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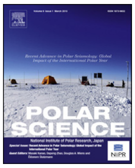

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Seismic and density heterogeneities of lithosphere beneath Siberia: Evidence from the *Craton* long-range seismic profile

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Abstract

The estimate of seismic lithosphere thickness in Siberia remains controversial in spite of long-range controlled–source data available from peaceful nuclear explosions (PNE). Published models of layered upper mantle based on this evidence fail to unambiguously constrain the asthenospheric depth. The observed velocity changes may be due either to vertical layering or to lateral heterogeneity, which are difficult to discriminate because of large (1000 km) PNE spacing. Among the upper mantle models, obtained with reference to Moho velocities derived from higher-resolution chemical explosion data, we focus especially on lateral density heterogeneity. The model reveals three velocity layers, with velocities 8.0–8.5 km/s in Layer 1, 8.6–8.7 km/s in Layer 2, and ~8.5 km/s in Layer 3. Layers 2, which varies strongly in thickness, may consist of dense eclogite, judging by the high velocities. Its base may correspond to the base of the lithosphere underlain by the lower-velocity asthenospheric material of Layer 3.

The lateral variations in velocity within Layer 1 and in thickness of Layer 2 correlate with major tectonic units: the West Siberian basin, the Tunguska basin with the Permian–Triassic continental flood basalts (the large igneous province of Siberian Traps), as well as the Vilyui basin and the Yakutian kimberlite province. Isostasy in the West Siberian and Vilyui basins results in thick sediments and thin crust, while the large depths of the basement and the intra–crustal discontinuity in the Tunguska basin isostatically compensate the elevated surface topography due to voluminous lavas. The magmatism left its imprint in the mantle as an attenuated "eclogitic layer" beneath the Tunguska basin. However, the available data are still insufficient to understand the exact causes of this attenuation, because mantle conditions may have changed during the elapsed 250 m.y. since then.

Keywords: Nuclear explosion; Upper mantle; Siberian craton

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1. Introduction

Modeling of seismic lithosphere in Siberia remains controversial, even though a wealth of data have been available from peaceful nuclear explosions (PNE). They recorded large offsets on long-range profiles (Fig. 1) (Egorkin et al., 1987,; Egorkin, 2004; Cipar and Priestley, 1997; Mechie et al., 1997; Pavlenkova et al., 1996, 2002, 2006; Pavlenkova, 1996, 2006, 2011; Nielsen and Thybo, 1999, 2006; Thybo and Perchuc, 1997; Thybo, 2006; Yegorkin and Pavlenkova, 1981 странная последовательность ссылок — ни по алфавиту, ни по году, только сейчас обратила вниМание — прверьте, поЖ-та). Among numerous published models, we discuss below only

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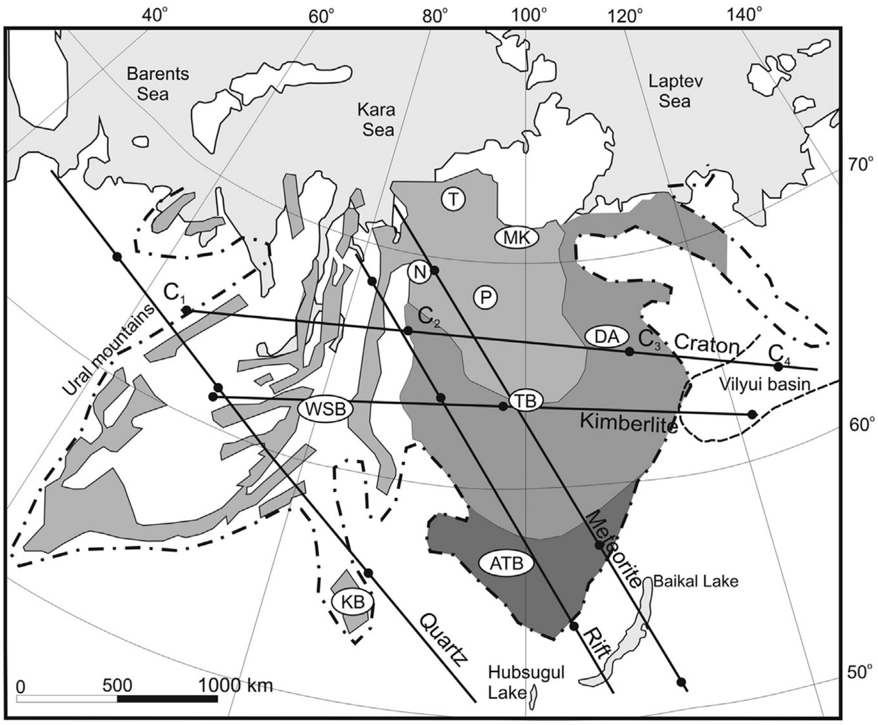

