nection with the deep structure and dynamics of the lithosphere of the Ukrainian Shield // Geophys. J. — 2007. — **29**, № 5. — P. 3—34 (in Russian).

Starostenko V. I., Lukin A. E., Kobolyev V. P., Rusakov O. M., Orlyuk M. I., Shuman V. N., Omelchenko V. D., Pashkevich I. K., Tolkunov A. P., Bogdanov Yu. A., Burkinsky I. B., Loiko N. P., Fedotova I. N., Zakharov I. G., Chernyakov A. M., Kuprienko P. Ya, Makarenko I. B., Legostayeva O. V., Lebed T. V., Savchenko A. S. Model of deep structure of the Donets folded construction and surrounding structures according to the regional geophysical observations // Geophys. J. — 2009. — **31**, № 4. — P. 44—68 (in Russian).

Stephenson R. A., Van Weiss Ja. D., Stovba S. N., Shymanovsky V. A. One-dimensional numerical modeling of tectonic immersion of DD within the concept of extension of the continental lithosphere by Mac Kenzie // Geophys. J. — 1997. — **19**, № 3. — P. 25—41 (in Russian).

Deep structure and geodynamics of the Kirovograd ore district (Ukranian Shield): correlation of geological and seismic data

© V. Starostenko[1], V. Kazansky[2], G. Drogitskaya[1], N. Popov[1], A. Tripolsky[1], 2010

[1] Institute of Geophysics, National Academy of Sciences of Ukraine, Kiev, Ukraine
earth@igph.kiev.ru
[2]Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry,
RAS, Moscow, Russia
director@igem.ru

The central part of the Ukrainian shield, where the Kirovograd ore district is located, has been the subject of prolonged investigation of the Institute of Geophysics in cooperation with another research Institutions. Around 20 years ago, A. V. Chekunov et al. (1989) proposed a geodynamic model of this territory, derived from geophysical and geological data. The model is illustrated by the geotraverse VIII Odessa — Krivoy Rog, which intersects the Kirovograd (now Ingulets) lithospheric block and adjacent protogeosynclines (Fig. 1). The Kirovograd block is distinguished from them in seismic velocities in crust and at the Moho discontinuity and in thickness of the crust (35—38 km against 54—58 km). The block is cut by steep faults and gentle tectonic zones which extend into upper mantle. The suggested model explained these phenomena by the continuous development of a mantle plume or a protoasthenolite, which originated at the beginning of Early Proterozoic, influenced the deposition of the ingulo-ingulets series and caused the emplacement of granites, anorthosites and rapakivi granites in crust at the mature stage.

The current study of deep structure of the Kirovograd ore district [Starostenko et al., 2010], is based on the correlation of geological and seismic data, using modern technologies, and accounts for new isotopic dating [Shcherbak et al., 2008]. The study proceeds from a broad interpretation of space boundaries of the Kirovograd polymetal ore district and the incorporation of uranium, lithium, gold and titanium deposits in these boundaries (Fig. 2).

The study indicates that in the Kirovograd ore district, the Paleoproterozoic magmatism started after deposition of the ingulo-ingulets series and developed in two short-lived (30—40 Ma) stages. During the first stage (2.06—2.02 Ga), the crustal Novoukrainsk-Kirovograd granitoid massif formed. During the second stage (1.75—1.72 Ga), the mantle-derived Korsun’-Novomirgorod rapakivi-anorthosite massif originated. In conjunction, they constitute the Novoukrainsk-Korsun’-Novomirgorod pluton which defines the surface structural pattern of the ore district.

