et al., 2006) and southwestern Japan (Iida et al., 2015; Imaoka et al., 2014; Kinoshita, 1995, 2002; Kutsukake, 2002), and the peak magmatism of the adakites and I-type granitoids migrated from southwest to northeast at a rate of ∼3 cm/y (Kinoshita, 2002). To explain the characteristic tectonic history of East Asia during the Cretaceous, passive upwelling of deep asthenospheric mantle or ridge subduction have been suggested. The passive upwelling of deep asthenosphere resulted in various types

* Corresponding author.
E-mail addresses: inchang@knu.ac.kr (I.-C. Ryu), changyeol.lee@gmail.com (C. Lee).

http://dx.doi.org/10.1016/j.epsl.2017.09.032

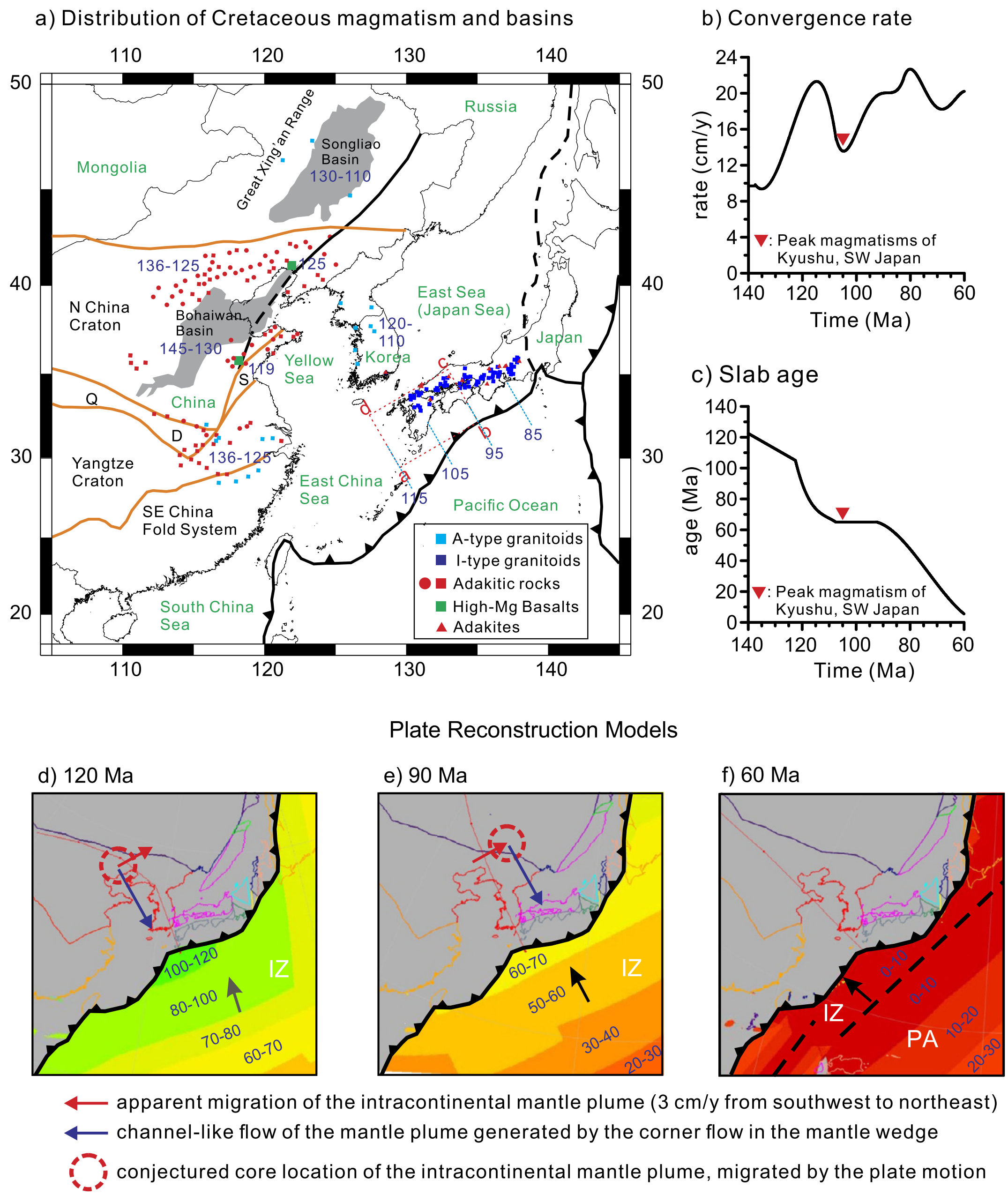

Fig. 1. Distributions of Cretaceous magmatism and basins in East Asia on a present-day map, the trench-normal convergence rate and age of the Izanagi oceanic plate in ancient southwestern Japan through time, and snapshots of the plate reconstruction models during the Cretaceous. a) A-type granitoids (cyan squares), I-type granitoids (blue squares), adakitic rocks (extrusive: red circles; intrusive: red squares), high-Mg basalts such as picrites (large green squares), adakites (red triangles), and basin-and-range-type fault basins (gray shaded areas) are compiled from the references in the text. The numbers indicate the representative ages of the igneous rocks and basin development. Major tectonic lines are from Ren et al. (2002) and Xu (2001). The red dashed rectangle labeled 'abcd' corresponds to the top surface of the numerical model domain used for this study, shown in Fig. 2a and b. b and c) Trench-normal convergence rate and age of the subducting slab in 5-Myr increments are interpolated using piecewise polynomials, respectively. Slab age linearly decreases with time because of convergence of the mid-ocean ridge separating the Izanagi and Pacific oceanic plates. The inverted red triangle indicates the peak magmatism of the adakites and I-type granitoids in ancient Kyushu, southwestern Japan. d, e and f) Snapshots at 120, 90 and 60 Ma, respectively, based on the plate reconstruction models (Gurnis et al., 2012; Sdrolias and Müller, 2006) with a conjectured core location of the intracontinental mantle plume and channel-like flow of the mantle plume generated by corner flow. The intracontinental mantle plume and channel-like flow of the mantle plume apparently migrated from southwest to northeast because of the opposite migration of the East Asian continental blocks with respect to the Izanagi oceanic plate. The numbers on the colored isochrons represent the ages of the oceanic plate. The black dashed line in f indicates the mid-ocean ridge separating the Izanagi and Pacific oceanic plates. The thin red line indicates the accumulated relative motion of the Izanagi oceanic plate with respect to the East Asian continents. Figures from b to f are modified from Lee and Ryu (2015). (For interpretation of the colors in this figure, the reader is referred to the web version of this article.)

of magmatism in eastern China (Imaoka et al., 2014; Menzies et al., 2007; Ren et al., 2002; Wang et al., 2006b). Along with the intracontinental magmatism, the southwest-to-northeast migration of the subducting mid-ocean ridge (Isozaki et al., 2010; Maruyama et al., 1997) separating the Izanagi and Pacific oceanic plates resulted in extensive slab melting that generated the adakites and I-type granitoids in southern Korea (Wee et al., 2006) and southwestern Japan (Iida et al., 2015; Imaoka et al., 2014; Kinoshita, 1995, 2002; Kutsukake, 2002).

Although the abovementioned hypotheses are promising, several issues remain unresolved. First, the picrites in eastern China are attributed to the delamination of the Archean mantle lithosphere of the eastern part of the North China Craton but the passive (adiabatic) upwelling of deep asthenospheric mantle could not