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Age of the Siberian craton crust beneath the northern kimberlite fields: Insights to the craton evolution

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ABSTRACT

Comprehensive studies of zircon xenocrysts from kimberlites of the Kuoika field (northeastern Siberian craton) and several kimberlite fields of the eastern Anabar shield, along with data compilation on the age of kimberlite-hosting terranes, reveal details of the evolution of the northern Siberian craton. The age distribution and trace element characteristic of zircons from the Kuoika field kimberlites (Birekte terrane) provide evidence of significant basic and alkaline–carbonatite magmatism in northern Siberia in the Paleozoic and Mesozoic periods. The abundance of 1.8–2.1 Ga zircons in both the Birekte and adjacent Hapchan terranes (the latter hosting kimberlites of the eastern Anabar shield) supports the Paleoproterozoic assembly and stabilization of these units in the Siberian craton and the supercontinent Columbia. The abundance of Archean zircons in the Hapchan terrane reflects the input of an ancient source other than the Birekte terrane and addresses the evolution of the terrane to west (Magan and Daldyn terranes of the Anabar shield). The present study has also revealed the oldest known remnant of the Anabar shield crust, whose 3.62 Ga age is similar to that of another ancient domain of Siberia, the Aldan shield. The first Hf isotope data for the Anabar shield coupled with the U–Pb systematics indicate three stages of crustal growth (Paleoproterozoic, Neoarchean and Paleoarchean) and two stages of the intensive crustal recycling in the Paleoproterozoic and Neoarchean. Intensive reworking of the existing crust at 2.5–2.8 Ga and 1.8–2.1 Ga is interpreted to provide evidence for the assembly of Columbia. The oldest Hf model age estimation provides a link to Early Eoarchean (3.7–3.95 Ga) and possibly to Hadean crust. Hence, some of the Archean cratonic segments of the Siberian craton could be remnants of the Earth's earliest continental crust.

1. Introduction

Early Precambrian cratons are the most informative areas for unraveling the history of continental growth and evolution. The age and structure of the cratonic lithosphere is one of the most problematic issues in Earth studies (Pearson et al., 1995a, 1995b; Jahn et al., 1998; Griffin et al., 1999; Artemieva et al., 2002; Griffin et al., 2002; 2003; Wittig et al., 2006; Wu et al., 2006; Pearson et al., 2007; Simon et al., 2007; Wu et al., 2008; Aulbach, 2012; Zheng et al., 2012; Doucet et al., 2015; Shatsky et al., 2015). To assess the age and tectonothermal evolution of cratons, provenance studies of a sedimentary substrate (e.g. Hirata, 2001; Gerdes and Zeh, 2003; Condie et al., 2005; Belousova et al., 2010; Parman, 2015) and magmatic rocks (e.g. Condie, 1998, 2008) are commonly used. Resulting age distributions, commonly coupled with zircon Hf and O isotope data (e.g. Belousova et al., 2010), yield major stages of crustal growth and orogenic events within the continent. For the buried granulite-facies basement of the oldest cratons, the most reliable clues can be found in the age data for zircons and zircon-bearing xenoliths trapped by ascending kimberlites (Davis et al., 2003; Schmitz and Bowring, 2003; Downes et al., 2007; Flowers et al., 2008; Koreshkova et al., 2009; Zheng et al., 2012 and references therein; Wei et al., 2015). Kimberlites are well known as occurring within early Precambrian cratons and sample deep lithospheric roots. In this case, the zircon age data should directly characterize the vertical section of the corresponding lithosphere segment. This approach is required in particular for evaluating histories of composite cratons with a complex and unclear structure such as the Siberian craton (Rosen et al., 1994; Griffin et al., 1999; Rosen et al., 2000, 2002, 2006; Koreshkova et al., 2009).

Current understanding of the age and structure of Siberian cratonic basement and lithospheric mantle has been outlined mostly through studies of exposed rocks of the Anabar and Aldan shields, and the

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Olenek, Kan, Birusa and Sharyzhalgai uplifts (e.g. Rosen et al., 1994, 2006; Wingate et al., 2009; Turkina et al., 2012, 2013; Donskaya et al., 2013), as well as petrological, isotope and zircon age studies of xenoliths in kimberlites (e.g. Neymark et al., 1992; Rosen et al., 1994; Smelov et al., 1998; Kovach et al., 2000; Buzlukova et al., 2004; Shatsky et al., 2005; Rosen et al., 2006; Koreshkova et al., 2009; Vladykin and Lepekhina, 2009; Koreshkova et al., 2011), and a minor amount of geophysical data (Kobussen et al., 2006; Cherepanova et al., 2013; Cherepanova and Artemieva, 2014 and references therein). According to a number of studies, the Siberian craton is composed of several Middle Archean to Early Proterozoic (mostly within 2.4–3.3 Ga) superterranes (Tungus, Anabar, Aldan, Stanovoy) that are believed to have assembled into a single structure and finally stabilized at 1.8–2.1 Ga (Griffin et al., 1999; Parfenov and Kuzmin, 2001; Rosen et al., 2006; Smelov and Timofeev, 2007; Gusev, 2013) (Fig. 1). The assembling event is marked by widespread collision-related granulite metamorphism and collisional and post-collisional granitic magmatism (Rosen et al., 1994, 2000; Donskaya et al., 2003; Larin et al., 2006). Superterranes are suggested to have ancient granulite–gneiss (lower crust) or granite–greenstone (upper crust) basement underlain by lithospheric mantle of the same age but different thicknesses. The latter varies significantly (150–200 km) for different terranes (Pearson et al., 1995a, 1995b; Griffin et al., 1999; Pokhilenko et al., 1999). Strong coupling between the processes of formation of lithospheric mantle and cratonic crust has been pointed out in a number of studies (Griffin et al., 1999; O'Reilly et al., 2001; O'Reilly and Griffin, 2006; Pearson et al., 2007; Doucet et al., 2015 and references therein). Rb–Sr, Sm–Nd, and Re–Os isotope studies have given model ages for peridotite xenoliths from diamondiferous kimberlite pipes of 1.7 to 3.0 Ga (Pearson et al., 1995a, 1995b; Jacob and Foley, 1999; Griffin et al., 2003; Doucet et al., 2015; Pernet-Fisher et al., 2015) that evidently span several stages of tectonothermal history of the craton.

