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GR focus review

Accretionary complexes in the Asia-Pacific region: Tracing archives of ocean plate stratigraphy and tracking mantle plumes

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ABSTRACT

The accretionary complexes of Central and East Asia (Russia, Kazakhstan, Kyrgyzstan, Tajikistan, Mongolia, and China) and the Western Pacific (China, Japan, Russia) preserve valuable records of ocean plate stratigraphy (OPS). From a comprehensive synthesis of the nature of occurrence, geochemical characteristics and geochronological features of the oceanic island basalts (OIB) and ophiolite units in the complexes, we track extensive plume-related magmatism in the Paleo-Asian and Paleo-Pacific Oceans. We address the question of continuous versus episodic intraplate magmatism and its contribution to continental growth. An evaluation of the processes of subduction erosion and accretion illustrates continental growth at the active margins of the Siberian, Kazakhstan, Tarim and North China blocks, the collision of which led to the construction of the Central Asian Orogenic Belt (CAOB). Most of the OIB-bearing OPS units of the CAOB and the Western Pacific formed in relation to two superplumes: the Asian (Late Neoproterozoic) and the Pacific (Cretaceous), with a continuing hot mantle upwelling in the Pacific region that contributes to the formation of modern OIBs. Our study provides further insights into the processes of continental construction because the accreted seamounts play an important role in the growth of convergent margins and enhance the accumulation of fore-arc sediments.

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1. Introduction

Recognizing oceanic basalts of intraplate origin – oceanic islands, seamounts and plateaus – as elements of ocean plate stratigraphy (OPS after Isozaki et al., 1990) is important for reconstructing the periods of mantle plume and superplume activity and the surface/global impact including environmental changes the formation of plume-related mineral deposits (e.g., Morgan, 1971; Campbell and Griffiths, 1990; Hofmann, 1997; Maruyama et al., 2007; Pirajno, 2009; Safonova et al., 2010; Santosh et al., 2009; Santosh, 2010b; Seltmann et al., 2010). Also, oceanic rises being prominent topographic features on the oceanic floor, affect processes of oceanic crust accretion and subduction (Scholl and van Huene, 2007; Stern, 2011) and therefore contribute to continental growth and/or destruction at active convergent margins. Furthermore, oceanic islands formed over the same hot spot are characterized by different ages and usually different degrees of enrichment in incompatible elements (e.g., Regelous et al., 2003 and references therein; Safonova, 2008).

There has been much discussion about the existence of mantle plumes in general and superplumes in particular, especially about their role in the formation of age-tracked intraoceanic islands (e.g., Hawaii) and large igneous provinces (LIP). Some of the typical examples include the oceanic plateaus of Ontong-Java and the continental flood basalts in the Siberian and Deccan Traps. The “Great Plume Debate” divided the global geological community into plume advocates and plume skeptics (Foulger et al., 2006). Since the first hypotheses of Wilson (1963), who suggested that the Hawaiian Islands were produced by the oceanic lithosphere moving over a stationary ‘hot spot’ in the mantle, and Morgan (1971), who suggested that plumes exist in the Earth's mantle and play an important role in convection, the plume advocates, along with Wilson and Morgan, attributed many LIPs, large oceanic plateaus and smaller-volume chains of seamounts to mantle plumes (e.g., Griffiths and Campbell, 1990; Hofmann, 1997; Maruyama et al., 2007; Safonova et al., 2009; White, 2010; Dobretsov, 2011). On the other hand, those who opposed the plume hypothesis were critical about the viability of a number of deep mantle plumes, and even questioned the very existence of plumes (Anderson and Natland, 2005; Ivanov, 2007; Foulger, 2010). However, the recent advancements in seismic tomography and core–mantle boundary petrology (e.g., Ohtani and Maeda, 2001; Hernlund et al., 2005; Ono and Oganov, 2005; Zhao, 2006; Zhao et al., 2012), have confirmed the existence of mantle plumes, although uncertainty still prevails about superplumes, with some authors ruling out these (Ivanov, 2007), whereas others hunting for and finding several superplumes with a distinct mantle plume periodicity (Larson and Olson, 1991; Dobretsov, 2010).