Lithium, uranium and gold deposits are located in the Novoukrainsk-Kirovograd granitoid massif and the connected Kirovograd and Zvenigorod fault zones [Bakarzhiev et al., 2005]. Lithium deposits are close in age (2.0 Ga) to the Novoukrainsk-Kirovograd massif and associated with local granite-migmatite domes. Uranium deposits are dated at 1.8 Ga, overprinted on the massif and controlled by its rejuvenated structural elements. Gold deposit’s age is unclear. In combination, the deposits outline a wide

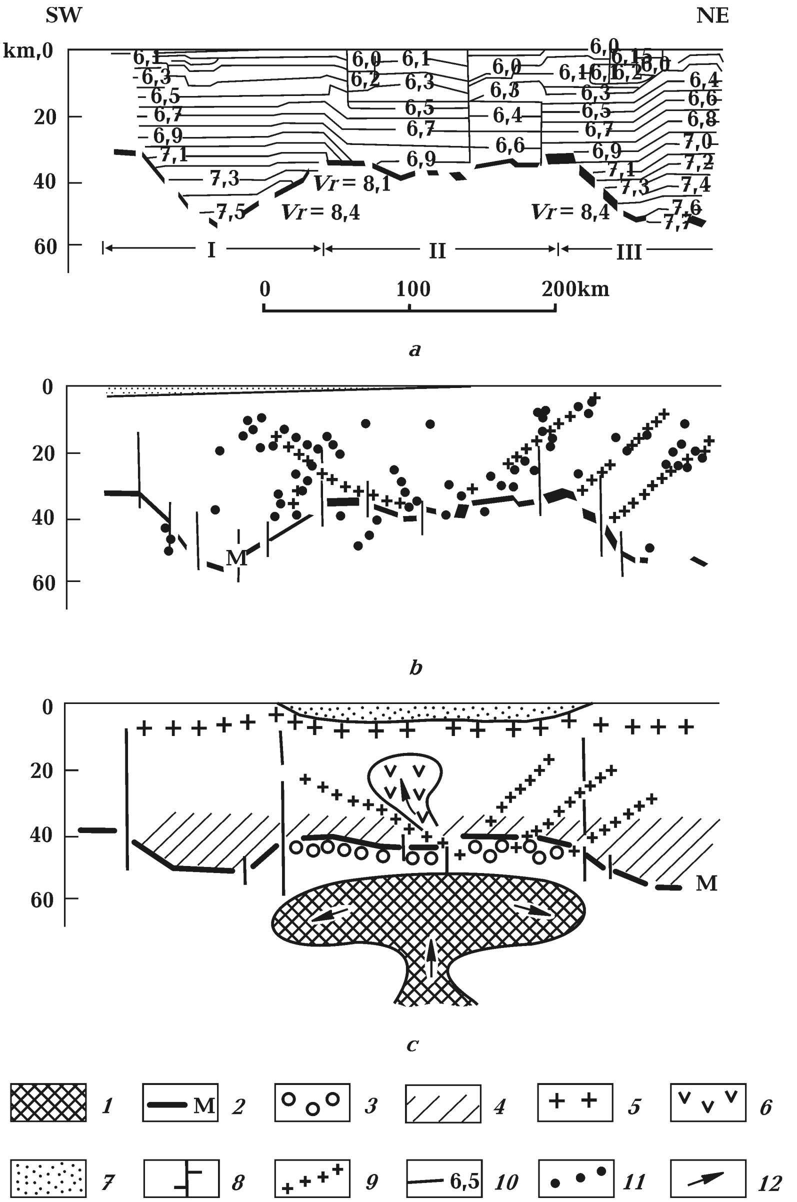

Fig. 1. Deep structure of the Kirovograd lithospheric block along the geotraverse VIII (modified after Chekunov et al., 1989): *a* — velocity section, *b* — seismic section, *c* — geodynamic section *(1* — protoasthenolite; *2* — Moho discontinuity; *3* — zone of the matter transformation at the crust-mantle boundary; *4* — basaltic layer; *5* — crystalline basement; *6* — mantle-derived magmatic rocks in crust; *7* — sediments; *8* — faults; *9* — gentle thrusts; *10* — seismic velocities (km/s); *11* — diffraction points; *12* — direction of the matter transfer); I — Odessa-Yadlov protogeosyncline; II — Kirovograd lithospheric block; III — Krivoy Rog protogeosyncline.