So far, the U–Pb zircon data for the Siberian craton sampled by kimberlites have been reported in detail only for granulite xenoliths from the Udachnaya pipe (Daldyn kimberlite field of the Markha terrane) (Koreshkova et al., 2009) and a few individual zircon xenocrysts from several other pipes (Vladykin and Lepekhina, 2009). This contribution provides the original zircon trace element, age and Hf-isotope data for the cratonic basement beneath the northern kimberlite fields of the Yakutian kimberlite province in order to reassess the tectonothermal history of the Siberian craton. Here we are aiming to give new insights into the Early Precambrian crustal growth and reworking that involved the northern cratonic terranes of Siberia.

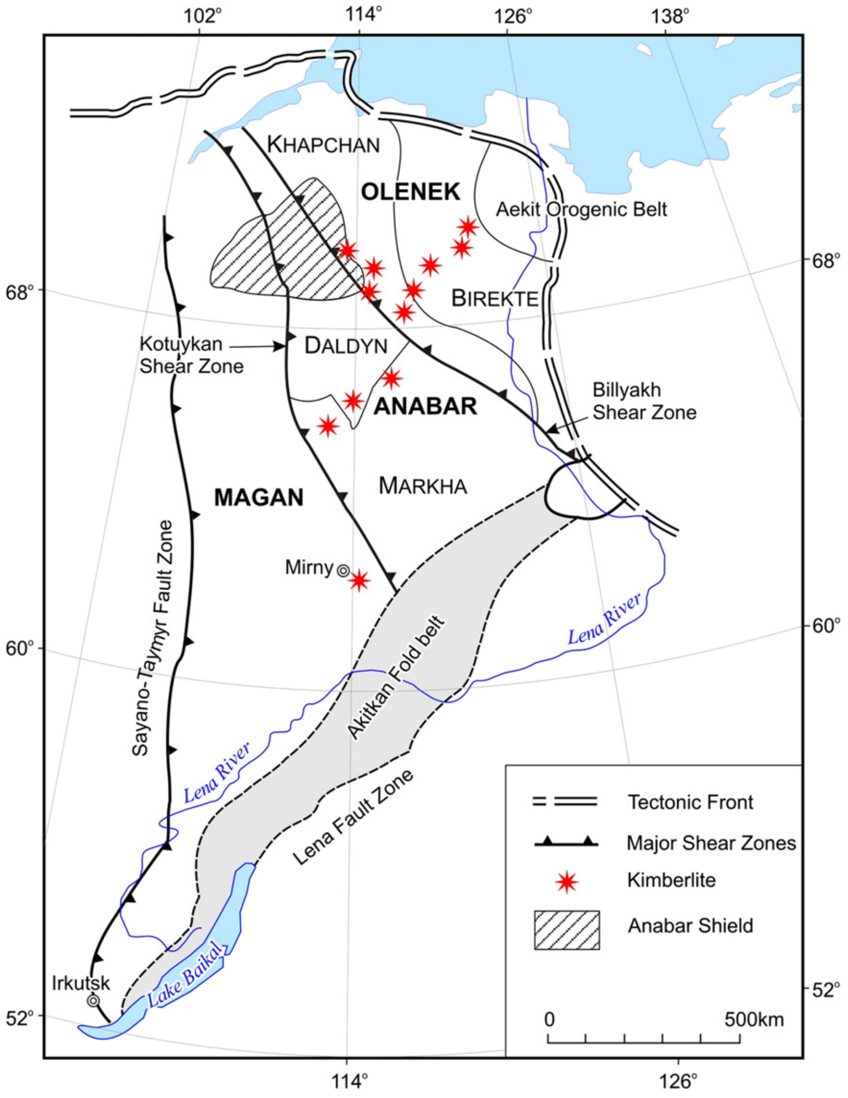

Fig. 1. Terrane structure of the eastern part of the Siberian Platform with the major kimberlite occurrences. *Modified from* Rosen et al. (1994).