STRUCTURE AND EVOLUTION OF THE CRUST AND UPPERMOST MANTLE BENEATH YAKUTIAN KIMBERLITE PROVINCE FROM SEISMIC DATA

V.D.Suvorov[1], K.V.Timirshin [1], Yu.A.Yurin [1], S.V.Krylov[2], B.S.Parasotka [3], S.D.Cherny [3], V.S.Seleznev [4], V.M.Soloviev [4], V.D.Matveev[5]

1. Yakut Institute of Geosciences, Siberian Branch, Russian Academy of Sciences, Yakutsk, 677891 Russia
2. Institute of Geophysics, Siberian Branch, Russian Academy of Sciences, Novosibirsk, 630090 Russia
3. Diamonds of Russia-Sakha Company, Mirnyi, 678170,Yakutia, Russia
4. Vibroseismic Expedition, Siberian Branch, Russian Academy of Sciences, Novosibirsk, 63060 Russia
5. Regional State Enterprise "Yakutskgeofizika", Yakutsk, 67700, Russia

Detailed studies of the crust and uppermost mantle in the province started in 1980. At that time, a profile across the Mirnyi kimberlite field revealed an anomalously high boundary velocity at the Moho (Uarov, 1981; Suvorov et al., 1983). Field studies were financed by the Yakutskgeologiya production-geological association and carried out jointly with the Siberian Branch of the Academy. The purpose was to map velocities at the Moho and the crystalline basement and study the topography of marker boundaries in the crust in order to identify seismic anomalies typical of the kimberlite fields. The work was performed on three profiles (across two kimberlite fields) totalling 1100 km in length using reversed seismic refraction data. In addition, a technique of special areal deep seismic observations was used (Krylov et al., 1983; Suvorov et. al., 1985; Suvorov et al., 1989). Seismic data were obtained on a 400 km by 1000 km area that covers four Middle Paleozoic diamondi kimberlite fields. Also used in these studies were the Taiga-2 seismic refraction recording stations (mainly of one-component type) with analogue tape recorder.

For Western Yakutia, the principal waves are basement-refracted Pg (traceable interval 15-150 km from the source), Moho-refracted Pn (traceable for 200-400 km) and Moho-reflected PmP (traceable for 100-180 km). There is also a very strong wave (PcP) at a distance of 180-370 km in secondary arrivals, quite similar to wave reflection from the top of the lower crust. Shear waves from the same boundaries permit one to derive Vp/Vs ratios for the crust. The weak Sn-wave could not be reliably defined and digital data processing is required.

Topographic maps of the Moho, basement and inner crustal boundary of the study area have been constructed, as well as maps of velocity variations at the Moho and the basement.

The strongest anomaly are abrupt Moho velocity fluctuations (from 8 to 9 km/s) within a 220 km wide corridor extending for at least 1000 km in a SNP direction. It bifurcates into two branches at the north, one in NW direction and the other in NE. Within the corridor, local high-velocity (8.6-9 km/s) anomalies can be traced as 40-60 km wide, elongated strips separated by similar strips of normal velocities (8-8.2 km/s). The strike of the high-velocity strips differs from that of the regional corridor, being submeridional in its southern part, north-western in its central part and north-eastern in its northern part. There is no clear azimuthal dependence of the Pn velocities. Therefore, the observed velocity anomalies are interpreted as upper mantle inhomogeneities, although no rock readily offers itself as having such a high velocity (Christensen,1994; Sobolev, et al.,1994). All six kimberlite fields known in this region are located within the corridor above the edges of local high velocity anomalies. This suggests that the corridor of the highly heterogeneous Moho velocities controls the regional localisation of the kimberlite fields. The Moho depth increases northwards from 39-42 km to 55-60 km. The Moho trough with about 100 km width and 12-20 km amplitude is located in the north-eastern part of the area. The orientation of the trough changes significantly and it can be traced in a southerly direction with amplitude decreasing to 2-4 km. The trough correlates well with the corridor of velocity inhomogeneities and bounds it from the east.

The topography of the inner crustal boundary shows a well-defined submeridional linearity. The depth of the boundary changes from 18-22 km to 34-38 km to form narrow (50-70 km wide) synclines and anticlines with up to 4-6 km amplitude in the most raised central part.

The basement depth changes from 1-1.5 km to 5-6 km. Basement uplifts occur in the central part where kimberlite fields are located. The depth increases significantly in the Vilyui (Middle Paleozoic) and Tunguska (Lower Paleozoic) basins and the Patoma foredeep (Middle Paleozoic and possibly, younger). There are two 30-40 km wide local grabens, possibly of Precambrian age: one near the Daldyn-Alakit kimberlite field and the other in the south-western part of the study area.

Example of the relationship between the structure of the crust and sedimentary cover is shown in a cross-section intersecting the area from the north-west to the south-east (Figure). Local troughs of the Moho correlate with the raised parts of the inner crustal boundary. The latter, in turn, correlate well with the basement topography derived from drilling and seismic data. Paleostructure cross-sections of the sedimentary cover indicate that basement uplifting commenced in the Middle Paleozoic and continued at least till the Mesozoic (central part of the structure is missing rocks from the Silurian up to Pz_3-Mz). The basement topography and cover structures (from CDP data) form a regional uplift of submeridional strike, coincident with the strike of the raised parts of the inner crustal boundary. The Moho topography anomalies show a very weakly defined submeridional strike. From this there is ground to suggest that uplifting of the basement and the sedimentary cover was due to processes responsible for the formation of the lower crustal structures. This could caused by east-west lithospheric compression (Mezhvilk, 1977) leading to tectonic flow and linear folds in the lower crust. This process could also cause displacements along maximum tangential stresses in more rigid upper mantle and basement rocks, reflected in alternation of normal and abnormal velocity zones at the Moho. Such zones may correspond to trap dikes in the sedimentary cover.

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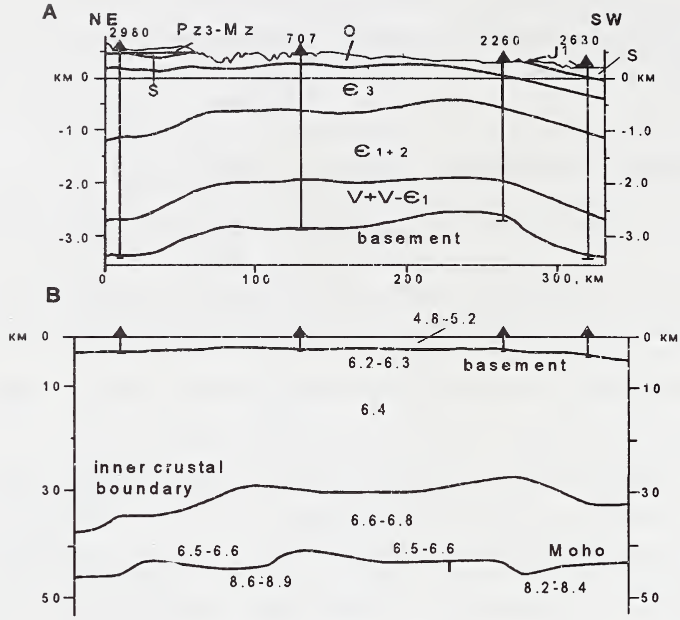

Figure. Structure of the sedimentary cover (A) and crust (B) in the south-western part of the province. Shown in the cover are major rock complexes by age. Shown in the crust are surfaces of the basement, mantle, inner crustal reflecting boundary ,as well as velocities in km/s.