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The Cretaceous climax of compression in Eastern Asia: Age 87–89 Ma (late Turonian/Coniacian), Pacific cause, continental consequences

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A B S T R A C T

In Turonian/Coniacian time a major plate reorganization occurred in Pacific Ocean that resulted in synchronous climax of compression in Eastern Asia. At this time the spreading rate in the Farallon-Pacific-Izanagi center increased to its maximum, the Kula plate replaced the Izanagi plate, and the convergence angle between the Pacific and Eurasia plates experienced fast rotation. This geodynamic culmination was caused by the peak of overall extension of Pacific lithosphere which could be precisely fixed at ~89–87 Ma, based on the age/spatial patterns of the Cretaceous seamounts. The maximum of Pacific stretching induced the coeval westward compression both along subduction boundaries and in intraplate environment of Eastern Asia. We summarize and reevaluate the reliable geochronological data of the main Late Cretaceous geological events in Eastern Asia caused by the peak of Pacific dynamics. Increasing westward subduction and compression produced: (a) maximum of high-pressure metamorphism in the Cretaceous accretion units of Taiwan, Japan and Sakhalin islands, (b) immense subduction related volcanic belts extending along the northeast Asian boundary, (c) vast volumes of granitoids which were emplaced during the 95–85 Ma interval everywhere from Chukotka to Sikhote-Alin in Russia, throughout Japan, Korea and SE China. Thermochronological data suggest that (d) the Pacific-induced compression triggered uplift, exhumation and cooling of East China granites with the peak age of orogeny in Great Xing'an Range at 89–87 Ma. Simultaneously, as thermal history results revealed, (e) subsidence and burial heating in Cretaceous sedimentary basins inverted to cooling. This compressional peak is also well documented by (f) the ~88–86 Ma Qingshankou/Yaojia unconformity in the postrift successions of the lacustrine Songliao Basin. Seismostratigraphy study of the main (T11) unconformity shows huge, gentle folds whose apices were truncated by exposure and denudation caused by the westward compression. Thus the Pacific-induced deformation at ~87–89 Ma encompassed the whole eastern Asia from subduction boundary into the hinterland.

1. Introduction

The last twenty years of investigations have confirmed that the interior of eastern Asia was a region of intensive, sometimes violent, tectono-magmatic activity during the Cretaceous (Parfenov et al., 2009; Şengör and Natal'in, 1996; Wan, 2012). In this period a great volume of volcanic and granitic melts intruded along the entire continental margin, from north to south, in East Russia, Japan, Korea and China (Fig. 1) (Houck and Lockley, 2006; Ishihara, 2007; Lee et al., 2010; Rodionov, 2000; Sun et al., 2007; Wu et al., 2011; Xu et al., 2013; Yu et al., 2006). Another obvious manifestation of this Cretaceous activity is nonmarine sedimentary basins which are especially numerous in eastern China and extend into the continental hinterland for more than 1000 km, far away from the Pacific boundary (Carroll et al., 2010; Graham et al., 2001; Haggart et al., 2006; Hicks et al., 1999; Hong et al., 2012; Jerzykiewicz and Russell, 1991; Li et al., 2009a; Li et al., 2009b; Meng et al., 2003; Ren et al., 2002; Saiki and Okubo, 2006; Sha, 2007; Sha et al., 2003; Shen et al., 2012; Song et al., 2014; Yang and Zheng, 2003; Chen et al., 2014; Tian et al., 1992; Gilder et al., 1991; Zhou et al., 2012).

Reconstruction models suggest that the Izanagi, Kula, and Pacific plates strongly affected the eastern margin of Asia via the

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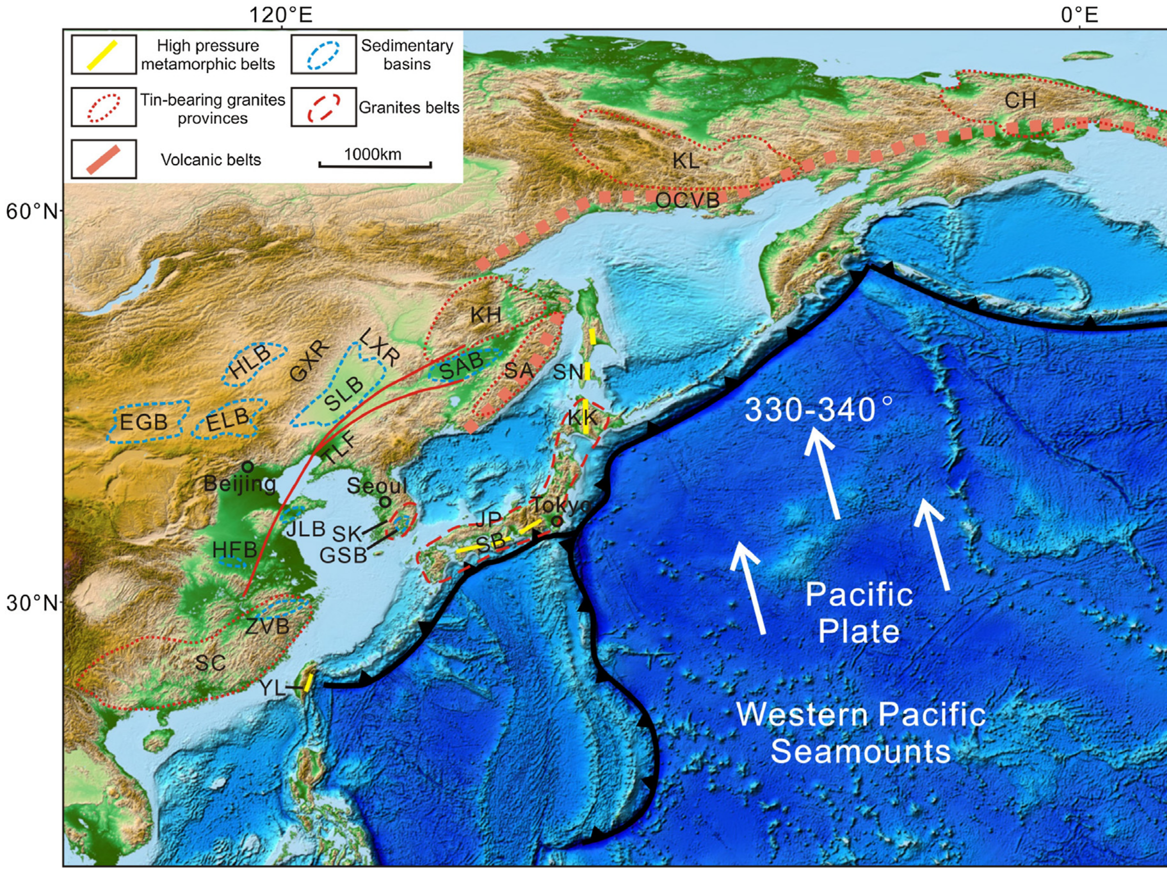

