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Review

Rifting, intraplate magmatism, mineral systems and mantle dynamics in central-east Eurasia: An overview

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ABSTRACT

The central-east Eurasia region comprising the Siberian Craton, the Central Asian Orogenic Belt, the Tarim and Sino-Korean cratonic blocks bordered by the Phanerozoic Tethysides, Qinling and SE Asian orogenic belts preserve important imprints of geodynamic processes associated with the formation of continental crust and associated mineral deposits, as well as the assembly and dispersal of supercontinents. From a comprehensive overview of the geologic, geochronologic and metallogenic history of Central-East Eurasia, as well as the recent conceptual models on plate and plume tectonics, we demonstrate that intraplate tectonics, particularly those driven by plumes, exerted an important control on mantle dynamics, magmatic pulses, and the formation of a variety of mineral systems of economic significance. Models of mantle dynamics that attempt to explain intraplate magmatism invoke mantle plumes, various forms of lithospheric delamination, slab roll-back, stagnant slab subduction and hot trans-lithospheric strike-slip fault zones. We confirm that many of the features previously ascribed to subduction-related systems could be well explained by post-collisional intracontinental and extensional settings suggesting that intraplate tectonics played a key role in the secular evolution of the magmatic and metallogenic systems in the Eurasian region.

In this contribution, we provide an overview of the general geology and tectonic framework of central-east Eurasia, including the Siberian Craton, the western-Siberian Lowlands, the Central Asian Orogenic Belt (CAOB), and the Tarim–North China cratonic blocks. This is followed by a discussion and brief description of the rift systems and associated intraplate magmatism of central-east Eurasia, culminating with the giant Siberian rifts and large igneous province Lake Baikal rift system.

We then describe a selection of mineral systems that are unquestionably attributed to intraplate tectonomagmatic processes. These mineral systems include: the Ni–Cu–PGE deposits of Noril'sk–Talnakh, Jinchuan, and those associated with zoned mafic–ultramafic intrusions in NW China, and alkaline–peralkaline complexes, carbonatites and kimberlites in Siberia. In the last part of the paper, we provide an overview of mantle dynamics, for which we consider mantle plumes arising from the core–mantle boundary, asthenospheric mantle upwellings due to delamination, lithospheric thinning and/or subduction slab break-off, asthenospheric upwellings due to flat slab settings and those related to translithospheric strike-slip tectonics.

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1. Introduction

Intraplate tectonics in space and time is one of the keys to understand not only the regional magmatic and metallogenic provinces, but also in evaluating global geodynamic processes including the assembly and dispersal of supercontinents (e.g., Aitken et al., 2013; Bozhko, 2009; Bradley, 2011; M. Santosh et al., 2009; Nance et al., 2014). One of the important windows on the globe to intraplate tectono-thermal events and related mineral systems is the region that extends east of the Ural mountains (Uralides) in the west to the coast of the Pacific Ocean in the east, encompassing Siberia (sensu lato), NW and NE China and Mongolia, north of and excluding the Alpine–Himalayan orogenic belts (or Tethysides) (Fig. 1). This part of central-east Eurasia comprises the Siberian (or Angara) Craton, its marginal fold belts (Baikalides, Yana-Chukotka), the North China (Sino-Korean)-Tarim cratonic blocks and the Altaids or Central Asian Orogenic Belts (CAOB) wedged between the Uralides, and the Siberian and North China–Tarim cratons. Between the Uralides and the Siberian Craton the CAOB is covered by Mesozoic–Cenozoic volcano-sedimentary successions (Western Siberian lowlands, Siberian Traps and associated rift system). The Baikal rift system and accompanying volcanic rocks are superimposed on the Baikalides on the southern margin of the Siberian Craton. Unfortunately, as yet there is no consistent internationally accepted terminology for tectonic units or domains in the whole of Eurasia; for more on this topic and aspects of the geodynamic history of the central Asia region the reader is referred to Faure and Natal'in (1992), Şengör and Natal'in (1996), Hendrix and Davis (2001), Dergunov (2001), Badarch et al. (2002), Nikishin et al. (2002), Dobretsov et al. (2004), Wang et al. (2005), Briggs et al. (2007), Xiao et al. (2004, 2008a), Yakubchuk (2009), Seltmann et al. (2010), Yin (2010), Dobretsov (2011), Xiao et al. (2012), Wilhem et al. (2012), Pirajno (2013), Xiao and Santosh (2014) and Xiao et al. (2014). A comprehensive account of the geodynamics and metallogenesis of northeast Asia is provided by Nokleberg (2010); an edited book on the Precambrian ore systems of the Siberian Craton was published by Rundqvist and Gillen (1997).

Following the closure of the Palaeotethys Ocean, central-east Eurasia effectively became a continental plate, which from the Permo-Carboniferous onward was involved in various stages by rifting and intraplate anorogenic magmatism. We focus our discourse on these geological processes, which are generally accepted as being linked to some form of mantle upwelling (deep mantle plume, asthenospheric upwelling due to subcontinental mantle lithosphere (SCML) delamination, or even to subduction slabs retreat and break-off).

Fig. 1. Tectonic units of the eastern parts of the Asian continent, modified after Xiao et al. (2012).