NEW INSIGHTS INTO THE BASEMENT STRUCTURE OF THE WEST SIBERIAN BASIN FROM FORWARD AND INVERSE MODELLING OF GRACE SATELLITE GRAVITY DATA

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The West Siberian Basin is one of the largest intracratonic basins of the world, with an areal extent of approximately 3.2x10^6 km^2 (corresponding to the basin outline reported in Fig. 1), and holds the primate of largest flat area of the world (Peterson and Clarke, 1991). The basin is of broad interest due to its relation to the oil- and gas- potential, as well as the association to the end-Permian mass extinction. In 2004, 7% of the world's oil production was from the basin, almost entirely from Jurassic and Cretaceous clastic rocks deposited during the post-rift thermal subsidence phase of the basin (Vyssotski et al., 2006). The potential of undiscovered conventionally recoverable oil and gas resources are enormous (Peterson and Clarke, 1991). Another important aspect is related to the end-Permian Siberian trap-basalts, which are a possible cause for the end-Permian mass extinction (e.g. Lane, 2007). Recently coeval basalts underlying the basin have been detected in wells several kilometer deep (Saunders et al., 2005), and this finding increases the total basalt emission at the end-Perm considerably and is an important aspect in the discussion of the origin of the climate

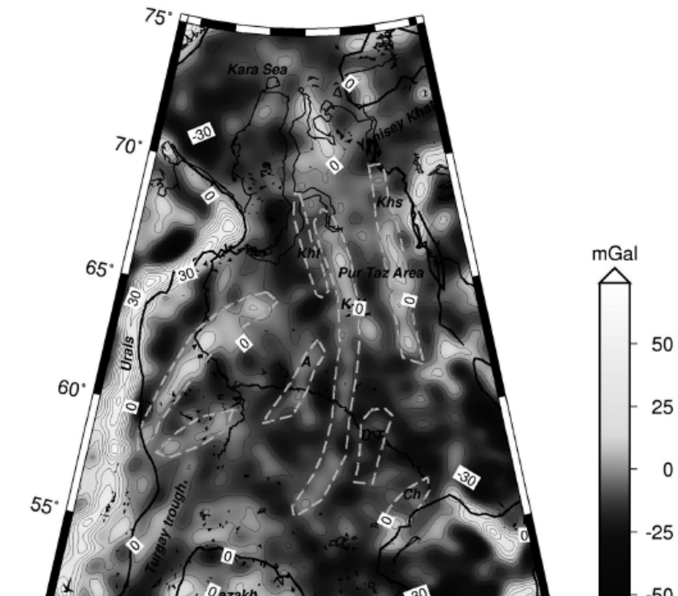

Fig. 1 - Free-air gravity anomaly (mGal = 10^{-5} m/s^2) for the West Siberian Basin area. (Data: EIGEN-GL04C, Förste et al., 2007). Coastline and major rivers. Isoline interval 10 mgal. Basin outline (bold black). Also shown are the proposed graben-rift structures (stippled grey; after Pavlov, 1995). Names of graben-rifts: K-U, Koltogory-Urengoi; Khs, Khudosei; Kht, Khudottei; A, Agan; U'T, Ust' Tym; Ch, Chuzik.

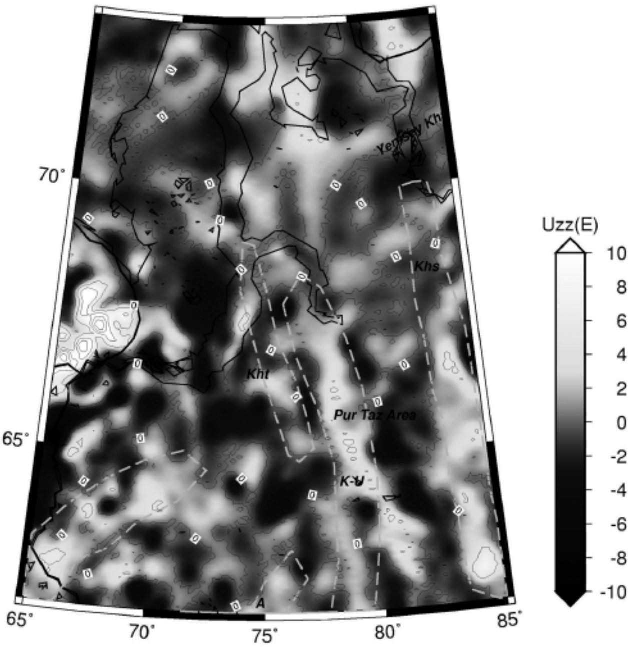

Fig. 2 – Gravity tensor component Tzz (Eötvös) for the Pur Taz area, a central segment of the West Siberian Basin. This gradient component enhances the presence of the proposed graben-rift structures. Geographic features as in Fig.1. Tensor derived from potential field model EGM2008 (Pavlis et al., 2008).

change that produced the mass extinction. An improved knowledge on the crustal structure is the first step towards a realistic estimate of the basalt volumes and thus to a better understanding of the above aspects, placing the West Siberian basin among the topics of broad scientific interest. A key to understanding the formation of the basin is to understand the underlying crustal structure and the sedimentary thickness. The object of our study is to study the crustal structure and segmentation of the West Siberian basin, as it can be recovered from the modelling of the gravity field. We aim to differentiate between the basement units that can be characterised by a diversification of the crustal structure. Our study contributes a new element to the understanding of the basin, by using the newly acquired and developed GRACE gravity field and its derivatives (e.g. Förste et al., 2007; Pavlis et al., 2008) with well developed and established methodologies (e.g. Braitenberg et al., 2003; 2006; 2007; Braitenberg and Ebbing, 2007; Ebbing et al., 2007; Shin et al., 2007; Wienecke et al., 2007).

We reduce the observed gravity field to the basement level, estimating the gravity field of sediments and of known basalt. Published seismic sections are used to constrain the sediment isopachs and to estimate a depth-density-function. We use published models of crustal thickness and basement depth. The resulting 3D-density model gives information on density anomalies in the lower crust and upper mantle and the basalt thickness. We use the gravity tensor to identify structures of the basalt layer (see Fig. 2 as an example). The lower crust below the West Siberian Basin shows considerable density variations, synthesizable into four blocks. We identify several rift-graben structures which presumably are filled with basalt. The eastern part of the basin towards the Siberian platform shows an evident arch-shaped density increase in the lower crust, accompanied by a linear high-density anomaly extending for over 1500 km length bending into the Yenisey-Khatanga trough. We show that the GRACE-gravity field and its derivatives can be applied to map geologic structures as buried rifts and large basins. The same technique can be used for other remote large basins as the cratonic South-American basins.

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