(30—35 km) longitudinal band going in parallel to the Subbotin-Moshorin fault zone and across the Novoukrainsk-Korsun'-Novomirgorod pluton. It was previously assumed that within the latitudinal band, the uranium deposits and host rocks had been subsided by east-west faults that preserved them from erosion [Genetic …, 1995]. Nowadays the band is related to a deep sublatitudinal trough in the Moho discontinuity relief (Fig. 3). The discovery is the first to establish the spatial association of Paleoproterozoic hydrothermal ore deposits with a middle-scale anomaly of the crust-mantle boundary [Starostenko et al., 2007].

The Korsun'-Novomirgorod rapakivi-anorthosite massif is devoid of Li, U, Au deposits and contains titanium mineralization of magmatic origin. Where-

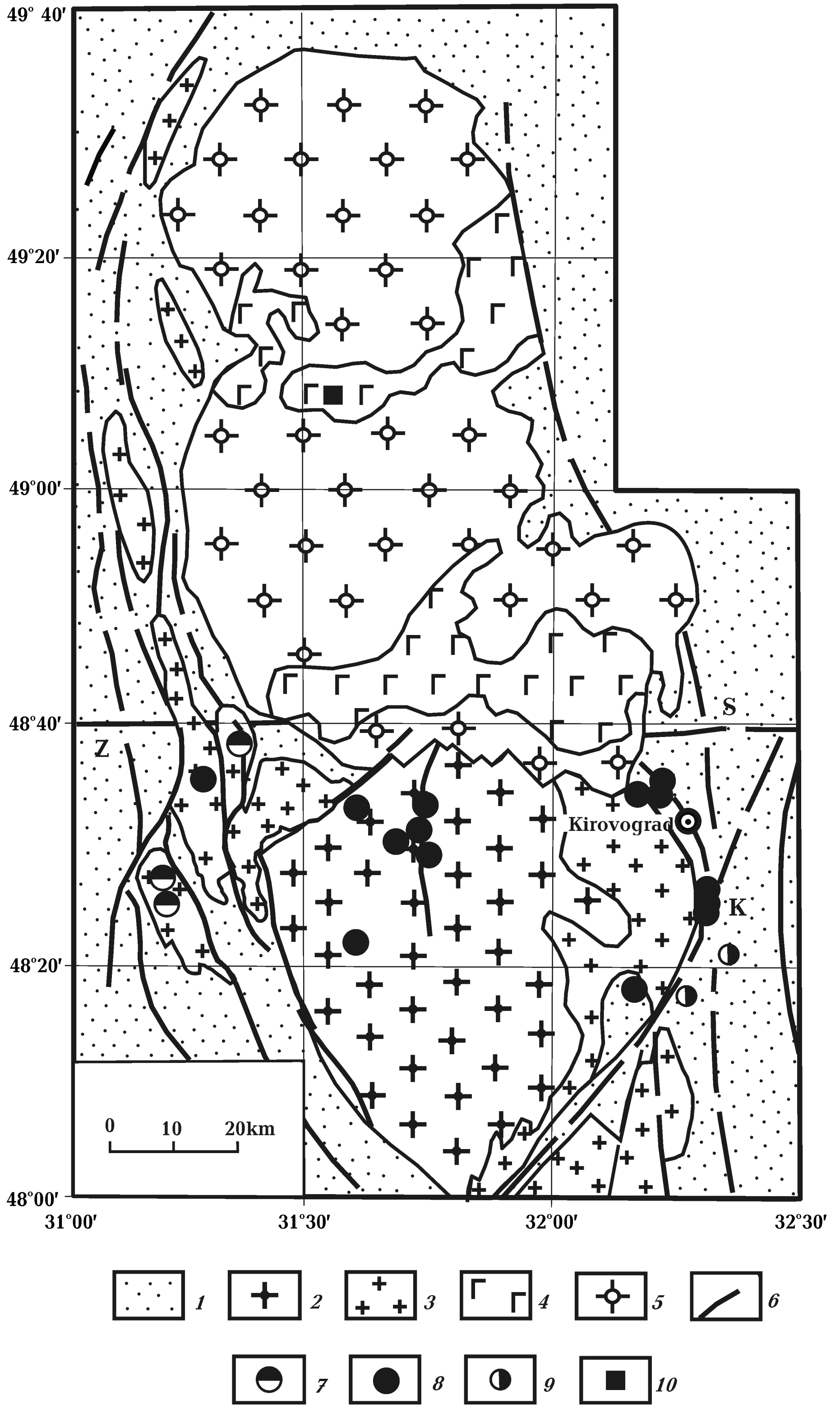

Fig. 2. Geological map of the Kirovograd polymetal ore district (modified after Starostenko et al., 2010): *1* — stratified ingulo-ingulets series; *2*, *3* — Novoukrainsk-Kirovograd massif (*2* — diorite-monzonite complex, *3* — granite-migmatite complex); *4*, *5* — Korsun'-Novomirgorod massif (*4* — gabbro-anorthosites, *5* — rapakivi granites); *6* — faults; *7—10* — ore deposits (*7* — lithium, *8* — uranium, *9* — gold, *10* — titanium). Fault zones: K — Kirovograd, S — Subbotin-Moshorin, Z — Zvenigorod.

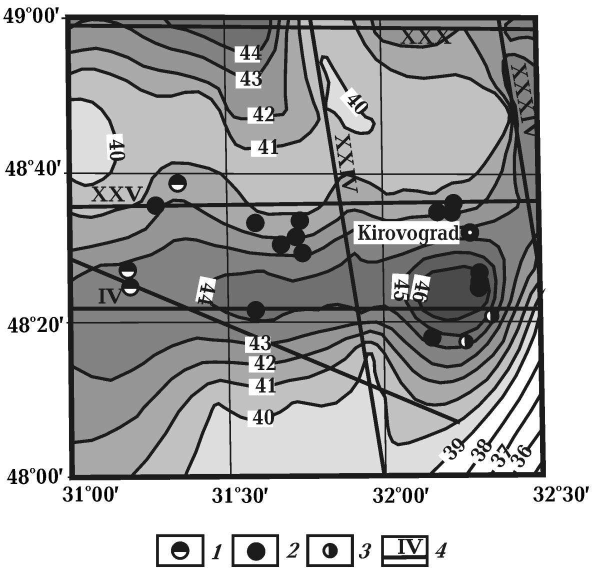

Fig. 3. Projection of ore deposits on the Moho discontinuity relief (depth isolines in km): *1—3* — ore deposits (*1* — lithium, *2* — uranium, *3* — gold); *4* — DSS profiles.

as the Novoukrainsk-Kirovograd massif and the ingulo-ingulets series build up an intrusive-ultrametamorphic basement of the district, the autonomous Korsun'-Novomirgorod massif is inserted in the basement. By seismic methods, the first is traced to a depth of 15—20 km, the second to a depth of 40—50 km, that is below the Moho boundary (Fig. 4). Against this background seismic anomalies are interrupted over and below the mantle trough. It should be emphasized that this seismic "gap" extends from the surface into the upper mantle.

The above-listed geological, age and seismic data suggests that the Kirovograd ore district developed under three different geodynamic environments (Fig. 5). The first was marked by the formation of the Novoukrainsk-Kirovograd granitoid massif as a constituent of the intrusive-ultrametamorphic basement, the second resulted in the tectonic activization of the basement, the third was dominated by the emplacement of the Korsun'-Nowomirgorod rapakivi-anorthosite massif. Taking into consideration a unique combination of tectonic structures, intrusive rocks, deposits and geodynamic environments, we regard the Kirovograd ore district as a Paleoproterozoic center of intense conjugated mantle-crust magmatism and endogenous ore formation.

The work is performed according to a research agreement between IGPH and IGEM and supported by the program P-22 Rassian Academy of Sciences.