In our previous works we discussed the occurrences of plume-related oceanic basalts hosted by accretionary complexes (ACs) of Central and East Asia and suggested that the process of plume-related (intraplate) oceanic magmatism was practically continuous (Safonova et al., 2009). However, mantle plume activity during the same period has been recorded from regions that are far apart on the globe. In this paper, we provide an overview on the occurrences of two major pulses of oceanic intraplate magmatism during the Late Neoproterozoic–Early Cambrian and Cretaceous, and compare them with similar events during the rest of the Paleozoic and Mesozoic. The first pulse of superplume is correlated to the breakup of the Rodinia supercontinent and subsequent formation of the Paleo-Asian Ocean with oceanic islands (oceanic island basalt — OIB), seamounts and plateaus (oceanic plateau basalt — OPB) (e.g., Dobretsov et al., 2003; Maruyama et al., 2007; Li et al., 2008; Safonova et al., 2009). The second pulse during the Cretaceous was generated from the Rodinia-derived slab graveyard at the core–mantle boundary (Maruyama et al., 2007) and formed oceanic plateaus and chains of seamounts/islands in the Western Pacific. OIB-type basalts, i.e. those possessing geochemical affinities to “classic Hawaii OIBs”, of this age have been found in accretionary complexes located far away from the modern Western-Pacific triangular zone: in Japan and Russian Far East including Kamchatka. The nature of occurrence of OIB-type lavas in Russia, Kazakhstan, Mongolia and Japan with a special emphasis on their association with OPS sedimentary units and geochemistry has been brought out in some of our recent studies identifying 9 and 15 ACs in Safonova (2009) and Safonova et al. (2009), respectively. In this paper, we follow the concept that the OIB-type basalts formed in relation to mantle plume and provide an overview of 35 OIB-hosting accretionary complexes in Central and East Asia (including China, Mongolia and Japan), the North-East (Kamchatka) and South-Western (Solomon) Pacific (Fig. 1). Based on this synthesis, we address the two major pulses of superplume-related magmatism as well as the two smaller pulses of oceanic mantle plume magmatism. We also compare these pulses with the major production of continental granitoid magmatism, both juvenile and recycled.

2. Ocean plate stratigraphy

Oceanic rises are important units of OPS and are typical components of most accretionary complexes worldwide (e.g., Isozaki et al., 1990; Wakita and Metcalfe, 2005; Safonova et al., 2009; Isozaki et al., 2010). OPS is defined as the original composite stratigraphy of the ocean floor before it was incorporated in an accretionary complex (AC) and records the succession from the initiation of the oceanic plate at a mid-oceanic ridge to subduction at an oceanic trench (Isozaki et al., 1990). The idealized travel history of an oceanic plate from mid-oceanic ridge to subduction zone is discussed in Santosh (2010b) and Maruyama et al. (2010). At or near the mid-oceanic ridge, pelagic chert is deposited on the base of oceanic crust (Fig. 2). If the ridge rises above the carbonate compensation depth, the chert may be overlain by marine carbonates. As the ocean floor spreads, the basal chert is transported towards the subduction zone, during which period a considerable thick succession of chert layers forms. When the pelagic sediments reach a hemipelagic environment on the offshore side of a trench typically near a continental margin, the oceanic cherts are succeeded by hemipelagic siliceous shales and mudstones that consist of radiolaria and fine-grained continent-derived detritus. Finally, once all these units enter the trench, a voluminous cover of continent-derived detritus is deposited on the top, in the form of shales, sandstones, conglomerates and turbidites. Thus, a typical OPS section is characterized by mid-ocean ridge basalt (MORB)-pelagic chert–hemipelagic siliceous shale, mudstone,