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The heterogeneous lithosphere beneath the Ukrainian Shield

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The tectonic history of the Sarmatian crustal segment and the Ukrainian Shield (UkS) included: a) collision of 3.7-2.6 Ga Archaean and 2.3-2.1 Ga Palaeoproterozoic terranes between 2.1 and 2.0 Ga, b) subduction of oceanic crust and formation a large magmatic belt along its NW margin at 2.0-1.95 Ga, c) collision of Sarmatia with Fennoscandian terranes at 1.82-1.80 Ga and intense post-collisional AMCG (anorthosite-mangerite-charnockite-granite) magmatism at 1.79-1.74 Ga, d) incipient rifting at ca. 1.3-1.0 Ga, e) formation of SW passive margin with continental flood basalts at ca. 570-550 Ma, and f) major rifting and formation of the Devonian Pripyat'-Dniepr-Donets Aulacogen at ca. 380-360 Ma. Concomitantly, both lateral and vertical compositional variation in the mantle was defined by the degrees of mantle differentiation and depletion during recurrent magmatism and due to metasomatic enrichment of the depleted mantle during its fluidization. Juxtaposition of tectonic terranes of different ages also contributed to the UkS mantle heterogeneity. This is confirmed by petrological and isotopic studies of mantle-derived tholeiitic and alkaline ultramafic rocks of Palaeoproterozoic and Devonian ages, which occur in the different blocks of the UkS. These rocks are: Palaeoproterozoic (Kirovograd) and Devonian (Azov and NW Volyn) basaltoid and mica-rich kimberlites, (2) Palaeoproterozoic lamproites (Azov and Kirovograd), (3) Palaeoproterozoic carbonatites, ijolites and other alkaline ultramafic rocks (the Azov, Podolian and Volyn blocks).Other evidence derives from

mantle- and lower- crustal xenoliths, particularly abundant in some Palaeoproterozoic and Devonian kimberlites, and also from mantle minerals in alluvial placers. Various geophysical approaches, and particularly seismotomography and heat flow modelling, suggest that the lithosphere beneath the UkS can be as thick as 250 km, while large regions of “cold“ and thick lithosphere generally coincide with Archaean crustal blocks. These regions are separated by the N-S trans-cratonic Ingul/Kirovograd zone of high heat flow and electric conductivity, which most probably was developed at ca. 1.8 Ga. The seismic images of the upper lithosphere obviously change at depths of more than 100 km, which appears to have been due to Devonian or later arrivals of deep mantle plumes. In the upper mantle, reconstructions of compositional variation by employing xenoliths and alluvial minerals indicate significant diversity with depth. Garnet-spinel ś phlogopite bearing harzburgites, lherzolites, pyroxenites, dunites and eclogites occur in various proportions. Their chemistry was defined by both depleted and enriched mantle sources. Isotopic (Nd-Sr-Pb) analyses of mantle-derived rocks in the different crustal blocks are still relatively few and occasionally the isotopic compositions have been modified by post-magmatic processes. Nd-isotope data typically show mildly depleted to slightly enriched compositions for almost all the studied rocks, which range in age from Archean to Devonian. Sr isotope data are quite variable, comprising both unrealistically low and very radiogenic ratios when calculated to the times of rock crystallization. Post-magmatic open-system behaviour and crustal assimilation during magma generation may therefore have played a role. However, a majority of the Sr isotope data appear to yield consistent and reasonable initial 87Sr/86Sr ratios, e.g. between 0.702 and 0.703 for the 2.1-1.8 Ga rocks. The Pb isotope data suggest that at least some parts of the mantle were enriched in uranium already in the Archaean as evidenced by highly radiogenic Pb compositions for rocks of different ages. Moreover, several whole-rock analyses suggest elevated 207Pb contents, consistent with an enriched source of the protoliths. In summary, the geophysical, mineralogical and isotopic data demonstrate that the most pronounced structural and compositional changes of mantle composition probably occurred at ca. 2.1-2.0, 1.8, and 0.4 Ga.