

Deep structure of the Ural orogen as derived from the global tomography model Ehime-2006

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The Ural Mountains are a narrow range of low to moderate topography extending for nearly 3000 km from near the Aral Sea in the south to the islands of Novaya Zemlya in the Arctic Ocean, forming the geographical and geological boundary between Europe and Asia. They were formed during the Carboniferous-Permian (345-230 Ma) by the collision of the Baltic shield (East Europe plate) with the Siberian plate and related microblocks and volcanic arcs in between. The collision between the two plates involved the accretion of several volcanic arcs and the obduction of ophiolites. Some of the largest and most extensive ophiolite belts in the world are exposed there. Different from several other mountain ranges of comparable age (like the Variscides, the Appalachians, and the Caledonides), the Urals were not significantly remobilized after the Jurassic. Therefore they are one of the best preserved Palaeozoic orogens.

So far a number of studies have been conducted to investigate the crustal structure under the Urals using the seismic reflection and refraction methods, but the mantle structure under the region is almost unknown. The only study of the upper mantle structure until now is Poupinet et al. (1997) who used teleseismic tomography to estimate a 2-D P-wave velocity structure down to 250 km depth across the middle Urals. They found an east-west asymmetry both in the crust and the lithosphere down to 100 km depth and high-velocity bodies east of the main Uralian fault.

In this work, we have used our Ehime-2006 global tomography model to investigate the deep structure under the Urals. This model was determined by using a flexible-grid parameterization and over one million arrival times of P, pP, PP, PcP and Pdiff waves in the mantle. In and around the Ural region, the Ehime-2006 model has a lateral resolution of 200-300 km and a vertical resolution of 50-100 km. An intriguing feature under the Urals is found from the Ehime-2006 model. A prominent, north-south trending, linear low-velocity (low-V) zone is visible in the depth range of 300-700 km right east of the Ural Mountains between 60 and 70 degree east longitudes. The low-V zone starts at about 80 degree North latitude (north of the islands of Novaya Zemlya) and extends southward to 48 degree North latitude with a total length of over 3000 km. The low-V feature is the most significant in the mantle transition zone depths. We consider that the low-V zone mainly reflects compositional variations such as the buried crust and shallow mantle rocks as well as volcanic materials which were formed during the creation of the Ural orogen by the collision of the East Europe plate with the Siberian plate and related microblocks and volcanic arcs in between. Some fluids in the old subduction and collision systems may be also preserved to the present in the transition zone. It is less possible that a high-temperature anomaly causes the low-V feature because the Ural orogen was formed more than 230 Ma ago. The present result has important implications for the understanding of the old orogens and the dynamic evolution of the Earth.