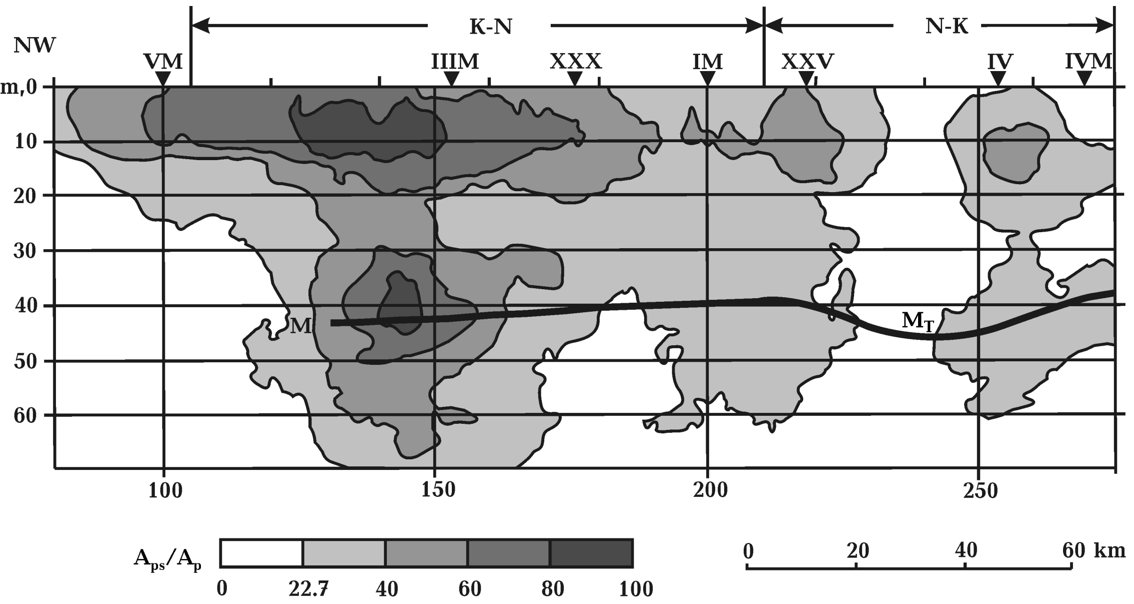

Fig. 4. Convertability of environment by MCWE data along vertical section of the Novoukrainsk-Korsun'-Novomirgorod pluton. A_{PS}/A_P — ratio of the converted wave amplitude to same of *P*-wave generates by former one. K-N — Korsun'-Novomirgorod rapakivi-anorthosite massif; N-K — Novoukrainsk-Kirovograd massif; M — M discontinuity; M_T — mantle trench. VM, IIIM, IVM — intersection points by deep sections along MCWE profiles; XXX, XXV, IV — intersection points by deep sections along DSS profiles.