Fig. 1. Large igneous province of the Siberian Traps, added to Ivanov (2007), while Ivanov (2007) was simplified and modified from Masaitis (1983). The abbreviations are: WSB = West Siberian Basin, N = Norilsk, MK = Maimecha–Kotui, P = Putorana, T = Taymyr, TB = Tunguska Basin, ATB = Angara–Taseeva Basin, KB = Kuznetsk Basin, DA = Daldyn–Alakit field of pre–trap kimberlites. Straight lines are seismic profiles, black circles are shot points (Sultanov et al., 1999). Chain contours: the Siberian Trap Province; dash contours: the Vilyui basin. Gray-shaded areas show different types of dominant igneous rocks: lavas (light); sills (dark); tuffs (intermediate).

those relevant to the region of the long-range profile *Craton*. The profile runs along the W–E direction in northern Siberia at about 65° N across the West Siberian Plate of thick Mesozoic–Cenozoic sediments and the Archean Siberian craton. It traverses two Permian–Triassic large igneous provinces: one in the Siberian craton and the other within West Siberia. Continental flood basalts in West Siberia are associated with the Koltogory–Urengoi rift extending northward from the southernmost part of the plate (e.g. Saraev et al., 2009). In the Siberian craton this is the so–called Siberian Trap Province in the Tunguska basin (Dobretsov, 1997, 2005; Ivanov, 2007; Masaitis, 1983; Nikishin et al., 2010, Reichow et al., 2009). Further eastwards, the profile runs through the Yakutian kimberlite province and the Vilyui basin (Fig. 1). The major tectonic units and igneous provinces show up as changes in the thickness of sediments of different ages and in the respective basement topography (Egorkin et al., 1987; Frolov et al., 2011; Nikishin et al., 2010).

The upper mantle velocity structure has been imaged in 1D, 2D layered, tomographic (Nielsen et al., 1999), and laterally heterogeneous models based on *P* wave arrivals from nuclear explosions.

The 1D velocity models commonly adopt vertical stratification with main control of offset-dependent variations in wave patterns (mostly first arrival data, with few reflections in later arrivals). However, the velocity–depth profiles for different shot points are often inconsistent due to lateral heterogeneities (Cipar and Priestley, 1997; Mechie et al., 1997; Ryberg et al., 1998, 2005; Thybo and Perchuc, 1997; Nielsen and Thybo, 2006; Thybo, 2006).

The two-dimensional velocity structure is characterized by ray tracing of first arrivals and later strong events with high apparent velocities which are interpreted as reflections. These models image the upper mantle down to 410 km depth as consisting of five to eight layers with varying velocities. The layer number and depth differ in different models, though the misfit between observed and computed travel times is quite small (Egorkin, 2004; Egorkin et al., 1987; Morozova et al., 2000; Pavlenkova, 1996, 2011; Pavlenkova and Pavlenkova, 2006; Pavlenkova et al., 1996, 2002; Priestley et al., 1994; Yegorkin and Pavlenkova,