



Lithological crust-mantle boundary in Precambrian areas: constraints from S-wave velocity models and gravity modelling

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Controlled source seismic experiments in the Fennoscandian Shield and in the western part of the East European Craton (EEC) demonstrated that the Moho boundary is not always easily detectable by the methods based upon interpretation of P-waves (e.g. reflection profiling and wide-angle reflection and refraction experiments). Generally, the Moho appears to be reflective in the areas where the depth to the Moho is of about 38-45 km, while in the areas of deeper Moho (>50 km) it appears as a weakly reflective boundary or transition zone. In this case the position of the lithological crust-mantle boundary cannot be easily retrieved. However, in shield areas the quality of S-waves in wide-angle reflection and refraction data is comparable with that of P-waves due to absence of thick sediments. This opens possibility for developing independent S-wave velocity models of the crust and estimating the V_p/V_s ratio in various crustal layers and geological units. Analysis of S-wave recordings of several wide-angle profiles in the Fennoscandian and Ukrainian Shields showed that in contrast to P-waves, the recordings of S-waves demonstrate clear reflections from the Moho boundary (SmS), both in the areas of thick and thin crust. The reflections can be explained by strong contrast of S-wave velocity at the Moho, which agrees with the results obtained by teleseismic receiver function studies based on analysis of P- to SV conversions. This suggests that the Moho obtained from S-waves indicates the present-day position of

the lithological crust-mantle boundary. The depth to this boundary varies in a wide range (e.g. 38-65 km), indicating that the present-day crust-mantle boundary was formed at different time by a variety of tectonic processes. In addition, the S-wave velocity models can be used to calculate density models of the crust. For this purpose we used a method of gravity data inversion, in which the density model is parameterised by the relationship connecting density to both P- and S-wave velocity models. Such a parameterisation makes it possible to obtain not only the density model, but also the relationship between density and seismic velocities. Using this technique, we obtained and analysed relationships between density and seismic velocities (V_p and V_s) for selected geological units of the Fennoscandian and Ukrainian Shields. Generally, all these relationships are close to linear. However, they are scattered, differ from each other and deviate from the corresponding relationships for anhydrous magmatic rocks with averaged chemical composition selected as reference curves. Comparison of these relationships to the petrophysical data suggests that deviations of density-velocity curved from reference density- V_p and density- V_s curves can be explained by specific mineral composition of rocks, resulting from different age and conditions of crust formation. Therefore, the analysis of density-velocity diagrams can be used to restrict the composition of the crust and, in particular, the composition and metamorphic grade of the lower crust. Thus, if the density-velocity relationships are close to the reference curve in the range of velocities corresponding to the lower crust and the density values are less than 3.0 g/cm³, it may indicate that the lower crust is composed of rocks of mafic composition and granulite metamorphic grade. The density- V_p relationship shifted to the higher velocities from the reference curves indicates the high plagioclase content and absence of amphibole, which is typical for igneous rocks. On the contrary, the shift from the reference curve to the lower velocity values may indicate the high content of amphibolite facies rocks. The density values in excess of 3.0 g/cm³ indicate that the lower crust was metamorphosed under high pressure conditions and contains high proportion of garnet-bearing rocks, i.e. mafic garnet granulites and/or eclogites.