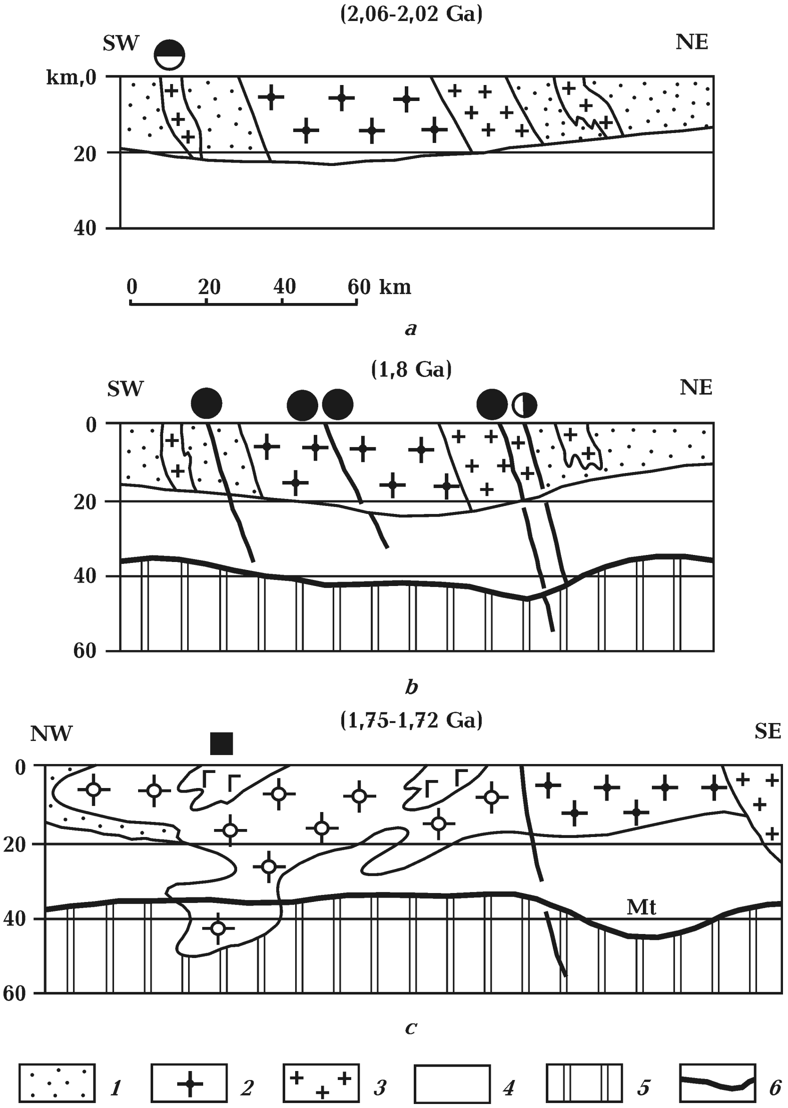

Fig. 5. Geodynamic and metallogenic evolution of the Kirovograd ore district: *a* — formation of the intrusive-ultrametamorphic basement and lithium deposits; *b* — tectonic activization of the basements and metasomatic uranium ore formation; *c* — emplacement of mantle-derived anorthosites and rapakivi granites accompanied by titanium mineralization. Figure captions: *1*—*3* — intrusive-ultrametamorphic basement (*1* — stratified ingulo-ingulets series; *2* — diorite-monzonite complex; *3* — granite-migmatite complex); *4* — middle-low crust; *5* — upper mantle; *6* — Moho boundary; Mt — mantle trough. For other captions see Fig. 2.

References

Bakarzhiev A. Kh., Makivchuk O. F., Popov N. I. Development of mineral-resource base of Ukraine // Razv. okhr. nedr. — 2005. — № 10. — P. 50—58 (in Russian).

Chekunov A. V., Sollogub V. B., Galetskii L. S., Kurlov N. S. Geodynamic model of the central part of the Ukrainian shield and the Krivoy Rog superdeep borehole // Geophys. J. — 1989. — **11**, № 4. — P. 3—13 (in Russian).

Genetic types and occurance mode of uranium deposits of Ukraine / Eds. Ya. N. Belevtcsev, V. B. Koval. — Kiev: Nauk. dumka, 1995. — 396 p. (in Russian).

Shcherbak N. P., Artemenko G. V., Lesnaya I. M., Ponomarenko A. N. Geochronology of Early Precambrian of the Ukrainian shield. Proterozoic. — Kiev: Nauk. dumka, 2008. — 299 p. (in Russian).

Starostenko V. I., Kazansky V. I., Drogitskaya G. M., Makivchuk O. F., Popov N. I., Tarasov N. N., Tripolsky A. A., Sharov N. V. Relationships of surface structures of the Kirovograd ore district (Ukrainian shield) with local heterogeneities of the crust and the Moho discontinuity relief // Geophys. J. — 2007. — **29**, № 1. — P. 3—21 (in Russian).