Fig. 1. Simplified map of the Eastern Asia and northwest Pacific Ocean showing the distribution of Upper Cretaceous metamorphic, magmatic and sedimentary units related with the dynamics of the Pacific plate. High pressure metamorphic belts: SB-Sanbagawa (SW Japan), KK-Kamuikotan (Hokkaido), SN- Susunui (Sakhalin), YL-Yuli (Taiwan). Tin-bearing granites provinces of Russia and China: KH-Khingan-Okhotsk, KL-Kolyma, CH-Chukotka, SA-Sikhote-Alin, SC-Southeast China (Cathaysia block). Granites belts: SK- South Korea, JP-Japan. Sedimentary basins: SLB-Songliao Basin, SAB-Sanjiang-Amur Basin, HLB- Hailar Basin, EGB-East Gobi Basin, ELB- Er'lian Basin, JLB-Jiaolai Basin, HFB-Hefei Basin, ZVB-Zhejiang Volcanic Basins, GSB-Gyeongsang Basin. Volcanic belts, SA-Sikhote-Alin, OCVB- Okhotsk-Chukotka. Other units: TLF- Tanlu Fault, GXR-Great Xing'an Range, LXR-Lesser Xing'an Range. Arrows show the trajectory of the Pacific plate in Late Cretaceous period.

subduction mechanism and subsequent backarc extension during late Mesozoic times (Engebretson et al., 1984; Kelley et al., 1999; Khudoley and Sokolov, 1998; Maruyama and Send, 1986; Naruse, 2003; Rea and Duncan, 1986; Takashima et al., 2004; Zakharov et al., 1999; Hlide et al., 1977; Hsü et al., 1990; Faure and Natal'in, 1992; Matsud and Uyeda, 1971). This impact is not in doubt, considering the events that took place in the collision zones or were directly connected with them. However, the actual mechanisms of interaction of oceanic plates with the continent remain poorly understood and continue to be a subject of debate. Accordingly, the Pacific origin of the granite complexes and particularly nonmarine sedimentary basins that occupy a more intraplate position in eastern Asia is not so immediately obvious. Many alternative models of Cretaceous activity on the Asian margin have been proposed (Cloetingh and Burov, 2011; Graham et al., 2001; Matthews et al., 2012; Meng, 2003; Xu et al., 2007). According to the most advocated tectonic mechanisms, the Cretaceous intraplate deformations here were caused by the gravitational collapse of orogens, and/or basalt underplating which led to the thermal uplift and crustal thinning, or asthenospheric upwelling and heating induced by deep plume activity.

From our point of view, new data and results achieved in recent years verify the leading role of the Pacific plate in Cretaceous tectono-magmatic activity in eastern Asia. We integrate our results with the existing data, mainly tectonic and geochronological, to highlight and refine the Pacific nature of the Cretaceous stress field on the continental margin. Our approach includes four steps. First, we use the age/spatial pattern of Cretaceous seamounts in the western Pacific to strictly constrain the time (~89–87 Ma) of the major reorganization event of the oceanic lithosphere. During this short interval, stretching of the crust increased drastically both in the Pacific spreading center and in the intraplate environment (Stepashko, 2006, 2008). Second, this peak of tension of the Pacific plate induced the coeval compression impact on the Asian margin, primarily in subduction zones. We test for the existence of this major event in the fore-land setting based on the geochronological data of high-pressure metamorphic rocks in Cretaceous accretion belts of Taiwan, Japan and Sakhalin islands, and on the recent precise dating of the subduction related Okhotsk-Chukotka volcanic belt in NE Russia (Kotlyar and Rusakova, 2005; Tikhomirov et al., 2006; Tikhomirov et al., 2012). Third, we summarize and discuss the available ages of Late Cretaceous granitoid complexes in East Russia, Japan, Korea Peninsula and East China which demonstrate that the projected Pacific contraction spread far into the hinterland along the entire Eastern Asian margin. Fourth, we present new fission track data in the Songliao Basin and reassess the recent thermochronology results in adjacent regions (Choi and Lee, 2011; Guo, 2014; Li and Gong, 2011; Li et al., 2010b; Li et al., 2011; Liu et al., 2010b), which suggest that the change at ~90 Ma from burial heating to prolonged cooling in thermal history of intracontinental Cretaceous basins in eastern Asia and coeval maximum orogeny in adjacent granite mountains were caused by the same Turonian/Coniacian peak of Pacific compression. Finally, we demonstrate that the detailed interpretations of high-resolution