Starostenko V. I., Kazansky V. I., Popov N. I., Drogitskaya G. M., Zayats V. B., Makivchuk O. F., Tripolsky A. A., Chicherov M. V. From surface structures to the integrated deep model of the Kirovograd ore district (Ukrainian shield), I // Geophys. J. — 2010. — **32**, № 1. — P. 3—33 (in Russian).

Variations in the crustal types of the Dnieper-Donets Basin and surrounding areas from 3D gravity modelling

Institute of Geophysics, National Academy of Sciences of Ukraine, Kiev, Ukraine
irinam@igph.kiev.ua

There are two reasons for constructing a new three-dimensional density model of the Dnieper-Donets Basin (DDB) and surrounding areas. 1) A lack of reliable data on the structure of the deep horizons in the sedimentary cover and crystalline crust. 2) Recently fresh geological and geophysical data have been obtained for the upper sedimentary layers (up to depths of 5—6 km) from seismic data (DSS and MCSP) along the DOBRE1 and DOBRE2 profiles [Grad et al., 2003, Maystrenko et al., 2003].

In this study modern software has been applied [Starostenko et al., 1997; 2004]. It has a principal advantage over standard approaches because density maps of individual layers are automatically input into a PC, enabling geological environments to be approximated very accurately. A technique of constructing a 3D model and converting it into a schematic map of layers types are described in detail elsewhere [Kuprienko et al., 2007].

3D modelling has resulted in a new pattern of the density for the whole crust of the DDB and surrounding areas. It has been used to compile schematic maps for a thickness of the "granitic, "dioritic" and "basaltic" layers (the upper, middle and lower crust). Earlier based on the generalization of relationships of velocity vs. depth and density vs. velocity for different types of the crust, it has been put forward a conditional subdivision of the whole crust into three stages without sharp boundaries between them. They have been defined as the upper, middle and lower crust. Due to traditions they have been named as "granitic, "dioritic" and "basaltic" layers. Their parameters are as follows: 1) $\rho<2.75$ gcm^{-3}, $V_P<6.30$ kms^{-1}; 2) $\rho=2.75\div2.90$ gcm^{-3}, $V_P=6{,}30\div6{,}80$ kms^{-1}; 3) $\rho>2.90$ gcm^{-3}, $V_P>6.80$ kms^{-1} respectively. Petrologically the first range of the parameters is a mixture of acid and intermediate rocks. The second series is composed of a mixture of intermediate and basic rocks (granodiorites, diorites, charnokites, many gneisses, shists, metabasic rocks, and gabbroids). The third row consists of intrusive rocks of basic and ultrabasic composition and metamorphic rocks (granulites, amphibolites) [Lithospheric …, 1993].

A relationship of a thickness of each layer to a total thickness of the crust demonstrates the contribution of each layer into a total thickness of the crust. The name of the crustal type corresponds to prevailing portion of any layer.

The portion of "granitic" layer (Fig. 1, *a*) within the DDB iz characterized by a ratio of 0—0.4. The highest values correspond to the southern flank of Poltavskii megabloc (0.4), the northern side and the southern preflank zone of the Lokhvitskii and Poltavskii megablocs, as well as most of the northern flank, where the percent ratio is 0,3. The smallest proportion of the layer belongs to the central zone of megablocs (0.0—0.1). On the rest of the areas layer portion is 0.0—0.2.

The portion of "dioritic" layer (Fig. 1, *b*) is the largest in the south of the DDB, in south-east of the northern flank, in the central zone and southern preflank zone of the Chernigovskii, and Poltavskii and Lokhvitskii megablocs (0.4—0.5). A small portion of this layer occurres in the southeastern part of the central zone of the Iziumskii megabloc and in the north-western Donbass (0.0—0.1). The rest of the area is characterized by the values of 0.2—0.3.

The maximum portion of the "basalt" layer (Fig. 1, *c*) is associated with the north-western Chernigovskii megablock and the north-western part of the central zone in the Lokhvitskii megabloc, the south-eastern Iziumskii megablock and the whole Donbass (0.5—